Abstract
This thesis is a history of science education reform in Ontario from 1880 to 1940. It examines successive eras of science education reform in secondary (pre-university) schools, including the rise of laboratory science; the spread of general science programs; and efforts to teach science “humanistically.” This research considers the rhetorical strategies employed by scientists and educators to persuade educational policymakers and the public about the value and purpose of science education. Their efforts hinged in large part on building a moral framework for school science, which they promoted as an essential stimulus to students’ mental development and a check on the emotive influence of literature and the arts. These developments are placed in international context by examining how educational movements conceived in other places, especially the United States and Britain, were filtered and transformed in the distinct educational context of Ontario. Finally, the sometimes-blurry boundaries between “academic” science education and technical education are explored, most notably in Ontario in the late nineteenth century, when science education was undergoing a rapid, driven expansion in the province’s high schools. This research contributes to a growing body of literature that
promotes a greater appreciation of pre-college science education – an area that has often been overlooked in favour of higher education and the training of specialists – as an important window onto the public perception of science.
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Introduction

In 1880, A. P. Coleman, a schoolmaster who taught science at Ontario’s Cobourg Collegiate Institute, Ontario issued a “Plea for More Science” to the Canada Educational Monthly, Ontario’s chief educational journal. For Coleman, science meant the physical sciences, which had been embraced in universities, but were still largely neglected in elementary and secondary schools. The pressing question, he noted, was “how far Science is suited for popular education in Public and High Schools.”

Coleman’s account of the special purposes of school science was a medley of characteristic late nineteenth-century images of science. First, he argued that the physical sciences honed a particularly rigorous kind of mental discipline, requiring close observation and conscientious truthfulness. Second, this discipline led to the moral betterment of society: “In this age of shams and defalcations and fraudulent bankruptcies, let us not neglect anything that trains the mind to scrupulous honestly,” he wrote. Third, science addressed matters of practical importance in everyday life, the attentive study of nature leading directly to the wonders of modern technology:

The process often goes on somewhat in this way: certain phenomena in nature, perhaps very trifling in appearance to an untrained eye, are observed; there relationship to previously unknown phenomena are studied, and the knowledge thus gained is by some inventive brain turned to practical use. Next day, the world, as it sips its coffee, reads in the morning papers of Edison’s last wonderful invention.

Fourth, school science, with its focus on the material world, was inherently democratic: it served the needs of the “majority of mankind [who] deal mainly with matter rather than mind.” Fifth, science was spiritually and culturally uplifting. To those who might suggest that secondary education should not just be about life preparation but also about “higher culture,” Coleman countered that the intricacies of Latin or Greek grammar could not possibly be more elevating than a “glimpse into the everlasting truths of God’s work in Nature!” Sixth, science was enjoyable for young boys: “the keen pleasure all boys feel in
practical work in science” could make school life “as attractive as it is now repulsive.”
And finally, Coleman warned that the world was changing and that Ontario needed to
keep pace with educational practice abroad: “Science must take the position it deserves in
our schools, or Germany, with her natural science and technical schools, will leave us far
in the rear.”

Coleman’s characterization of the promise of school science, appearing four years before
High School Inspector John Seath would initiate his major expansion and standardization
of Ontario’s high school science curriculum, neatly encapsulates the key justifications for
science that would be repeated, reshaped, and critiqued well into the twentieth century. In
the time period covered by this dissertation, which extends from the mid-1880s to the late
1930s, just before the outbreak of World War II, every one of Coleman’s confident
justifications would come under scrutiny. Psychologists would call into question the
special intellectual functions of school science. The privileged moral status of science
would clash with the emerging idea that scientists were morally ordinary. Some educators
celebrated the practical and instrumental aspects of science, but critics argued that its
materialism and utilitarianism cast doubt on its suitability for academic secondary
schools. Tensions between the vocational and academic qualities of science education
persisted well into the twentieth century. Scientists and educators also veered between
emphasizing the “democratic” and accessible attributes of science education, as Coleman
did, and underscoring its élite, rigorous, intellectually demanding nature, which were
touted as signs of its prestige. The widespread secularization of science, gathering
momentum at the turn of the century, would undermine the time-honoured conviction
that the study of nature was spiritually edifying. And finally, the argument that science
was fun ran headlong into misgivings about American-style progressive education – and
made it suspect in the eyes of those who felt that the schools were pandering to students’
natural interests. As one teacher alleged of the inclined plane experiment in physics
courses, students were amused by it but did not learn much at all: “The exercise had just
one merit, it was easy – and worthless.”

Association (1902): 253.
This dissertation examines the historical trajectory of rationales for secondary school science such as Coleman’s – namely, the social justifications for science that were formulated and circulated in late nineteenth-century and early twentieth-century Ontario. Secondary education in Ontario emerged in the latter half of the nineteenth century as a distinct step in the educational ladder, diverging from the work of both primary schools and universities. Over the first few decades of the early twentieth century, English Canadian national identity, particularly in Ontario, shifted from a strong allegiance to imperial Great Britain, which was galvanized by the Boer and First World Wars, to an emerging sense of independence and sovereignty after the Second World War. In matters of curriculum-making and textbook production, Ontario was keenly committed to self-sufficiency by the late nineteenth century, determined to produce and adopt Canadian rather than British or American textbooks in its public schools. The history of secondary school science shows how educators played a central role in generating and reinforcing cultural conceptions of scientific practice. The images of science codified in high school curricula and textbooks would reach an increasingly wide audience over the course of the twentieth century, as enrolments increased, mandatory attendance acts were enforced, and an increasingly wide swath of society did at least a few years of high school before entering the work force, in Ontario as well as across much of Canada and the United States.

This dissertation takes a particular interest in moral arguments for school science, and how these arguments both borrowed from and reinforced broader cultural representations of science in Canadian society. In the late nineteenth century, the beginning of the period covered by this research, moral arguments for school science were closely allied with the research ideal. At this time, the moral value of school science was especially tied to patient, scrupulous adherence to the inductive method. The applied science of technical schools, meanwhile, was taught in separate institutions, and the broadly cultural mandate of academic secondary schools was reinforced by the images of science that undergirded

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the construction of the high school science curriculum. However, as educators began to question the role of “scientific method” as an effective pedagogical device, the ties between morality and method were gradually loosened. By the late 1930s, when this dissertation concludes, Ontario high school science had embraced the engineering ideal, with the ambition of attracting students who would do the mandatory two years of high school before heading to jobs in industry. The disciplinary structures of science no longer held sway as the basis for constructing the school science curriculum. Rather, Ontario educators increasingly summoned research in applied psychology to support new pedagogical approaches that were heavily influenced by American-style progressive education. In tandem with these pedagogical changes, the moral value of school science was recast as a stabilizing force in society, but one that risked degenerating into a cold, amoral systematism if not tempered by the affective qualities of the humanities.

1. Main Themes

One of the primary themes of this dissertation is how scientists and science educators participated in building a moral framework for school science. In defending the role of science on the secondary school curriculum, educators promoted the moral benefits of the study of science. When Victorian critics charged science with materialism and utilitarianism and challenged the expansion of science in secondary schools, educators responded by signalling the virtues cultivated by science: qualities such as restraint, assiduousness, patience, and doggedness in the pursuit of truth. In their bid to show how science could mould the character of young students, science educators became influential participants in a time-honoured cultural enterprise whose historical roots reach back to the seventeenth century: the effort to demonstrate the superior morality of science and to justify the cultural authority of scientific knowledge.

Steven Shapin has pointed to the fundamental transition in scientists’ cultural identity that was underway in the late nineteenth and early twentieth centuries. The natural philosopher of the seventeenth or eighteenth century had been seen as an interpreter of divine Creation, gleaning privileged insight into nature and reality. As conceptions of the natural world became increasingly secularized during the nineteenth century, scientists
pointed more often to the civic, practical value of their work. Scientists were now seen less as “philosophers” with a special grasp of Truth than as doers with the ability to predict and control the natural world.\(^5\)

Late nineteenth-century reforms to Ontario’s science curriculum show that this changing cultural conception of science was also borne out and perpetuated in schools. Scientific subjects were charged with particular moral lessons and portrayed as a necessary complement to the traditional, cultural role of humanities subjects on the high school program. Science educators especially stressed the importance of emotional self-discipline as a corrective to the affective influences of literature and the arts. Significantly, these virtues of character were not just associated with science as way of knowing; they were also understood to be beneficial effects of science as a practice.

David A. Hollinger notes that in Victorian America, it was commonly held that “participation in scientific practice drew upon and reinforced desirable moral traits. Not only was science noble and pure; its practice was ennobling and purifying.”\(^6\) This point seems particularly applicable to the development of school science. This cultural avowal of the moral benefits of doing science dovetailed perfectly with the new appreciation of “learning by doing” that motivated reformers like Ontario school inspector John Seath. If scientific practice was ennobling and character-shaping, so was hands-on learning in the science classroom. All research, even the halting efforts of high school students, was held up as morally edifying.

Shapin notes that as science came to be valued as agency over nature rather than as metaphysical insight into underlying realities, “Method” took on a new role in circumscribing the morality of science. The virtuous character of the individual scientist no longer mattered in the same way, because scientists’ personalities were subsumed and held in check by the collective, disciplined application of Method. Significantly, Shapin

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notes, while scientists often disagreed about how scientific method should operate, they agreed on one thing: it could be “formalized, written down, transmitted with ease from one person to another, and implemented by each person so as to yield reliable knowledge.” This confidence in the transmissibility of Method explains in part why scientific method became the backbone of secondary school science teaching in the late nineteenth century. As school science was expanded and restructured in the 1880s in Ontario, its place on the curriculum was justified entirely in terms the intellectual discipline produced by the inductive method. Content was held to be virtually irrelevant.

Secondary schools did not simply reflect wider cultural images of science, they also moulded, perpetuated, and disseminated them. By virtue of their expanding social reach, particularly with the rise of mass education, schools exerted a powerful influence on the public perception of science. In the 1880s, when this dissertation begins, the notion that the study of nature was spiritually and morally uplifting was still in evidence among advocates of science education, particularly in their reflections about botany, zoology, and nature study. But the most prominently advertised moral benefits of school science were undoubtedly discipline, order, and self-control. This dissertation shows that in subsequent decades, when the pedagogical adherence to scientific method was relaxed, the moral framework of school science was also reconsidered. By the 1930s, educators increasingly took up the idea that school science needed an infusion of “human values” from the narratives of history. Scientific biography could provide the moral and civic lessons that were otherwise absent from the “cold” and purely technical science curriculum.

Just as scientists were beginning to shed their enduring image as “priests of nature” – and, in some cases, pointing to method rather than personal virtue as the grounds for the trustworthiness of their work – teachers were contriving a similar transformation of their cultural identity. Nancy Christie has argued that the professional ambitions of some schoolteachers in late nineteenth-century Ontario prompted them to reject the established Victorian model of teachers as moral guardians. Instead, reform-minded teachers promoted a new model of the teacher as a scientifically trained professional. In their

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campaign for professional stature, they tried to “organize the teaching profession around social science rather than the moral concerns of the humanities.” According to Christie, these teachers championed the “new psychology” emerging from the United States and were unworried about the materialist implications of scientific naturalism. The secularism of American psychologists such as G. Stanley Hall was unproblematic for Ontario’s reformist teachers, Christie claims, because they had deliberately jettisoned the traditional moral prerogatives of the teacher’s occupation. Instead, they “rather simple-mindedly” embraced the new psychology, seeking credibility and status by allying themselves with a scientific approach to education. As early as the 1870s, one prominent Ontario educator, George Paxton Young, expressed hope that the “science of education” would shed light on the “laws of the mind” and provide a solid basis for the teacher’s practice.

This dissertation, however, suggests that concerns about the moral foundations of education never fell by the wayside, and indeed were particularly in evidence when it came to negotiating the place of science on the high school curriculum. While reformist educators looked optimistically to psychology and the fledgling “science of education” as a way to buttress their professional ambitions, the morality of science was very much under scrutiny when science began to intrude on territory formerly enjoyed by Latin and literature. Moral concerns remained in the foreground of debates and discussions about science education in Ontario’s education journals and in the addresses of the Ontario Education Association from the 1880s until the 1940s. Much as it had in Great Britain, the expansion of science on the curriculum in Ontario met with vocal opposition from a literary and religious elite. In this climate of conflict, the differences in cultural values attributed to science and the humanities were drawn in sharp relief.

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8 Nancy J. Christie, “Psychology, Sociology and the Secular Moment: The Ontario Educational Association’s Quest for Authority, 1880–1900,” *Journal of Canadian Studies* 25, no. 2 (Summer 1990): 121. Christie notes that this definition of professionalism, which placed an emphasis on scientific training rather than personal moral virtues, was designed to exclude women. Female teachers formed the majority of Ontario’s teaching personnel, but their suitability for teaching children was often tied to their supposedly innate moral and nurturing qualities and not their academic credentials. In other words, female teachers were thought to represent the very kind of teacher from which reformist male teachers wanted to dissociate themselves (130).

The professional aims of both scientists and science teachers clearly provided an incentive to define and defend the moral credentials of school science. University scientists recognized that the high schools held the promise of disciplinary reproduction as well as a steady undergraduate clientele: aspiring high school teachers represented a major portion of enrolments in the province’s science faculties. Science teachers naturally wanted to protect the curricular ground they had gained in the schools and harmonize their subject with the reigning cultural aspirations of the high schools. While Christie implies that teachers’ professional ambitions were naïve and one-dimensional, this view of professionalization seems overly cynical. Scientists’ and teachers’ efforts to bolster the moral image of science should not be seen merely as a public relations campaign designed to impress a credulous public or win over traditionalist opponents. As Hollinger observes, advocacy for the moral efficacy of science was not just “a tool for manipulating non-scientists, but also a means of self-comprehension for scientists.” Moreover, it was not just “experts” – scientists and science teachers – who had a vested interest in shoring up the moral edifice of science. Hollinger points out that a wide swath of the (American) public, whose members saw themselves as participants in the growth of industry, were just as keen to embrace an honourable, edifying and purposeful conception of science. In other words, professionalization was a process that relied in part on wider public sanction and the common weal. Scientists and educators were not out to make science seem noble so that they could sneak it into the classroom. Rather, high schools became an arena where the moral image of science was expressed and contextualized, as scientists and teachers grappled with their own self-conceptions and shifting cultural identities in the early twentieth century.

A second major theme of this dissertation considers how educators contended with the instrumental aspects of science within the confines of the traditional “cultural” role assigned to secondary schools in turn-of-the-century Ontario. Peter Dear writes of the two faces of science – science as natural philosophy (as a way of knowing) and science as instrumentality (as practical efficacy) – and shows that cultural representations of modern science tend to focus on one or the other of these two “ideal types,” but not both at the

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same time. The history of school science shows that educators, too, alternately called up these two images of science in different contexts, for different purposes.

When educators advertised the moral benefits of school science, they were appealing to a fundamentally conservative view of secondary education: the widespread belief that a high school education should be about cultural polishing. The emphasis here was primarily on science as a “way of knowing.” Its thorough training in inductive reasoning produced personal and intellectual discipline in its practitioners. Students might learn by doing science through hands-on experiments, but this laboratory work was still understood to serve the traditional goal of fostering proper thinking, not to provide technical skills.

But science promoters did not appeal only to traditional educational ideals. When it was expedient to do so, some educators wielded science as a spur for reform, arguing that the curriculum needed to be diversified in order to appeal to students from different social strata or with varying natural interests and abilities. Here, educators turned to science’s other “face,” namely, its instrumental capacities. Bringing more science into high schools, they argued, would spur industry and modernize Canadian society. In these instances, science was cast as a democratizing force on the curriculum, opening up career options beyond the traditional pathways to teaching or the liberal professions.

The instrumental value of science and its evident role in technology and industry in turn-of-the-century Ontario, however, presented a tactical challenge for science educators: its instrumental role seemed to clash with its moral role. Some historians have argued that the material progress associated with science helped tip the balance of opinion in favour of school science. R. Gidney and W. P. J. Millar, for example, have argued that those campaigning for more science on the curriculum could summon science’s utility as a kind of trump card in the competition with traditional subjects for time and resources. If science advocates could persuade their critics that school science cultivated mental discipline just like the classical subjects of a liberal education, then science’s added

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distinction, its *usefulness* in modern society, sealed its claim on the curriculum. Indeed, as W. H. Brock has pointed out, educators in all western countries cited national prosperity and technological competitiveness in their arguments for expanding and improving school science: this was a ubiquitous strategy of late nineteenth-century science boosting. Yet science’s material value clearly became an albatross in curriculum disputes, which often pitted culture utility. Anna Katherina Mayer, writing about school science in Britain, points to the deep-seated “antithesis between progress and morality” that prevailed in the interwar period. The instrumental nature of science, firmly linked to industrial progress in the public imagination, was portrayed as a threat to the traditional moral functions of a classical secondary education. Science promoters in Ontario confronted the culture-utility divide head-on, and their efforts to challenge and dismantle it reveal how entrenched it was within the ethos of turn-of-the-century formal education. Arguments appealing to science’s technical, economic, and civic worth cut both ways, and therefore had to be deployed with great care. Nineteenth-century advocates for school science opted either to downplay the utilitarian features of science (as Ontario’s High School Inspector John Seath and Minister of Education George Ross did) or to insist, volubly, that the culture-utility opposition was a meaningless vestige of tradition. Ultimately, it took both the dire economic straits of the 1930s, as well as new pedagogical theories that cast doubt on the scope of the intellectual outcomes of the curriculum, for school science to embrace the applied, technology-laden, broadly instrumental aspects of science.

These tensions surrounding the instrumental nature of science and its place on Ontario’s school science curriculum came to the foreground in efforts to promote technical education in the province, which are examined in Chapter 2. How to reconcile the utilitarian nature of technical education with the Victorian conviction that public education was about liberal culture? Suzanne Zeller has argued that Canadian promoters of science “used the cause of technical education as a Trojan horse” in their efforts to

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“make liberal knowledge more practical and technical knowledge more theoretical.”15 In
the late nineteenth century, the relationship between academic school science and
technical education was in flux, as were the underlying distinctions between scientists
and engineers, or between “pure” and “applied science.”16 As Gidney and Millar write,
“The development of these modern dichotomies – pure and applied, professional and
technical, theoretical and manual – which are constitutive elements in our own
conceptions of how education should be organized, deserve more attention from
historians than they have received so far.”17

On the whole, Ontario’s technical education campaign prompted educators to
classify academic secondary school science in opposition to technical education.
Some teachers regarded science as a “bread and butter subject” whose claim on the high
school curriculum was as dubious as its “close relative,” manual training.18 Accordingly,
educationists took pains to emphasize the cultural, intellectual qualities of high school
science. The institutionalization of technical education drove a wedge between high
school science, which embraced the research ideal, and the science of technical schools,
which sought to create knowledgeable workers. Turn-of-the-century proponents of
technical education, meanwhile, advocated for federal funding, which they could only
secure by distancing technical schools from public education and positioning them under
the umbrella of industry, since the Canadian constitution had placed public education
within the provinces’ jurisdiction.19 Educators exercised the careful balancing act used by
research scientists, who sought to demonstrate the practical need for abstract research
(and by extension, for state funding of this research) while also retaining the freedom to
follow their own research agendas. Shapin writes that as of the late nineteenth century,
scientists began making their case for pure research by pointing to its promise of “an
indefinitely postdated utilitarianism”: they argued that an investment in pure science

16 Shapin, The Scientific Life, 43–44.
17 Gidney and Millar, Inventing Secondary Education, 290.
19 Aboriginal education was an exception. It came under the jurisdiction of the federal
government.
would bear practical results somewhere down the road.\textsuperscript{20} Similarly, high school educators made gestures toward the long-term economic rewards of school science, but placed a premium on its immediate disciplinary value, since they knew the latter was a much more palatable rationale. In the 1930s, enrolment surges caused by the Depression, combined with a surge of interest in American-style progressive education, prompted an effort to reconcile academic and vocational education in high schools. Facing these new pressures, the high school science curriculum substituted an engineering ideal for the research ideal that had galvanized science education reform in the late nineteenth century.

Finally, this dissertation also contributes to recent scholarship on the history of textbooks in science. Thomas Kuhn’s portrayal of science textbooks as repositories of “finished scientific achievements” that herald the final stage of scientific revolutions has come under scrutiny in recent years. In Kuhn’s view, textbooks convey a distorted understanding of the history of science because they are designed to be “persuasive and pedagogic” and therefore cannot be taken at face value.\textsuperscript{21} Antonio García-Belmar, José Ramón Bertomeu-Sánchez, and Bernadette Bensaude-Vincent argue, contra Kuhn, that textbooks should not be seen simply as canonized knowledge. Drawing on nineteenth-century French controversies over atomism and equivalentism, they show that textbooks do not stand outside theoretical controversies – rather, they have been “spaces of freedom” where scientists could expound their personal views. Individual textbooks can act as pockets of resistance to prevailing dogma.\textsuperscript{22}

Chapter 4 draws attention to the particular constraints and purposes of secondary school science textbooks. The high school chemistry textbook in Ontario became a flashpoint for debate about the merits of the atomic theory, both as a pedagogical tool and as a legitimate subject of scientific inquiry. In an era of increasing standardization of the secondary school system, the educators involved in this dispute were aware that the

\textsuperscript{20} Shapin, \textit{The Scientific Life}, 43.


contents of the authorized chemistry textbook represented the official curriculum of the Department of Education. In this system, all players knew that their dispute would inevitably culminate in an official verdict from the Department. While each side was invested in a theoretical standpoint, these theoretical commitments were rhetorically pushed into the background. Instead, the debate was couched in terms of how chemistry should be portrayed to students – mainly, whether students should be exposed to unproven theories. Thus, Ontario’s high school chemistry textbook did not stand outside theoretical controversy, as Kuhn believed textbooks do. But since it needed the official sanction of the Department of Education, neither could it act as a “pocket of resistance,” as García-Belmar, Bertomeu-Sánchez and Bensaude-Vincent argue that higher-level textbooks can. Rather, the constraints surrounding the production of standardized introductory textbooks for non-specialists compelled everyone involved in the atomic theory dispute to recast a theoretical debate in terms of conflicting pedagogical justifications. In doing so, they summoned pedagogical arguments to bolster their theoretical standpoints.

When scientists and educators design curricula and textbooks for a lay audience, they obviously have to be selective in their representation of science. As this episode shows, the selection process can be highly contentious. The end product is what John Rudolph has called a “stylized representation of science.”23 This dissertation argues that secondary school science textbooks, which had a broader reach than textbooks for specialists, were sometimes wielded as tools for disseminating controversial theoretical standpoints, but that their efficacy was hardly a given. To fulfill this purpose, they first needed to be assured of an audience – a goal that remained contingent on the will of teachers, on the prevailing pedagogical ethos, and on the sanction of educational policymakers.

2. Recent Historiography of Science Education

John Rudolph has argued that secondary school level science education is an area that deserves greater attention from historians of science, who have traditionally shown more

interest in postsecondary education, which contributes in clear ways to disciplinary reproduction, than in secondary education, which “has always existed at the periphery of elite science, far downstream from the laboratories and research seminars where scientific ‘truths’ are actively produced.”

Yet school science offers insight into which aspects of science have been valued as its essential features. It sheds light on why certain disciplines have acquired privileged institutional status, and shows what facets of scientific thinking have been prized as indispensable skills for the average citizen. “If we seek to consider questions of how scientific knowledge is taken up and circulated among ordinary citizens, we would be hard pressed to find a site that is more central than the school science classroom,” observes Rudolph. “The classroom is, after all, one of the few places where science has been deliberately crafted for public consumption.”

The history of school science offers a window onto the intersection between science and the public: in this regard, it has much in common with scholarship on the history of science popularization.

The history of secondary science education is also, clearly, an integral facet of the history of public education and curriculum history in general. For one thing, it shows how the growth of the science curriculum was a product of constant negotiations and clashes with those invested in other school subjects. The tensions created by the expansion of science on the curriculum illustrate what Ivor Goodson has called “the crucial conflict arena where… subject coalitions (and their representative associations) contest the right to material resources and career prospects.” For another, the history of school science sheds light on how broader cultural shifts and pedagogical movements sometimes effected different changes in different subject areas. Rudolph remarks that while American historians of education have examined the turn-of-the-century expansion of

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25 Ibid., 357.


public schooling and the proliferation of new subjects that ensued, “few studies have considered the changes that occurred within the boundaries of school subjects.” Science subjects, he points out, have received short shrift.\(^{28}\)

There is much left to be explored in the history of Canadian secondary science education in particular. There are few accounts of the history of science teaching in Canada. In Britain and the United States, by contrast, school science has received more historical attention. This has produced overviews of curriculum development – notably by George DeBoer and Kim Tolley for the United States, and E. W. Jenkins and David Layton for England and Wales – and an assortment of bibliographic essays.\(^{29}\) Sally Gregory Kohlstedt’s *Teaching Children Science*, which focuses on the nature study movement, spans both the United States and Canada.\(^{30}\) Science is mentioned peripherally in several general histories of Canadian education, but as Paul Axelrod acknowledges in his essay on the historiography of Canadian education, “the pure and applied sciences remain largely undiscovered by educational historians.”\(^{31}\)

Initial research into the historical investigations of the Canadian science curriculum turned up several doctoral dissertations from the early twentieth century and a historical overview drafted as an introduction to a 1985 science education policy analysis.\(^{32}\) In his 1990 essay on science education for the *Routledge Companion to Modern Science*, W. H.

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Brock remarked that while historians of science and education “have done a good deal of work on French, German and American science and education, little has been done on other countries.” Rudolph has highlighted the particular need for cross-national work that considers “the transmission of ideas across national boundaries during the rise of mass schooling – and how scientists and professional educators thought about and implemented (or reacted to) science education practices and philosophies from abroad.” Two recent essay collections with a deliberate international scope suggest that that gap is beginning to be addressed.

There are many avenues into the history of school science: curricula, pedagogical theory, classroom practices, teacher training, the professionalization of teachers and scientists, and gender inequalities, among others. Rudolph offers an overview of recent historiography of science education in his 2008 bibliographic essay, “Historical Writing on Science Education: A View of the Landscape.” This dissertation, for its part, focuses on the rationales for science education that were promoted “behind the scenes” – in other words, the discourse that surrounded curriculum-making in forums like educational journals and teachers’ associations. Educational historians have at times criticized this focus on the curriculum, because curricula often belie what is actually taught in classrooms. In her doctoral dissertation on history teaching in Ontario, Mary Anne Sodonis points to the backlash against curriculum studies initiated by University of Chicago educationist Joseph Schwab in 1969. Critiques of curriculum studies gained momentum during the 1970s, as Schwab and others castigated the overly theoretical, discipline-based tenor of curriculum research and argued that more attention needed to be paid to the commonplace, everyday routines of the classroom. When engaging in the

33 Brock, “Science Education,” 948.
34 See Peter Heering and Roland Wittje, Learning by Doing: Experiments and Instruments in the History of Science Teaching (Stuttgart: Franz Steiner Verlag, 2011) and “Cross-National and Comparative History of Science Education,” special issue of Science & Education (forthcoming).
historical study of curricula – that is, the programmatic objectives of educationists as they are codified and disseminated – it is indeed easy to overestimate the influence of a pedagogical movement if those curricula are considered in isolation. Nevertheless, while curricula may not always good indicators of educational practices, they do reveal educational ideals and priorities, which are in themselves well worthy of historical examination. These ideals show how much faith scientists and educators placed in public education as a way to secure cultural stature for science. It is worth noting that Ontario educators emphasized and downplayed certain features of science – for example, accentuating its methodologies and toning down its practical applications – in order to harmonize it with the intellectual values of a liberal education.

Both Brock and Rudolph have cautioned against focusing too exclusively on the content and organization of science instruction, which Rudolph likens to an internalist approach that isolates the history of science teaching from wider social history. Looking at how curricula have been organized in the past is important, but reasons for teaching science to the public are seldom tied to the disciplinary content of science subjects, he points out.37 “What has been neglected in historical studies of science and education, though, is an appreciation of the extent to which the disciplinary subject matter itself (over and above the processes of curriculum development or the organization of the school day) has been shaped by external forces,” he argues in his 2002 book, *Scientists in the Classroom*. It is important to consider not only the evolution of course content but also the underlying agendas that accompany revisions to the curriculum. Rudolph calls these the “collateral aims” of science education. They include such goals as managing the public perception of science, building or preserving a social order, recruiting into scientific communities, and promoting certain kinds of morality. By considering not only the end products of curriculum reform, such as textbooks and programs of study, but also the wide array of social and pedagogical justifications for school science that were articulated in the educational community at the time, this dissertation draws attention to the cultural images of science that gained currency as science became a staple ingredient of a general secondary education.

37 Rudolph, “Historical Writing on Science Education,” 70.
3. Historical Sources

This research examines the rationales articulated by scientists, educators, and teachers for expanding, revising, or defending the science curriculum from 1880 to 1940. Ontario’s programs of study rarely provide clues about their authorship and frequently simply list course topics with few or no introductory remarks about broader goals and methods. Accordingly, it considers the forums that both educators and scientists used to promulgate their views to Ontario’s educational community. The annual reports of the Ontario Educational Association (OEA) have been especially valuable in this regard. Chief Superintendent of Education Egerton Ryerson founded the OEA in 1861, partly to create an avenue for disseminating the Education Department’s ideas. By the turn of the century, the OEA had become a network of academics and schoolteachers, and it provided a forum for teachers to mobilize and assert their ambitions of professionalization. In the late nineteenth century, various special interest subsections were established, including groups organized around the different school subjects. In 1890, the Natural Science section was formed. Attendees met in plenary sessions and broke off into their own meetings to discuss their particular professional interests. The proceedings of the Natural Science section and the Mathematics and Physics section have been particularly illuminating to this research. The OEA proceedings also shed light on the factionalism and rivalries that arose between different subsections when science subjects began to gain status and resources that had previously been the preserve of humanities subjects.

Other important sources include archival inspection reports and the correspondence of school officials such as high school inspector (later Superintendent of Education) John Seath. Private correspondence between Seath and various school trustees provided insight into conflicts over allocation of space and resources in the initial wave of standardization and expansion of school science in the 1880s and 1890s. Approved textbooks, meanwhile, speak to the public face of science in Ontario schools and the finished products of school reform.

Another important source of information is educational journals, most notably the *Canada Educational Monthly* and *The School*. The *Educational Monthly* was launched in
1879 by publisher G. Mercer Adam and, in its early years, earned a reputation for being openly critical of the Department of Education. After 1896, when the Minister of Education began ordering copies for the Province’s normal schools, the journal tempered its censorious tone.\textsuperscript{38} \textit{The School}, meanwhile, was an indirect successor of the \textit{Educational Monthly} that ran from 1912 until 1948, when it was discontinued for financial reasons. According to Robert Stamp, it was Canada’s leading teachers’ magazine.\textsuperscript{39}

4. Chapter Summaries

This dissertation unfolds in five chapters. The first three chapters focus on how the science education community defined the social and cultural role of school science in response to outside pressures: university control over the high school curriculum, the rise of technical education, and competition with traditional subjects for resources and prestige. Chapter 1 examines the disputes that surrounded the advent of laboratories and hands-on science teaching in Ontario’s high schools. In the 1880s and 1890s, North American educators in universities and secondary schools began turning to professional research science as their model for pedagogical practice. At the University of Toronto, young professors trained in European research laboratories helped found Canadian professional science associations, engaged in original research, moved up the ranks of the university system, and advocated for better research facilities. The province’s high school science teachers earned their teaching credentials in these changing university science departments. Public school officials, in turn, eagerly embraced the research ideal in high school science teaching. In the mid-1880s, they wrote a new curriculum, instituted a grant scheme to encourage school boards to develop teaching laboratories, produced new textbooks, and carried out inspections to ensure that high schools were conforming to the new program.

\textsuperscript{39} Robert M. Stamp, \textit{The Schools of Ontario, 1876–1976} (Toronto: University of Toronto Press, 1982), 95.
These changes elicited controversy. Immediate points of contention were new expenses and demands on teachers’ time. Such practical concerns inevitably prompted scrutiny of science’s role in the high school program. The financial and time constraints that surrounded the expansion of school science in the 1880s forced school officials and science teachers to defend the value of science for high school students. Science, they argued, taught intellectual rigour and generalization skills: it exercised parts of the mind that the rest of the school curriculum did not. Their arguments relied on the conviction that students were to follow a strict inductive method in their experiments. Working with the apparatus and following the inductive method taught patience, carefulness, restraint, and objectivity. Yet others expressed concern that laboratory teaching might encourage sloppy thinking, because experiments geared to the high school level glossed over technicalities and required students to accept many premises on the teacher’s or textbook’s say-so.

School officials presented hands-on science teaching as the archetype of a new pedagogical approach in the high schools. School science that put students in “direct contact” with nature and required them to exercise independent reasoning in laboratory experiments and plant classification represented a rejection of passive learning through pedagogical practices like lectures, book learning, and rote memorization. John Seath, the school inspector at the helm of the reform project, portrayed school science as a turning point in high school teaching. In the course of these reforms, Seath’s pointed efforts to expand the science offerings became the vehicle for the standardization of curriculum, textbooks and pedagogical practice throughout the province.

Chapter 2 argues that the campaign for technical education, which unfolded at the same time as the expansion of high school science in Ontario, prompted educators to draw sharp differentiations between academic science education and the applied, vocational science to be taught in technical schools. While John Seath was administering the province’s high school science reforms, a vigorous campaign for technical education was simultaneously underway in the province. In both the academic high school program and vocational programs, the role of science was still unsettled. R. Gidney and W. P. J. Millar write that science education and technical education had been treated as close to
synonymous until the early 1870s: “There were only hazy distinctions between training for the workshop skills practiced by artisans and training for the so-called scientific professions.”

Even in the last decades of nineteenth century, the boundaries of the two reform movements blurred. It was unclear, for example, whether technical education would find a home within high schools or in separate institutions. Both fell under the jurisdiction of the Department of Education. Several of those advocating high school science education were also active in the campaign for technical education: John Seath is a prominent example of this overlap. His 1910 report Education for Industrial Purposes led to the Industrial Education Act of 1911, which provided provincial funding to school boards who established technical schools. Science teachers W. S. Ellis and William Pakenham were also outspoken voices in the cause of both school science and technical education.

In the high schools, proponents of expanded science offerings sought to shed widespread associations with trades and industry. They distanced academic science from vocational science by placing a premium on the cultural, intellectual benefits of the high school science program. Meanwhile, on the technical education side, educators emphasized the intellectual demands of their programs, noting that to rise above the menial nature of industrial labour, workers had to grasp the scientific principles that underlay their tasks. The relationship between vocational and academic science would continue to be negotiated until the 1930s, when they were briefly brought together within the new grade 9 general science course examined in Chapter 5. This chapter covers the period from the 1890s, when advocacy for technical education gathered significant momentum, to 1911, when Ontario’s Industrial Education Act was passed.

Chapter 3 considers how the constraints of the school curriculum intensified tensions between scientists and classicists in the first decade of the twentieth century. These constraints placed Latin and science in stark competition with one another as school subjects. Proposals to institute different curricular streams in the high school program and to replace Latin with nature study in the teacher’s course pitted science teachers against classics and language teachers in bitter disputes. This competition for curricular time and

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40 Gidney and Millar, Inventing Secondary Education, 287.
resources compelled both sides to advertise the special moral, intellectual, and social functions of their respective disciplines. These disputes reinforced prevalent dichotomies between science and the humanities: science was portrayed as dispassionate, amoral, materialist, modern, liberal, and forward-looking, while the humanities were understood to be emotional, spiritual, aesthetic, retrospective, and conservative. The schools, in other words, played an important role in demarcating a cultural role for science in the early twentieth century.

At the turn of the century, educational thought was in a period of significant flux. Increasingly, educationists began repudiating the theory of mental discipline that had justified the expansion of school science in the 1880s. The nascent field of experimental psychology offered new ways of conceiving of learning and teaching. Proponents of the “new psychology,” including James Baldwin and James Gibson Hume at the University of Toronto, positioned their discipline as a natural science to distinguish it from psychology’s parent discipline, philosophy. The emerging academic collaboration between psychology and education meant that many educationists were similarly keen to define education as a natural science, rooted in discernible “laws of the mind.” Others expressed hope that a natural science of education would provide objective, rational methods to resolve ongoing conflicts between humanists and scientists about curricular time and resources.

It is apparent that science teachers sought to situate the pedagogical methods of school science within these competing ideas about education. In particular, they stressed the intellectual demands of school science – its intrinsic difficulty – as its cardinal attribute. In doing so, they implicitly espoused a Hegelian conception of education that valued intellectual effort over students’ “natural” interests. Significantly, as science teachers advocated the difficulty of science, they moderated the earlier image of students as proto-researchers. High school students, some teachers argued, were not in fact intellectually equipped to generalize from an experiment to a law of nature. Such skills were the domain of the professional scientist, achievable only after years of experience and training. For high school students, experiments were pedagogical illustrations, not exercises in making inferences. Chapter 3 argues that this shift away from the
pedagogical principles that had been advocated by Seath in the 1880s was linked in part to shifts in science teachers’ own professional identities as they found the scientific research community increasingly closed off to them.

**Chapter 4** focuses on an internal dispute within the Natural Science section of the Ontario Educational Association about whether the atomic theory should be taught in high schools. William Lash Miller, a chemistry professor at the University of Toronto, tried to introduce a new high school chemistry curriculum and textbook that avoided all reference to the atomic theory. But Lash Miller’s efforts met with fervent opposition from George Cornish, a science teacher at Lindsay Collegiate Institute, who insisted that the atomic theory was an essential part of a basic education in chemistry. Significantly, the debate between Cornish and Lash Miller did not center on whether or not the atomic theory was correct, but rather on whether it was pedagogically useful. At the heart of their dispute were clashing assumptions about the goals of the chemistry course. Lash Miller, keeping future university undergraduates in mind, fought for a course that taught strict empiricism and avoided reference to theories. Cornish, arguing on behalf of non-university-bound students, contended that high school students should be initiated to the common vocabulary of chemistry, which necessarily included atoms and molecules. The debate over the teaching of the atomic theory highlighted several important tensions within high school science education: the role of high schools as feeders the universities, the proper place of theories and hypotheses, and the apparent trade-offs between rigour and relevance.

This episode also provides a compelling example of how high school curriculum-makers construct representative images of the scientific disciplines. The atomic theory controversy raised questions about how the chemistry course should portray the practice of chemistry to young students. Should the high school course be a scaled-down model of chemistry as a discipline, as some proposed? If not, which components of chemistry should be emphasized or omitted at the high school level? Educators also debated whether it was appropriate for the high school course to expose students to scientific controversy or simply teach the majority view. This chapter illustrates how conflicting pedagogical priorities of university science professors and educationists, as they were
hashed out in the OEA and ultimately adjudicated by the Department of Education, defined the image of chemistry that made its way into Ontario’s 1909 chemistry textbook.

**Chapter 5** is a comparative account of the adoption of general science courses in Quebec and Ontario in the 1930s. General science was deliberately interdisciplinary, and it rejected the idea that high school science courses should be patterned after their corresponding academic disciplines, particularly in the case of beginner courses. The ideal of science courses as scale models of scientific disciplines was jettisoned. Instead, general science courses adopted a thematic approach that emphasized the applied, technological, problem-solving dimensions of science. The pedagogical philosophy that undergirded the general science movement took shape in the United States and Britain in the early decades of the twentieth century. This chapter considers the measured implementation, in Quebec and Ontario, of these ideas from abroad. The factors that informed Ontario’s decision to introduce Grade 9 and 10 general science courses in 1937 are illuminated when contrasted with the limited adoption of general science in French Catholic schools in Quebec.

Educational research about the nature of learning facilitated the adoption of general science in Ontario. Transfer of training, which was first called into question by educational psychologists at the turn of the century, was further challenged in the 1920s and 30s. Mental discipline theory had assumed that intellectual skills acquired in one subject area could seamlessly be transferred to other fields. The content of the science program was held to be subordinate to these generalizable mental skills. As transfer came to be regarded as unreliable, it followed that the content of science courses – its direct relevance and usefulness to students’ daily lives – became much more significant as a measure of pedagogical value. Meanwhile, Depression-era enrolment pressures on the schools prompted more openness towards vocational options in the high schools.

This chapter also picks up the theme from chapters 1 and 3 of the persistent cultural dichotomies between science and the humanities. Bringing history of science into science courses was an important goal of the general science movement. Educators hoped that history of science would add moral lessons to the science curriculum, give courses
“human” appeal, and cultivate respect for scientists. This ambition reinforced the view that science was fundamentally objective, non-moralistic, and impersonal, and that it required an infusion of human values from the humanities.

The dissertation concludes at the turn of the 1940s, generally considered the high-water mark for progressive education in Ontario. The prewar embrace of American-style educational reforms would trigger a backlash in the 1950s, as the Report of the Royal Commission on Education in Ontario [Hope Commission Report] signalled a return to conservative educational policy. The adoption of general science in the lower grades of high schools was an episode when educationists rather than scientists held sway over the shape of the science curriculum, when the structures of scientific disciplines in the academy were held to be immaterial to the learning needs of young students, and when the applied, vocational components of scientific knowledge were briefly harmonized with the broad goals of a general secondary education.
Chapter 1

Learning in the Laboratory: The Introduction of “Practical” Science Teaching in Ontario’s High Schools in the 1880s

1. Introduction

In 1885, the Department of Education of the Province of Ontario initiated a concerted effort to introduce practical, laboratory-based science teaching into its high schools. Though a few natural science subjects had been prescribed on the curriculum since 1872, the reform effort of the late 1880s was truly a systematic overhaul, prompted by enthusiasm for the German model of scientific research that was quickly gaining currency in the United States and Canada. Within five years, many of the features that are today considered part and parcel of science classes were instated in Ontario’s high schools. At the helm of the project was newly appointed high school inspector John Seath, who applied himself zealously to the task and quickly became a gadfly to many school trustees. The top priorities were equipping schools with apparatus and dispatching inspectors to ensure that students and teachers were indeed using it. “In every High School and Collegiate Institute, . . . Chemistry and Physics should be taught experimentally, and Botany practically; and it shall be the duty of the High School Inspectors to report specially those schools in which this recommendation is not observed,” announced new regulations issued in August of 1885.¹ In physics and chemistry, experiments – performed not by the teacher, but by the students themselves – were paramount. In botany and zoology, the hands-on collection and examination of specimens were considered the natural analogues of the laboratory experiment, and nature itself was the laboratory. Grants were instituted to induce reluctant school boards to invest in apparatus and specimens, and a round of new textbooks was commissioned to canonize the modern methods of school science.

These sweeping changes were not unique to Ontario. In fact, they were representative of a wider North American trend in secondary education. Within Canada, Ontario’s reforms provided a template for other provinces to follow. At Confederation in 1867, the British North America Act had placed education squarely within the jurisdiction of the individual provinces. Even so, throughout the nineteenth century, Ontario’s textbooks were widely used in other provinces. “As Ontario textbooks came to dominate the national market in anglophone Canada a de facto national curriculum was created,” noted George Tomkins.² Moreover, even as Inspector Seath officiated over the introduction of apparatus and labs into Ontario’s schools, similar reforms were carried out in American high schools in response to the influential “Harvard lists” of experiments developed by physicist Edwin Hall and chemist Josiah Cooke.³

At the crux of these reforms was a growing allegiance to a novel pedagogical principle, that of independent, hands-on learning. Like many of their colleagues abroad, Ontario educators increasingly embraced the conviction that real learning required students to reason things through autonomously rather than be spoon-fed information for memorization. Critics took aim at the outdated, authoritarian ways of teaching repudiated by Herbert Spencer in his influential essays: “To tell a child this and to show it the other, is not to teach it how to observe, but to make it a mere recipient of another’s observations: a proceeding which weakens rather than strengthens its powers of self-instruction.”⁴ The schools’ longstanding reliance on bookwork, rote and drill was sharply criticized. In this effort, science seemed to hold more promise than any other subject. Properly taught, it was seen as an ideal field for putting into practice the pedagogical

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² George S. Tomkins, A Common Countenance: Stability and Change in the Canadian Curriculum (Scarborough, ON: Prentice-Hall Canada, 1986), 40.
ideals of practical, self-directed learning, as it drew on an array of skills in observation, interpretation, and handiwork.

In one respect, this episode of science teaching reforms is a story about the identity of the high school itself. In the 1880s, Ontario’s high schools had only just managed to carve out a distinct niche within the school system. For many decades, they had been plagued by persistent overlap between their work and that of the universities. Universities, starved for students, kept entrance standards low enough to compete directly with the high schools for enrolments. At mid-century it was not uncommon for rural students, especially, to bypass high school entirely and head to university directly from a common (public) school, doing any necessary remedial work at university. By the 1870s, most of this redundancy was eliminated, and high schools had secured their role as gatekeepers to the universities. In the 1880s, however, a different problem persisted: each university had its own distinct entrance requirements. This was a major logistical challenge for high school teachers and headmasters, who struggled to accommodate the various kinds of preparation that their matriculating students required.\(^5\) (American high schools at this time were similarly beleaguered by the multiplicity of college entrance requirements, a problem that prompted the Committee of Ten to convene in 1892 in an effort to standardize the curriculum.\(^6\)) In Ontario as in the United States, overhauling the science curriculum was unquestionably part of the project to harmonize high school work with university entrance standards and impose order on the system as a whole. High schools fell in line with the science requirements established at the University of Toronto, just as high schools across the United States gradually geared their programs to the entrance standards set by Harvard.

It would be a mistake, however, to see the reform effort simply as a top-down process dictated by the universities. The changes that were imposed on facilities, equipment, course content, teaching methods and textbooks also provided an opportunity for the Department of Education to assert control over its far-flung network of high schools and

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to uphold the authority of a standardized curriculum over the autonomy of individual teachers in the classrooms of Ontario. Furthermore, the high schools were seen as serving a very different social function than the universities. Though they catered to an educational elite, they aspired to provide a general education. Accordingly, although the laboratory model was inherited from the universities, the pedagogical rationales that accompanied it had to be filtered and transformed to match the stated mission of the high schools. It was not uniformly obvious to teachers and school trustees that science was an important element of a general education, nor that the laboratory was the best forum in which to teach it. Indeed, the varied response to the Department’s interventions illustrates how top-down decisions about the investment of time and money in the teaching of science became a catalyst for debate about how learning takes place, what a secondary education should offer to students, and what the proper role of the teacher should be.

In view of such debates, this account draws attention to the distinct pedagogical benefits that were ascribed to the study of science. Here, Ontario educators and officials drew on well-entrenched justifications popularized by Herbert Spencer, Thomas Henry Huxley, and James M. Wilson, a science master who had been instrumental in bringing a laboratory to England’s Rugby School. Following the lead of Wilson and others, Inspector Seath and Minister of Education George Ross anchored science subjects to the pedagogical dogma of mental discipline. The mental discipline attributed to the study of science was thoroughly conflated with the hands-on, inductive learning processes that science demanded. School officials could therefore argue that science not only deserved time on an already overburdened program of studies, but also that it required significant fiscal investments in renovations, furniture, apparatus, and specimen collections. As Ivor Goodson has shown, curriculum reform often triggers competition among school subjects for status, territory, and resources. This was indeed the case for science reform in the 1880s, as demonstrated by the often-hostile letters that flew between local school boards, the Department, and its inspectors, who wrangled over the allocation of time and money to laboratory science. Meanwhile, science teachers wrote to the Canada Educational Monthly, the leading educational journal of English-speaking Canada, emphasizing the

moral and intellectual rewards of school science and measuring its benefits against those of other subjects.

In 1889, in the wake of his unyielding campaign to compel change in the province’s high schools, Inspector Seath surveyed the work done over the previous five years and felt justified in declaring it largely complete. “The most gratifying increase,” he noted, “has taken place in the value of the scientific apparatus.” Yet in spite of the accolades for science teaching publicized by Seath and others, criticisms mounted. Significantly, these criticisms came not from those who opposed the expanded role of science in the schools, but from science teachers themselves. As the optimism of the 1880s gave way to a measure of disillusionment about the successes of science teaching, several Ontario educators expressed strong doubts about the effectiveness of practical science teaching and the much-acclaimed inductive method. Finally, challenges to faculty psychology in the 1890s meant that the rationale of mental discipline that had given impetus to the teaching of science lost much of its authoritativeness. As will be seen, however, thanks to the strongly centralized authority of the curriculum, the malleability of the notion of “practical” teaching, the rising cultural influence of the natural sciences, and mounting pressures on the traditional high school program, laboratory science retained its place on the curriculum and withstood the social and pedagogical changes of the 1890s.

2. Universities Pave the Way: The Research Laboratory Comes to Ontario

During the 1870s and 1880s, several factors combined to make the teaching of high school science a clear priority for reform. Most notably, significant changes were afoot in the province’s universities, particularly the University of Toronto. From the 1870s onward, university science departments in Canada were gradually transformed as their traditional teaching mandate expanded to include research. Yves Gingras has traced the changing tenor of teaching and publications among Canadian physicists as a new generation of European-trained researchers gradually took over the scientific professoriate. This transformation entailed a major change in purpose for university science courses. Science had previously been taught as part of a broad-based arts

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8 Report of the Minister, 1888/89, 187–188.
education for the upper classes. Under the new model, university students were trained in specialized research with a view to pursuing careers as professional scientists or skilled practitioners of medicine or engineering.⁹

At the University of Toronto, physics and mathematics chair James Loudon vigorously promoted the German research model and lobbied for the introduction of laboratory research and teaching. When the provincial government proposed building an engineering school in 1873, Loudon fought successfully for it to be affiliated with the University. Convinced that the University’s science departments would atrophy if they were forced to compete with a new, independent engineering school, Loudon insisted that affiliation was necessary for their survival. In 1878, the University of Toronto’s first instructional laboratories for chemistry, physics, mineralogy, geology, and biology were opened within the new School of Practical Science. That same year, laboratory work was introduced as an option for physics students. By 1885, it was mandatory for anyone seeking an honours degree in physics.¹⁰ Loudon was appointed president of the University in 1892 and redoubled his advocacy for scientific research in the province’s universities. For Loudon, the Johns Hopkins University was the exemplar of an institution that had successfully grafted the German university model onto the traditional higher education system inherited from Britain.¹¹

The laboratory-based instruction that defined the transformation of university science departments simultaneously became the pedagogical standard for high school science teaching endorsed by the Department of Education. This was a pattern also exhibited in American high schools, which took their cues from the program requirements of colleges and universities.¹² The universities also trained the province’s high school teachers. Indeed, earning a university degree was the standard route to the first-class certificate

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required for high school teaching. By 1896, an aspiring high school teacher could acquire “specialist” status by earning an honours degree in science, history, math, classics or a modern language. A specialist certificate qualified its holder to work at a higher salary in one of the province’s collegiate institutes, an elite tier of high schools. As science graduates educated in the new university laboratories entered the high schools, they brought their laboratory education to bear on their own teaching.

In 1885, the year that laboratory work became compulsory for honours degrees at Toronto, Inspector Seath went on the offensive in his inaugural high school inspection report. Running at more than 14,000 words – nearly five times the length of his fellow inspector John E. Hodgson’s – Seath offered a sweeping critical appraisal of the high school system. (The report was “exhaustive in more senses than one,” noted one commenter wryly.) Seath’s assessment of science teaching was particularly grim. “Probably no other subjects have been, confessedly, so badly taught as chemistry, physics, and botany,” he charged. He nevertheless expressed optimism that high school science would henceforth receive more attention, thanks to “the recent science additions to the matriculation curriculum of Toronto University.”

By this time, science had a stable, though not uncontested, position on the secondary curriculum. Natural philosophy, chemistry and natural history had made intermittent appearances in Ontario’s grammar schools since mid-century. In 1871, a pivotal high school act restructured the entire curriculum, granting physics, chemistry and botany a

13 The institutional structures for teacher education underwent frequent changes in the last decades of the nineteenth century. As of 1885, a university degree was no longer deemed sufficient for a high school teaching certificate: graduates now had to do a four-month “professional” training course in one of the province’s five new Training Institutes (which were in fact specially designated collegiate institutes). This new requirement was resented within university circles, where professors perceived it as an implicit reproof of their teaching methods. In 1890, the Training Institutes were abolished and professional teacher education was centralized at the Toronto School of Pedagogy, which itself was relocated to Hamilton in 1897. In 1906, faculties of education were established at Queen’s University and the University of Toronto and high school teacher education was henceforth undertaken within the universities, despite longstanding opposition from many university professors. See J. G. Althouse, The Ontario Teacher: An Historical Account of Progress, 1800–1910 (Toronto: Ontario Teachers’ Federation, 1967), 135–156; Stamp, Schools of Ontario, 44.


15 Report of the Minister, 1885, 161.
lasting place on the program. The landmark 1871 act was also an important step toward a centralized school system: it renamed the grammar schools, which henceforth were called high schools, made them legally co-ed, and brought them under the authority of the province’s Department of Education (then known as the Department of Public Instruction). Henceforth the Department had control over the curriculum, the authorization of textbooks, the setting of exams, and the education and certification of teachers.\(^{16}\)

John Seath was an ambitious and influential figure in Ontario’s educational system. The son of a Scottish engineer, he had emigrated from Scotland with his family in 1847, later leaving to study at Queen’s University in Ireland (now Queen’s University Belfast), where he acquired a BA (Honor) in 1861, including a First in natural science. He immediately embarked on a successful career in teaching that saw him rise steadily through the educational ranks, and was conferred a second BA (*ad eundem*) from the University of Toronto in 1864. After a prestigious headmastership at St. Catharines Collegiate Institute, a school that attracted students from all over the province, he was promoted to high school inspector, and eventually to Superintendent (effectively third-in-command of the Department of Education), a position he held until his death in 1919.\(^{17}\) Seath’s policies were reform-minded and comprehensive: most notably, he relentlessly championed the cause of technical education throughout his career.\(^{18}\) In his role as inspector, Seath rarely minced words and was not cowed by the grumblings of indignant trustees. Convinced that a strongly centralized school system was the best way to improve education, he was committed to bringing recalcitrant schools into line with Department policies. This conviction extended to his approach to science education reform. In his inaugural report, he asserted: “No plea should be necessary for the study of science. Its claims are now admitted by all, except, perhaps, the few whose liberality is

\(^{16}\) On the wide-ranging changes introduced by the 1871 Act, see Gidney and Millar, *Inventing Secondary Education*, 231–253.

\(^{17}\) Stamp, *Schools of Ontario*, 41.

bounded by the horizon of their own attainments or their own selfishness.”¹⁹ This kind of polemical statement did not help to heal the increasingly tense relationship developing between the inspectorate and local trustees.

3. Enticements and Threats: Getting Apparatus into Ontario’s Classrooms

In their 1885 assessment of school science, the Department’s two high school inspectors pointed to the schools’ lack of apparatus as both a symptom and a cause of ineffective science teaching. “Owing to the want of suitable apparatus and, in some cases, of the application of proper methods, of real science teaching there is very little,” Seath remarked.²⁰ Even John Hodgson, whose criticisms were nearly always much milder than Seath’s, noted pointedly that students had very few opportunities to perform experiments.²¹ Science also stood out as having a particularly high failure rate in the grade 13 examinations (the notoriously difficult “Departmentals”). Hodgson, reporting the figures, attributed the failure rate to a dearth of apparatus for practical science teaching. The failure rate for mathematics, by contrast, he attributed to the difficulty of the exam.²²

By this point, the Department of Education was on a clear campaign to change the situation. Seeking to encourage schools to invest in scientific apparatus, it announced in 1884 that it would provide annual grants based on the value of their apparatus collections. The grant scheme was somewhat complicated and slow to catch on: three years after it had been introduced, Seath complained that many boards had yet to realize how good a deal it was and tried to persuade them that it was even worth borrowing money if they needed to.²³ The new grants allowed most schools to recoup the costs of their equipment

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¹⁹ Report of the Minister, 1885, 161.
²⁰ Report of the Minister, 1885, 161.
²¹ Report of the Minister, 1884, 188.
²² Report of the Minister, 1885, 152. Only forty-two percent of the 4500 candidates who took the Departmental exam passed it, Hodgson reports. Of those who failed, twenty-five percent failed in science (chemistry, botany, physics and statics). The next-highest failure rate (eighteen percent) was in mathematics.
²³ Report of the Minister, 1887, 166.
within as little as five years. For Ontario’s collegiate institutes – larger, higher-status high schools – the apparatus regulations were not merely an incentive; they had teeth. The regulations stipulated that for a high school to qualify for or retain collegiate institute status, it had to own a minimum of $450 worth of science apparatus. As well, collegiate institutes were required to have a well-equipped laboratory and a staff of at least four teachers, including a science specialist. By 1887, however, only four collegiate institutes of the ten inspected had met the apparatus requirement, and Seath was threatening to demote non-compliant institutes to high schools.

Significantly, the provision of science apparatus had become another point of demarcation between regular high schools and the more prestigious collegiate institutes. The collegiate institutes had been created in 1871 under the direction of Chief Superintendent Egerton Ryerson, who had envisioned them as the last bastions of a classical education. Latin, he believed, would gradually be phased out of smaller high schools. But Ryerson’s plan failed: the enduring cultural prestige of Latin meant that, largely due to parents’ demands, it remained taught in schools throughout the province. By 1883, the distinction between high schools and collegiate institutes was based on staff qualifications and physical facilities – including, notably, science laboratories – rather than course offerings. In a sense, then, science facilities and apparatus would replace Latin as a demarcation criterion between Ontario’s high schools and collegiate institutes. As Seath remarked, the new equipment would mean that the inspectors would have “less difficulty hereafter in recognizing the difference between a Collegiate Institute and several of the high schools.”

24 The grants amounted to ten percent of the total value of the apparatus owned by a school, up to a designated maximum ($275 or $450, depending on the number of teachers on staff). Because the province’s grant was often matched by the county, schools stood to get a 20% annual return on their investment. These annual grants also applied to other forms of capital investment like library books, charts, maps, globes, and gymnasium equipment.
25 “Act respecting high schools and collegiate institutes,” in Revised Statutes of Ontario for 1887, vol. 2 (Toronto: John Notman, 1887), 2453. A similar strategy of enforcement would be adopted in New York State, where high schools in the rapidly expanding school system were required to build laboratories in order to qualify for state funding (Sheppard and Horowitz, 569).
26 Report of the Minister, 1887, 165; 177.
27 Stamp, Schools of Ontario, 7.
The Department’s new rules, particularly the apparatus requirement for collegiate institutes, did not pass uncontested. Much ink was spilled in letters between the inspectors and local boards indignant at the low grading of their facilities and the expense of meeting the new requirements. The board of St. Marys Collegiate Institute reacted with outrage to Seath’s 1887 inspection, venting its anger in an open letter to the Minister of Education. The board complained that it had only recently spent $3000 on a new wing, and was now being asked to set up a miniature laboratory for each pupil. It inveighed against the “autocratical” inspector, whose “dictum” they had to obey or else lose their standing. Seath, the writers alleged, was asking students to waste their time in “profitless experiments with expensive scientific toys, while that which will be of importance to them throughout their whole life work is almost wholly neglected.”

The board of Paris High School voiced similar annoyance at Seath, complaining that the all-too-frequent changes demanded by the educational department entailed “such heavy expense upon both school boards and parents.”

Compelled to build their apparatus collections, schools turned to Toronto-based dealers like Charles Potter, an enterprising optician and instrument-maker who quickly recognized the business opportunity presented by the new laboratories in the School of Practical Science and secondary schools. Potter established the Map and School Supply Company in the late 1880s, began tailoring his apparatus to the contents of high school textbooks, and over time, successfully expanded his instrument shop into a national school supply firm. But even as instrument dealers capitalized on the new requirements, the Department responded to the chorus of cost complaints from trustees by trying to persuade teachers to build their own apparatus. Seath, in particular, advocated this solution and insisted that “at least as satisfactory experiments can be performed with home-made as with bought apparatus.” This notion was pervasive at the time: Seath was

drawing on a trope of the educational literature, the image of the scientist as an inventive experimenter tinkering away in a homespun lab.\textsuperscript{32} “It is a well-known fact,” he wrote, “that some of the most important results in science have been obtained by means of very simple apparatus” – adding that pupils, too, should be encouraged to build their own equipment.\textsuperscript{33}

Perhaps not surprisingly, Seath’s suggestion met with resistance from some science teachers. One teacher bitterly dismissed it in the Education Monthly, writing, “Costly apparatus is necessary. It is useless to tell the teacher that with a little ingenuity he can prepare what is necessary. . . . It is hardly fair to expect spare time to be devoted to instrument-making, when so many other claims imperatively demand the teacher’s attention.”\textsuperscript{34} Despite such complaints, the practice of building apparatus by hand persisted well into the twentieth century. Thirty years later, a teachers’ guide issued by the Department of Education indicated the variety of workshop skills that students were expected to master: “In both Physics and Chemistry, practice in the preparation and manipulation of apparatus should form part of the Course. Where practicable, the Course should also include simple operations in glass-blowing and lathe work, and in hard and soft soldering.”\textsuperscript{35}

\textsuperscript{32} Alfred Gage, for example, asked rhetorically in the preface of The High School Physics: “Have lecture-room displays proved very effectual in awakening thought and in kindling fires of enthusiasm in the young? Or would a majority of our practical scientists date their first inspiration from more humble beginnings, with such rude utensils, for instance, as the kitchen affords? Is the efficiency of instruction in the natural sciences to be estimated by the amount of costly apparatus kept on show in glass cases, labelled ‘hands off,’ or by its rude pine tables and crude apparatus bearing the scars, scratches, and other marks of use?” See A. P. Gage and C. Fessenden, The High School Physics (Toronto: W. J. Gage, 1887), iv.

\textsuperscript{33} Report of the Minister, 1887, 167.

\textsuperscript{34} D. F. H. Wilkins, “Observations Regarding the Teaching of Science in Our High Schools,” Canada Educational Monthly 9 (1887): 89. This complaint was not confined to the high schools. Physicist James Loudon likewise recalled the labour of building apparatus in his early days in the University of Toronto physics laboratory. By 1907, he could rejoice that “the old drudgery” was largely a thing of the past: modern scientific equipment, he claimed, was delicate and expensive, requiring highly specialized skills. See James Loudon, “The Evolution of the Physical Laboratory,” University of Toronto Monthly 8 (1907): 44.

\textsuperscript{35} Ontario Department of Education, Manual for Suggestions for Teachers of Science (Toronto: L. K. Cameron, 1910), 226.
4. Science’s Contested Claim on a Crammed Curriculum

Another major obstacle to the Department’s reform effort was the already crowded curriculum. With the increased class time required not only by science courses but also by new subjects like bookkeeping and physical education, headmasters felt their resources being stretched to the limit.36 Reacting to yet another of Seath’s critical reports, the headmaster of Stratford Collegiate Institute protested that if teachers were spending too little time on newly-prioritized subjects, it was the Department’s fault for “putting on too many subjects” and demanding that pupils get “more lessons than there are spaces on the Time Table.”37 Likewise, members of the board of St. Marys Collegiate Institute added the overloaded program to its litany of grievances, targeting science classes for particular criticism:

The tendency of our educational system is to sacrifice thoroughness for brilliancy – to run over a great number of subjects, and to master none – to cram for examinations and to neglect thorough, honest work. It is of little importance that our children can blow hydrogen bubbles or demonstrate the binomial theorem, if they can not check over their washer-woman’s account or write an ordinary letter without murdering the Queen’s English, and mis-spelling Saxon words of four letters.38

Overextended school boards and headmasters were not the only ones complaining. Parents wrote too, complaining about the “cramming system” and the harm it caused to students’ health – especially, one letter-writer alleged, for girls.39 Inspector Seath’s reply to such complaints was characteristically uncompromising. He dismissed as nonsense the

36 The amount of time devoted to science remained officially at the discretion of the headmaster, but in practice inspectors strongly recommended minimum time allotments: Seath advised 45 minutes, 3–4 times a week for Form II chemistry, and 45 minutes, 4 times a week for Forms I and II botany and physics. (Kincardine High School, Complaint from science teacher (AH Smith) that his subjects are given a disproportionately small share of time, 1889, Department of Education select subject files, RG 2-42-0-4543, Microfilm reel 5656, Archives of Ontario.)
37 Stratford Collegiate Institute, Improvements in response to Inspector Seath’s report, particularly as regards laboratory, 1888, Department of Education select subject files, RG 2-42-0-4609, Microfilm reel 5656, Archives of Ontario.
idea that it was best to know “a few things well” and declared that there were many subjects that an educated person could not afford to be ignorant about. “That man is best educated who knows something of a good many subjects and knows at least one subject well,” he declared.\textsuperscript{40}

These complaints and the inspector’s response suggest that the teaching of science had become a flash point for changing ideas about the proper function of a high school education. The board of St. Marys Collegiate Institute challenged the value of science not on its academic nor pedagogical merit, but on its alleged irrelevance to the more pressing skills of everyday life. As Seath’s comments indicate, a broad-based, non-specialized program of studies was central to the high schools’ identity. Despite calls from some quarters for applied coursework that was better attuned to developing life skills, the Department of Education resolutely adhered to the tenet of mental discipline as its guiding priority.

Mental discipline was the pedagogical application of the doctrine of faculty psychology, which held that the various powers or faculties of the mind required different kinds of mental training, just as the various muscles of the body required specific exercises. Seath, for example, distinguished between subjects such as geography and history, which “involve largely the exercise of the ‘portative’ memory,” and those such as languages, mathematics, and the inductive sciences, which “are intended to promote thought.”\textsuperscript{41} In North America as in Britain, mental discipline remained the stated purpose of a secondary education throughout the nineteenth century. Any practical skills or useful knowledge that pupils might glean from their studies were secondary. In the case of the teaching of grammar, for instance, the Ontario Minister of Education George Ross noted that the provincial exam was “constructed in accordance with the view that, while the subject is a science which is capable of important practical applications, it has a distinct value as a means of mental training, to which the practical applications are subordinate in a high school course of study.”\textsuperscript{42}

\textsuperscript{40} Report of the Minister, 1885, 165.  
\textsuperscript{41} Report of the Minister, 1885, 166.  
\textsuperscript{42} George Ross, “Memo to Head Masters” in Report of the Minister, 1885/1886, 21.
The Minister’s reflections on science teaching further reinforced the overarching mission of the high school curriculum:

A general literary acquaintance with scientific facts is undoubtedly of practical value . . . but the main reason for the introduction of the study of Science into our schools is the mental discipline to be obtained therefrom. The training of the reasoning powers and the acquisition of the scientific habit of mind are the objects with special reference to which the method of instruction should be chosen, and these also will be the main objects of the examination papers.43

Ross seems to have been drawing on the arguments of James M. Wilson, a science master at Rugby School in England. In 1859, Wilson had set up a chemistry teaching laboratory at Rugby, with guidance from Scottish chemist Lyon Playfair. Though Ross did not cite Wilson, the latter’s 1867 essay “On the Teaching of the Natural Sciences in Schools” expressed the advantages of studying science in strikingly similar words. Wilson’s essay originally appeared in Anglican cleric Frederic W. Farrar’s influential Essays on a Liberal Education, which challenged the monopoly of the traditional classical curriculum in late nineteenth-century Britain and set the stage for related developments in Ontario schools.44

The doctrine of mental discipline was traditionally the preserve of the classics, but many nineteenth-century scientists and science boosters in Britain nevertheless quickly appropriated it.45 Robert Gidney and Wyn Millar have shown that in Ontario, by the 1860s, the traditional Georgian distinction between a liberal and an “ordinary” education was breaking down. As science and other new subjects made inroads into the high schools, reformers challenged the exclusive claim of the classics on the development of mental culture. Furthermore, advocates of science argued that subjects like botany,

chemistry, and physics were particularly well-suited to the dual mission of conferring mental culture and meeting the “utilitarian demands of a new age.”

Those who took up the refrain of mental discipline often argued that science was the best possible mind trainer, because it employed the range of skills required in everyday reasoning. In 1854, Thomas Huxley famously claimed that science was “nothing but trained and organized common sense.” In Ontario as elsewhere, this claim was still widely repeated in the 1880s. Science’s claim to disciplinary value took on added weight in the face of the common perception that the curriculum was already “crammed” with an excess of subjects: any new claimants had to defend their value against the rest of the curriculum. A. P. Coleman, a science master at Cobourg Collegiate Institute, published a “Plea for More Science” in the *Educational Monthly* that compared the educational advantages of natural science with those of other subjects. Mathematics, Coleman reasoned, did not reflect the complexities of everyday problem solving, because it built up from a few intuitive premises. The languages, in all their complexity, exercised the judgement more than mathematics, but were taught too superficially to provide real proficiency. History and geography, meanwhile, taught useful facts, but mainly trained the memory, which was “far from being man’s most lordly part.” The physical sciences, by contrast, excelled at providing mental discipline because they followed “the methods of actual life, only with more exactitude, gathering facts by observation, arranging them, and generalizing and theorizing from them.”

It was this careful, inductive process of scientific reasoning that made science so promising in the eyes of many educators. Seath emphasized the kinship between scientific reasoning and ordinary, everyday thinking in his monumental report of 1885. Like the Minister of Education, Seath drew on James Wilson’s 1867 essay, which he quoted at length:

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47 Thomas Henry Huxley, “On the Educational Value of the Natural History Sciences [1854],” in *Science and Education* (New York: P. F. Collier, 1902), 45. Huxley continues: “The man of science… simply uses with scrupulous exactness the methods which we all, habitually and at every moment, use carelessly.”
The investigations and reasoning of science, advancing as it does from the study of simple phenomena to the analysis of complicated actions, form a model of precisely the kind of mental work which is the business of every man, from his cradle to his grave. . . . Science teaches what the power and what the weakness of the senses is; what evidence is, and what proof is. There is no characteristic of an educated man so marked as his power of judging of evidence and proof.

For Seath, these benefits were contingent on the implementation of proper methods in the classroom. In chemistry and physics, this meant imposing a four-step inductive method: experiment, observation, inference, and when possible, generalization to broader principles. Pupils were to carry out experiments themselves, under the teacher’s guidance, and to write a careful account of their procedures and findings under each of these headings. In botany, the inductive approach entailed manipulation and examination of specimens with minimal guidance from the teacher, who would provide technical terminology only after the observational work was completed.49

Although the presumed benefits of a practical and experimental approach to teaching science were most often linked to mental discipline, they were not confined to it. Educators contended that laboratory work developed not only the mind but also the body and the character. “Science,” Coleman declared, “trains us to observe with unprejudiced eyes before forming a judgment. The chemist, making an important analysis, if he spills a drop or two from his [beaker], patiently goes back and begins anew, even though he has spent days on his work, and is on the point of finishing.”50 Coleman’s image of the patient and meticulous chemist exemplifies another often-claimed outcome of the study of science: the cultivation of a “scientific” temperament – cautious, methodical and conscientious. Working with delicate apparatus was also said to help curb unruly behaviour. In the opinion of one contributor to the Educational Monthly, science combatted the inherent tendency of boys to “muck about.” Working with a fine balance, for example, required patience and carefulness; with practice, the instrument commanded the student’s respect. The natural sciences, their proponents argued, offered lessons that

49 Report of the Minister, 1885, 161–162.
50 Coleman, “Plea for More Science,” 147.
literature and mathematics could not: they refined the skills of the eyes and the hands. While rote learning of definitions might train the memory, proper scientific method instilled sound judgement and wisdom. Just as science obliged restless school boys to settle down and behave in the classroom, so it helped to promote a broader social order: “Scientific men, in general, it will be observed, are not revolutionary in their opinions; they work on patiently, and hate nothing so much as premature production of results,” observed one editorialist in the Educational Monthly.

Arguments citing the moral and humanistic rewards of studying science were presented alongside pragmatic appeals to economic development and national prosperity. Donnelly notes that “as natural science gained ground, supported by its growing economic significance, the question of its wider curricular claims receded.” It is not surprising that in Canada, a recently established nation, calls for improved science education were often underpinned by concern that the dominion would lag behind the pace of industrial growth abroad, particularly in Germany. “What a list of discoveries and inventions, profitable to us and honourable to us as a nation would result from this attention to science during the next half-century!” effused Coleman, the Cobourg science master. “We are justly proud of our system of education in Ontario, but the world is moving and if we would keep our rank, we must move too.” Kingston Collegiate principal (and chemistry textbook author) Archibald P. Knight similarly pointed to the urgency of science teaching for harnessing the resources of a new country. Knight argued that the urgency of national development dictated a clear hierarchy among the school subjects. “Until the forces of nature in this land are conquered to man’s use, the study of science in its various branches is an indispensible necessity,” he wrote, borrowing directly from Herbert Spencer’s 1861 essays on education. “History, poetry, music, logic, moral philosophy, classical literature, are excellent as ornament; but as they must, in the present stage of our country’s development, occupy the leisure part of life, so they should occupy

52 “Relation of Science to Culture,” Canada Educational Monthly 7 (1885): 139.
53 Donnelly, “‘Humanist’ Critique,” 550.
the leisure part of education.” Even Seath, despite his thorough belief in the primacy of mental discipline, acknowledged that the economic aspects of science should receive “more emphatic recognition.”

5. Physics and Chemistry

How did this wide range of educational ideals translate into pedagogical practice in Ontario’s classrooms? This is inevitably difficult to assess, but inspection reports provide clues. Throughout the 1880s, physics came in for special criticism by Seath. He reported that schools were reasonably well equipped for chemistry experiments, but that the situation was dire for physics: no inspected high school had a decent collection of physics apparatus, and in many places an “antiquated air pump” was the only item of note. Physics lagged behind chemistry in terms of facilities and support largely because natural philosophy had been primarily a mathematical, theoretical subject throughout the nineteenth century, in contrast to the more empirical nature of chemistry. As Seath noted, “The instruction in physics has been, so far, chiefly of a mathematical character. The truth is, both physics and chemistry, the former especially, have run to mathematics.” This reality extended to teacher education: an ability to teach mathematics had long been assumed sufficient to teach science.

Steering teachers toward an experimental approach meant demoting the mathematical aspects of the course. As of 1886, high school physics examinations – particularly the exam for Third Class (public school) and Second Class teaching certificates – were revised to reduce the traditional emphasis on quantitative topics like statics. Math

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55 A. P. Knight, “The High School Curriculum,” *Canada Educational Monthly* 6 (1884): 286. (Cf. Spencer, 72–75.) Queen’s University chemistry professor W. L. Goodwin also correlated industrial progress with science education, arguing that “the arts and manufactures flourish most vigorously in countries where liberal provision is made for diffusing a knowledge of the principles and applications of science.” See W. L. Goodwin, “A School of Science,” *Canada Educational Monthly* 9 (1887): 85.
56 *Report of the Minister, 1887*, 179.
59 *Report of the Minister, 1887*, 175.
teachers felt their territory shrinking. “English and Science are thrust forward, almost offensively—Mathematics pushed into the back ground (sic),” protested one disgruntled mathematics master. Physics had been better taught in the past, he complained, “in spite of our present elaborate apparatus, and pretence of experimental and inductive study.”

The wedge that was driven between physics and mathematics in the high schools reflected institutional changes in the teaching of physics at the University of Toronto. In 1887, physics gained a distinct institutional identity within the University when the professorship in natural philosophy and mathematics was officially separated into distinct chairs in physics and mathematics.

These curricular changes were reinforced by the introduction of new textbooks in the late 1880s. The undertaking was partly motivated by efforts to modernize the curriculum, but it also reflected the Minister’s ambition to replace all the province’s textbooks, many of which had been imported from the United States, with books by Canadian authors. “Our text books should reflect Canadian sentiment,” he stated. “I believe that there is no better, and consequently I desire to see it pervade without obtrusiveness, all the literature placed in the hands of our school children.”

The Minister was also convinced that teachers should prepare the new textbooks. The “practical teacher,” by virtue of having grappled with the difficulties of how to present a subject to students, was best equipped for the task. Textbooks were to be considered coextensive with the curriculum: “In every subject, the text-book prescribed contains the whole course, and as a rule the text-book follows the order in which the subjects should be taken up by the teachers.”

The new physics book, however, received an apparent exemption from the Minister’s mission of Canadianization. The task of preparing this textbook had been assigned to Napanee science teacher Cortez Fessenden. After surveying existing textbooks, Fessenden opted to adapt Alfred Gage’s widely used American textbook, Elements of

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62 Gingras, Physics, 15.
63 “Text-books,” Report of the Minister, 1887, xliii. Ross noted the Department’s progress in this regard: whereas in 1883, only five of 21 subjects had textbooks with Canadian authors, by 1887 all but five did. (None of the five exceptions was a science textbook.)
64 “Text-books,” Report of the Minister, 1887, xxxviii.
Physics, rather than start from scratch. In 1887, Gage’s textbook was introduced in Ontario schools under the title The High School Physics. Gage’s preface, retained in the Canadian edition, articulated the pedagogical principles that underpinned his approach. Gage reiterated the widely held principle that proper learning required direct contact with nature. Noting that many textbooks opened with abstract definitions, Gage asked, “Why should the pupil so frequently, to his great discouragement, be called upon to break through a wall of such difficulties before coming in contact with Nature?” In his own foreword, Fessenden added that he had revised the Canadian edition by removing excessive description, in an effort to ensure that pupils would perform the experiments themselves rather than “simply [take] them for granted as is too often the case.”

The 1887 physics curriculum was a far cry from the natural philosophy taught a decade earlier. In 1876, natural philosophy had been grouped with arithmetic, algebra and geometry as a branch of mathematics and had focused on problems like the composition and resolution of forces, moments, centre of gravity, and hydraulic pressure. In 1887, the physics course was applied and thematic. The first year of the course included units on heat, electricity, sound and light, as well as brief discussions of topics such as the constitution of matter, physical and chemical changes, force, and the states of matter. The second year introduced topics in dynamics (velocity, acceleration, momentum, energy, work, etc) and hydrostatics, as well as applications of the latter in pumps, siphons and the barometer.

A textbook of “practical chemistry” was also introduced in 1887, written by Archibald P. Knight, then Principal of Kingston Collegiate Institute. Knight wrote in the introduction that he had long believed that a beginners’ textbook in chemistry “should consist mainly of directions for performing a series of experiments.” These experiments should be designed such that “all the prominent facts and principles of the science could be re-discovered, as it were, by any intelligent pupil.” He was sharply critical of textbooks that spoon-fed the details of experiments to students, insisting that pupils should take observations with no help from the teacher or the textbook. Knight also described how the subject was taught in his own classroom: all the simpler experiments (about two-

65 Gage and Fessenden, vii–viii.
thirds of them) were performed by students individually, working at separate tables, while the more difficult experiments were performed by him before the class. Knight believed that even beginners should attempt to engage in original research. To that end, he included “a few simple problems which are intended to stimulate in the pupil a desire for original research, as well as to test his power of applying the knowledge he has already acquired to the solution of new problems.”

In 1887, Seath presented a brief account of the extent to which the laboratory method had permeated Ontario schools. His observations suggest that instructional methods were slow to adapt to the ideals promoted by the Department. The preferred method, whereby each student performed experiments individually, was taken up in only three schools for chemistry and nowhere for physics. In many schools, a few students performed experiments while the class collectively made observations and drew conclusions. This method, Seath conceded, was likely to remain common in physics. A third approach, whereby the teacher performed experiments and students interpreted them, remained common in many schools. Teachers pleaded lack of time in defence of this approach, but Seath disapproved of it nonetheless: “Though possessing value, it is defective [in that] the pupil is not brought into direct contact with nature, and, under the circumstances, cannot make satisfactory observations.” Finally, Seath noted the persistence of the “lecture method,” whereby the teacher both performed the experiment and led the class through its interpretation. He remarked with satisfaction that instances of this were now rare and could be regarded as “anachronistic survivals of an almost extinct species.”

6. Botany and Zoology

It was generally assumed that hands-on analysis of specimens in botany and zoology was the methodological counterpart to laboratory experimentation in physics and chemistry. As with physics and chemistry, direct contact with nature was stressed: students would

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66 A. P. Knight, *High School Chemistry: Consisting of Directions for Performing a Series of Experiments* . . . (Toronto: Copp, Clark, 1887), v–vii. The research questions he mentions might include the following, drawn from the chapter on chlorine: “If the waste pipe of a kitchen sink were foul smelling, devise a method of deodorizing it” (160).

examine and sketch fresh specimens in spring and fall and study seed and fruit samples and dried leaves in winter. Use of the microscope, if available, was encouraged. This direct contact propelled the natural unfolding of the inductive learning process. Seath believed that by examining and drawing a sufficient diversity of specimens, students would unconsciously absorb the principles of classification. If, for example, they examined the sweet pea in one lesson, and, without any hints from the teacher, were introduced to a clover plant in the next, “there [would] not be one whose face [would] not light up” as they recognized the resemblance, Seath promised.

In some instances, nature and the laboratory were explicitly conflated: nature itself became the student’s makeshift laboratory. “The study of the natural sciences furnishes the very thing wanted [to cultivate the spirit of inquiry] – that is, the study by direct reference to and questioning of nature herself;” wrote A. McGill, the science master at Ottawa Collegiate Institute. “No text-book work here. A laboratory is wanted, to be sure, but every roadside, every ditch, every day and night of the year furnish you a laboratory.” McGill’s remarks highlight the ambivalence and criticism that sometimes surrounded the use of textbooks in the botany course. Educators frequently suggested that overreliance on the textbook undermined the central tenet of direct contact with nature. It was foolish to assume that botany “or any other science taught from a text-book bristling with technical terms” could interest pupils, McGill argued. “We must bring them face to face with nature herself; make them observers; help them skilfully, but not obtrusively; taking the greatest care to avoid any attempt to see for them, or to think for them.”

The premise that plants held particular interest to children was one of the main arguments for introducing botany in the lower years of high school. “Of all natural subjects there can be no doubt whatsoever that plants are the most suitable for the young observer to begin with. They are naturally attractive to the young, and they can be had everywhere without cost, and in sufficient abundance to enable every pupil of a class to handle and examine a specimen for himself,” wrote Henry B. Spotton, principal of Barrie Collegiate Institute. Like many others, Spotton advocated a natural progression through the sciences that

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began with botany and proceeded in turn to natural history, physics, and chemistry. Botany fit neatly into the rationale of mental discipline, being regarded as the ideal purveyor of skills in observation. Many science educators regarded observation as the fundamental skill that advanced science courses would subsequently call upon. Furthermore, botany helped students learn to describe things with accuracy (“translation out of nature into one’s own speech,” as Spotton put it) – a skill that, like observation, was considered foundational for the meticulous reporting that would be required in chemistry and physics laboratory work. Many secondary benefits were attributed to the study of botany, including the cultivation of an aesthetic sensibility, a practical knowledge of principles of scientific agriculture, and the development of moral virtues. All these positive outcomes were contingent on the pupil’s interaction with the natural world. Time spent in nature, much like time spent in a garden, “tends to the eradication of certain moral defects and the development of various excellences,” observed Andrew Stevenson, principal of Arthur High School.

Many changes to the program were necessary if hands-on learning was to become the norm. For Seath, the main culprit was the examinations. The teacher’s matriculation exam in particular needed to be more practical, requiring candidates to examine and compare actual plants. Seath also recommended that the Department provide summer classes for teachers. Two years later, in July 1887, a weeklong summer course was held in the public hall of the Education Department in Toronto. It was taught by Spotton, who also authored a new high school botany textbook, which was published that same year. Spotton’s course included lessons on common plants and discussions about how to introduce the subject to young students. Mornings were spent in lectures illustrated with microscope sections, and afternoons in outdoor fieldwork. By 1887, Seath was praising

69 H. B. Spotton, “Natural Science: The Inductive Method,” Canada Educational Monthly 2 (1884): 176–177. V. M. Spaulding, professor at the University of Michigan, similarly emphasized the importance of clarity of expression in the study of botany: “It is certainly [the Botany teacher’s] business to impress the cardinal truth that whoever has occasion to write a scientific description has no right to leave it in any other than accurate, clear, and concise form.” See V. M. Spaulding, “Botany in the High School,” Canada Educational Monthly 12 (1890): 295.
70 A. Stevenson, “A Wider Botany for High Schools,” Canada Educational Monthly 17 (1895): 205–209. “Next to fine literature botany is the subject on our school programme along with which can best be given some measure of esthetic cultivation,” Stevenson claimed (206).
71 “Circulars from the Minister: Botany Class.” Report of the Minister, 1887, 57.
the improvements he saw in the teaching of botany. He noted with pleasure that the practice of testing students on a few definitions or descriptions, which had been nearly universal in 1885, was disappearing.\footnote{Report of the Minister 1887, 174.}

Fall of 1887 saw the introduction of Spotton’s newly authorized textbook, \textit{High School Botany}. The new manual came as a long-awaited replacement for Asa Gray’s \textit{How Plants Grow}, an American textbook that had been in use in Ontario since 1867. Spotton’s manual featured common Canadian plants, many of which had not appeared in imported books. Indeed, within the Ontario Teachers’ Association, Gray’s textbook had been criticized as being unfit for Canadian schools.\footnote{Albert G. Croal, “The History of the Teaching of Science in Ontario, 1800–1900” (DPaed diss., University of Toronto, 1940), 165.} By the late 1880s, it was falling out of favour even among some American educators: “Whoever had tried to teach the subject by making the learning of Gray’s Lessons the main part of the work . . . has found out the dreary dissatisfaction of it and does not need to be told how very dry such botanizing is,” wrote a University of Michigan professor.\footnote{Spaulding, “Botany in the High School,” 297.} Spotton, who acknowledged his debt to Joseph Hooker, Asa Gray, Robert Bentley and Daniel Oliver in his book’s preface, sought to introduce what he believed was a “more rational” method of studying botany by designing a course that progressed from systematic botany to morphology and finally to vegetable histology. Previously, students had been required to memorize a host of technical terms before handling any plants. Spotton’s approach set out to reverse this order, guiding the student through the examination of various plants, then “lead[ing] him, by his own examination of these, to a knowledge of their various organs – to cultivate, in short, not merely his memory, but also, and chiefly, his powers of observation.”\footnote{H. B. Spotton, \textit{The Elements of Structural Botany: With Special Reference to Canadian Plants} [a.k.a. \textit{High School Botany}], Rev. ed. (Toronto: Gage, 1888), 1.} Spotton emphasized that the book’s many woodcuts were taken from living specimens – implying, it would seem, that they were just one remove from nature itself – yet he cautioned that illustrations should not replace the study of living plants: “It is strongly
urged upon teachers and students not to be satisfied with them as long as the plants themselves are available.”

Zoology, considered the natural adjunct of botany, was introduced into the course of studies in 1887. Robert Ramsay Wright, the University of Toronto’s first professor of biology, prepared the province’s authorized zoology textbook, which was introduced alongside Spotton’s botany textbook in 1887. Zoology was to be taught in Form II, once students had already received a year of botany. Wright conceded that zoology was less suited than botany to teaching basic observation skills because animal forms were more difficult to draw and specimens more difficult to collect, but he argued that it was especially successful at cultivating a love of nature, by “awakening an interest in the habits of animals.” Zoology, he proposed, offered students an “equally valuable discipline [to training in observation] – the tracing of the modifications of form throughout less nearly allied groups.” Accordingly, zoology could introduce students to the broader principles of biology, which Wright considered to be a primary objective of the course. A zoology summer course for teachers was held in 1889, following on the success of Spotton’s summer course in botany. Perhaps because it did not correspond as well as botany did to the deal of practical, hands-on science teaching, but more likely because it was never placed on the Departmental exams, zoology was rarely taught in nineteenth-century high schools.

77 Seath indicates that its inclusion was controversial but does not indicate why this was so: it may have been simply because the program of studies was already thought to be overfull.
78 R. R. Wright, An Introduction to Zoology for the Use of High Schools [a.k.a. High School Zoology] (Toronto: Copp, Clark, 1889) Like many of Ontario’s textbooks of this period, it was used widely in other provinces. Wright introduced an explicitly Darwinist understanding of evolution, making reference to both Darwin and A. R. Wallace.
7. Critiques and Disappointed Hopes

In 1889, Inspector Seath took stock of science teaching in the province and reported significant progress:

The most gratifying increase has taken place in the value of the scientific apparatus. Five years ago, what is now known as science was taught in only two or three of the high schools in the Province. Then, botany was a matter of “getting up” definitions and memorizing characteristics, physics was purely mathematical, and chemistry was taught practically in but few of the schools. Now botany is taught practically in every High School in the Province; thanks to the amended examination requirements and to the fact that it is now to the financial interests of boards to equip their schools with scientific apparatus, physics and chemistry – the latter more particularly – are taught in most cases as elementary science should be taught; and zoology, the necessary biological complement of botany . . . has been successfully introduced into most of our leading schools.\(^{83}\)

Despite the increased availability of apparatus and Seath’s positive appraisal, however, the optimism that marked the reform efforts of the 1880s was giving way to a measure of scepticism and disillusionment. In 1890, William Lawton Goodwin, professor of chemistry at Queen’s University, signalled disappointed hopes about the effectiveness of high school science: “It seems to be a pretty general opinion that, as a school subject, science has not fulfilled the expectations of her friends,” he reflected. “The study of science in the schools has too often developed neither accuracy of observation nor clearness of thought.” Goodwin alleged that the curriculum still relied far too much on abstruse definitions. It was misleading to call the physics and chemistry course experimental – after all, he noted, the experimental treatment of abstract subjects like the constitution of matter, attraction, sound waves, refraction of sound, and electric polarization “must tax rather severely, not only the ingenuity of the master, but the capacity of the pupils.”\(^{84}\) His reproaches compromise Seath’s tidy picture of pedagogical

\(^{83}\) Report of the Minister, 1888/89, 187–188.
progress in the late 1880s, and cast doubt on the assumption that “practical” science teaching had largely swept aside the rote learning of the past. The province’s science masters did not mutely convert to the new pedagogical methods. One high school principal wrote to Seath complaining that “only the other day my science teacher told me he thinks little of experimental work.” The teacher’s recalcitrance could ruin the whole science department, he fretted.  

Outside the official spheres that prescribed the new teaching methods, some educators had expressed doubt about the efficacy of experiment-based pedagogy from the outset. In a markedly critical 1887 Educational Monthly essay, science teacher D. F. H. Wilkins of Beamsville High School took aim at the teaching of chemistry in particular. Chemistry’s equipment was expensive, its experiments time-consuming and prone to failure, and its preparation and clean-up requirements a tax on the overburdened science teacher, Wilkins alleged. But his chief criticism struck at the core of the pedagogical method advocated by the Department of Education. Do “brilliant and showy” experiments really lead the student to the underlying law? he asked. Wilkins argued that reliance on experiment frequently led to one of two evils. Most often, teachers stopped at the experiment and went no further. The experiment was assumed to speak for itself, and students never drew a connection to the law it was supposed to illustrate. And then there was the opposite danger – that students would jump to sweeping conclusions based on the scanty evidence of one or two experiments. Wilkins concluded (speaking specifically about chemistry):

> It is entirely out of the question to expect the pupil to perform an elaborately detailed set of costly experiments, in order to verify a “law of Nature”; and yet, in order that the student may acquire the correct ‘scientific method’ of reasoning, nothing else ought to be done. . . . To expect aught else than crude guesses, hasty generalizations, imperfect abstractions, confusion of analogy with induction, etc., is to put

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altogether too sweetly serene a faith in the embryonic student nature, besides losing the value of chemistry as a ‘mind-trainer.’\(^{86}\)

One prominent university professor, Nathan Fellowes Dupuis, likewise emerged as an outspoken challenger to the gospel of learning by conducting experiments. Despite his appointment as Dean of the new Faculty of Applied Science at Queen’s University in 1894, Dupuis had little interest in the German research model. Much like Wilkins, Dupuis dismissed the notion that the inductive method could properly be applied by means of laboratory experiments. In his view, scientific theories were far too complex to be grasped from small number of experiments:

> People who know little or nothing of science will cry out, Experiment, experiment; nothing is to be learned but by experiment. . . .

> A science needs theory – a long experience in teaching a science taught me that experiment alone cannot impart a knowledge of science, and that experiment at random unites utility to amusement to about the same extent as a game at base-ball. . . . How absurd then to put a lot of apparatus into the hands of boys, and to ask them to work out the explanation of phenomena. To do so requires the matured mind of men, and even ten of these fail for every one that succeeds. The theories must be given to the boy dogmatically, and then rendered probable by experiment.

> In all that I have said I do not mean that experimenting will do a lad any harm. . . . But I do mean to assert that scientific experiment is not as great an educator of the young mind as many people suppose it to be.\(^{87}\)

Lone voices of dissent like Dupuis’s and Wilkins’s were ultimately drowned out by pervasive enthusiasm for the inductive approach as it was legitimated not only in the high

\(^{86}\) Wilkins, “Observations,” 88–90. Physics, on the other hand, Wilkins exempted from these concerns: “[T]he leading facts of physics may be presented to the mind as both to communicate knowledge and to develop the entire mind-nature, the character. Here by an appeal to common, every-day phenomena, there by simple and cheap experiments, here by Socratic questioning, there by direct dogmatic teaching, all other means being out of our power, or by a combination of these, we have in physics a most valuable educational agent” (88).

school science curriculum and textbooks, but also in wider efforts to apply the scientific method to other branches of knowledge. For critics like Goodwin, the problem was not the experimental method itself but its failure to sufficiently permeate classroom teaching.

As the 1890s progressed, concern shifted to yet another question: could science truly engage students’ interest? The somewhat naïve confidence in the intrinsic appeal of science that had buoyed up promotional efforts in the early 1880s was beginning to fade. Coleman, the author of the “Plea for more science,” had displayed typical optimism when he emphasized the “keen pleasure all boys feel in practical work in science.” Coleman had expressed confidence that introducing practical science into schools would “to many, make school life as attractive as it is now repulsive.” Eleven years later, by contrast, another contributor to the *Educational Monthly* bluntly declared, “The present age has outlived the sanguine hopes once expressed for the regenerating influence of scientific study in the education of boyhood. He must be superior to reason or experience who still believes that natural science will transform learning from a pain to a pleasure in boys’ eyes. . . . Natural science possesses no special charm for boys.”

8. Educational Introspection and the Decline of Mental Discipline

Although student interest had been an important ingredient in the rationales for science teaching that were advanced in the 1880s, it took on renewed importance in the 1890s. As in other Canadian provinces and the United States, high schools in Ontario faced drastic enrolment increases in the late nineteenth century, thanks in part to population growth and immigration. Historian Robert Stamp reports that between 1883 and 1904, enrolments more than doubled from approximately 11,500 students to well over 27,000. This trend was even more pronounced in urban areas: Toronto’s high schools, for instance, saw an eightfold increase in enrolments between 1870 and 1900. Even so,

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88 For an overview of the adoption of the inductivist approach in American high schools as well as Karl Pearson’s advocacy for broader application of the scientific method, see Rudolph, “Epistemology,” 352–354.
Ontario’s high schools remained highly selective and academic. This was in fact the case across English-speaking Canada: in 1900, fewer than ten percent of fifteen- to nineteen-year-olds attended high school.92

As the high schools expanded, their curriculum faced increased scrutiny. In particular, educators debated whether high school work should be made more relevant to the needs of the expanding student body. Such re-examination of the curriculum was hardly unique to Ontario. Foreign commissions such as the British Association for the Advancement of Science’s inquiry into the teaching of chemistry (1889) and the report of the Committee of Ten in the United States (1893), which was circulated to every school principal in Ontario, helped stimulate educational introspection in Ontario. In 1895, Minister Ross addressed these pressures in a carefully worded statement seemingly designed to appease both traditionalists and reformers:

> When the High School system of the province was first inaugurated, its primary object was to prepare pupils for the learned professions and especially for the University. While in that respect our High Schools amply fulfil their original purpose, in later years the course of education which they provide has been considered a desirable qualification for various other pursuits in life. Many young men in preparing for mercantile life or for agriculture take advantage of the High School, perhaps not so much because of the direct training which it gives for their intended calling as for the superior culture which it provides.

The Minister noted that more than twice as many pupils were leaving high school for careers in business or in agriculture than for university or the professions.93 Nevertheless, as his statement indicates, the mission of the high schools remained resolutely tied to broader cultural ideals rather than to the provision of occupational skills.

Proponents of school science, however, had long negotiated the balance between the cultural and utilitarian advantages of studying science, playing up one or the other as

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needed. Within the pronouncements of Department officialdom, any practical benefits of studying science were firmly subordinated to its value as mental training. But science teachers themselves did not always toe the Department line. In 1890, they founded the Natural Science section of the Ontario Educational Association meetings in Toronto (the predecessor of the Science Teachers’ Association of Ontario). The Natural Science section provided a forum for teachers to reflect on the shape and purpose of the curriculum and to lobby the Minister and the universities for needed reforms. Teachers frequently emphasized the need to make science courses more practical. One science teacher argued, for example, that the botany course needed to devote more time to agriculture and horticulture. Another claimed that it needed to move away from classification in favour of ecology, physiology, and “the economic importance of our ordinary plants.”

Meanwhile, faculty psychology – and accordingly the tenet of mental discipline that had given science a foothold in the traditional curriculum – was under fire. The first blow to faculty psychology was its failure to hold up to empirical tests by American psychologists William James and Edward Thorndike. Herbert Kliebard argues, however, that faculty psychology gave way primarily because of the many social changes of the 1890s that made the traditional high school curriculum seem obsolete. Like their American counterparts, Ontario educators turned to the ideas of the new breed of educational psychologists such as G. Stanley Hall and John Dewey. These men were seen as having placed educational theory on a scientific basis while supplanting the speculative notions of faculty psychology. In 1889, Director of Normal Schools James McLellan published a textbook in applied psychology that was based heavily on Dewey’s first book, *Psychology* (1887), and introduced teachers-in-training to the concepts of “scientific psychology.” In 1894, Hall visited Toronto to deliver a series of lectures on

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97 Although *Applied Psychology* was published with Dewey listed as co-author, a range of evidence suggests that McLellan was in fact the sole author. McLellan and Dewey did, however, later collaborate on a textbook on the teaching of arithmetic, *The Psychology of Number* (1895). See Jo Ann Boydston, “A Note on *Applied Psychology,*” in *The Early Works of John Dewey.*
child study, an event that prompted the Ontario Education Association to form a child study section.  

By 1897, Elora High School science teacher Norman MacMurchy felt confident in asserting that “the old idea that the mind is made up of separate parts is being discarded, the modern view being that the mind is a unit and should be developed as such.” If faculty psychology was discredited, the consequences for the teaching of science were profound, MacMurchy believed. Educators and policymakers could no longer assume that studying subjects like chemistry or physics trained the mind in a general sense for the broader pursuits of everyday life, as Huxley and others had claimed. Science conferred scientific knowledge and skills, and nothing more. MacMurchy wrote:

If this view of mental science [i.e., the mind as an indivisible unit] is correct, the old doctrine that the work of the mind in any direction develops power that may be used equally well in all directions, is wrong. To put the case broadly, no person will maintain that the study of physics will prepare a person for the practice of law as well as if he had read jurisprudence.

... Study in any particular line will limit our faculties to development in that direction. If this is so, surely no subject should be studied merely for the discipline alone it may be supposed to give ... The old idea of formal discipline by certain subjects is losing ground, and those subjects which will have a direct value in giving the pupil knowledge that will be of service to him in after life will in the future receive more prominence.

In other words, the curriculum more than ever needed to be practical – not in the hands-on, empirical sense underscored in the Department regulations ten years prior, but in its straightforward relevance to students’ interests and ambitions. The value of any subject

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98 Stamp, Schools of Ontario, 52.

on the program was necessarily tied to its content. Accordingly, this content needed to relate to pupils’ everyday lives and future pursuits.

Inspired largely by the ideas by American educationists, Ontario’s “New Education movement,” as Stamp has called it, had its greatest impact within the elementary schools. Another major contributor to the reformist momentum was Ontario public school inspector James Hughes. Drawing on the ideas of Johann Pestalozzi and Friedrich Froebel, Hughes campaigned successfully throughout the 1880s for the institution of kindergartens across Ontario. In Hughes’ view, kindergarten should not be viewed as just one year of school, but rather as a pedagogical method that extended throughout the whole elementary school. At the centre of Hughes’s philosophy was Froebel’s principle of the self-activity of the child. According to MacMurchy, this principle applied just as well to high school laboratory science:

If we consider the kindergarten we find that the child is there active and not passive; his activity is a self-activity. . . . The senses are being employed with a definite end in view for him and thus they are being cultivated. The power gained for the child is a power to use power. This is the reason, or at least one of the main reasons, why we in our high schools have our pupils perform their own experiments in chemistry and physics and do not perform them ourselves. That can only become a part of the child’s knowledge which he has obtained by a free action of his perceptive faculties and thus made his own.”

Ultimately, however, New Education made few inroads beyond the elementary schools, with some conservative critics dismissing its reforms as “Yankee frills.” Despite MacMurchy’s pronouncement about the demise of faculty psychology, mental discipline kept a firm hold on educational thought in Ontario. Twenty years later, Peter Sandiford, a professor in the University Toronto’s short-lived Faculty of Education (and later its successor, the Ontario College of Education), would report with exasperation that

100 Stamp, “James Hughes,” in Patterson, Profiles, 199–200.
102 Stamp, Schools of Ontario, 52; 71.
“elsewhere, the theory [of formal discipline] is discredited, but Canada clings to it with mid-Victorian tenacity.”

9. Conclusion

A recurring theme in the history of nineteenth-century Canadian education is the ongoing tension between the bureaucratic authority of the Province and local trustees, parents, and teachers over management of the curriculum. The standardization and reform of science teaching during the 1880s represents an era of tightening central control over Ontario’s high schools, largely by virtue of the influence of the inspectorate, and particularly John Seath. Due primarily to Seath’s outspoken support for the ideal of “practical” and experimental science teaching, the Department of Education enforced teaching methods, oversaw the purchasing of equipment and the construction of laboratory spaces, and regulated the adoption of new Canadian-authored science textbooks. Although Seath’s sometimes severe reports and abrasive manner triggered an initial outpouring of complaints, the Department could ensure that science was being taught to its specifications by withholding grants and shaming non-compliant schools with low inspection grades. Its efforts to promote experimental science teaching were reinforced by the advocacy work of science teachers in the pages of the Canada Educational Monthly.

The pedagogical changes that were instituted in Ontario schools were closely aligned with the cultural shift that was underway within university science departments. The changing norms of professional science as practised in the universities demanded a wholesale revision of the perceived role of science in a general education. Seath’s 1889 remarks on the schools’ successful implementation of “what is now known as science” (my emphasis) – in contrast to the science of five years prior – illustrate how quickly laboratory practice redefined the common understanding of what it meant to learn science. Nonetheless, the research model inherited from the universities did not make a seamless transition into the high schools. The firsthand experience of teachers such as

Wilkins points to the challenges teachers encountered in converting a simplified experimental method into fruitful pedagogical practice. Wilkins and Dupuis challenged core assumptions of experiment-based pedagogy – the notion, for instance, that laboratory work inculcated rigorous reasoning skills (Wilkins claimed that it sanctioned rash conclusions) or that it fostered a “scientific habit of mind” (Dupuis claimed it flouted the true processes of theory formation). But they were aiming at a receding target: the priority of mental discipline was gradually giving way to the perceived need to equip growing numbers of non-university-bound students with useful knowledge and skills. While the principles of formal discipline were slow to be relinquished within the high schools of Ontario, educators at the turn of the century increasingly drew on the charged rhetoric employed by educationists from the United States, where demographic pressures on the school system were even more pronounced. Amid this educational ferment, the hands-on, empirical methods of laboratory science, practical in more ways than one, were there to stay. The research laboratory had become an enduring symbol of scientific progress and expertise, a model that school science would continue to emulate. Harmonized as easily with the learning theories of psychologists and reformers in the early twentieth century as they had been with the intellectual and humanist goals of the traditional curriculum in the 1880s, the methods of laboratory science proved to be amazingly adaptable to the changing mission of the high school.

Chapter 2
Demarcating Science and Technical Education in Turn-of-the-Century Ontario

1. Introduction

While high school inspector John Seath was resolutely working to introduce and standardize laboratory science teaching in Ontario high schools, another movement was taking shape among educators at various levels of the school system. Inspired by the successes of German industries – successes that were confidently attributed to its tiered science and technical education system – as well as the growing prominence of American schools of science and manual training schools, educators began to call for the development of technical education in Ontario. It is misleading to refer to this as a single movement, because it drew support from so many different groups – educators, labour groups, and politicians, who were remarkably diffuse in their goals and visions. Advocates for expanded technical education offerings disagreed markedly about where this should happen and what it should look like. Some, like University of Toronto president James Loudon, insisted that the major push should happen in higher education, with institutions like the School of Practical Science leading the way. Groom an elite tier of experts, bankrolled by captains of industry, and industrial ascendancy would follow, he argued. Others, most notably the Canadian Manufacturers’ Association, set their sights on secondary-level technical education for workers and artisans. Their arguments focused on the need for schools to step in and fill the void left by the decline of the apprenticeship system. Still others, such as Public School Inspector James Hughes, spoke out in support of manual training, an enterprise that was sometimes subsumed within technical education and other times purposefully differentiated from it. Proponents of manual training sought to teach handiwork skills to young students, especially in public schools. This was not meant to be direct trade training, but they were certainly seen as providing foundational skills that would be particularly useful to the future workman. In conjunction with the manual training movement came the domestic science movement,
which aspired to train young female students in the household skills needed for either homemaking or employment.

These various efforts gathered momentum in tandem with the expansion of high school science in the 1880s and 1890s. In the 1880s, the School of Practical Science (established in 1877) was formally affiliated with the University of Toronto, thanks in part to James Loudon’s persistent efforts. The Toronto Technical School, a pioneering technical secondary school, was established in 1890. In the late 1890s, the manual training and domestic science movements redoubled their efforts, and in 1899 both subjects were approved as options in Ontario’s elementary schools. The manual training movement received a significant boost in 1900 when it attracted the attention of philanthropist William C. Macdonald, who provided seed funding for manual training and domestic science centres across the country.

Another notable feature of these developments was the overlap in participants between school science advocacy and technical education campaigns. W. S. Ellis, a science teacher and principal of Kingston Collegiate Institute, crusaded tirelessly and sometimes bitterly for diversified science offerings as well as for elementary technical education (see Chapter 3). William Pakenham was a science teacher who assumed the leadership of the Toronto Technical School from 1901–1907, a position he left to become Dean of the University of Toronto’s new Faculty of Education (and subsequently Dean of its successor, the Ontario College of Education). John Seath, however, is the most prominent example of this overlap. Both before and after the period when he was doggedly pushing through reforms to the school science curriculum, he was also tasked with monitoring the state of technical education in Ontario and beyond. In total, he was assigned to three major tours of technical and manual training schools in the United States: the first in 1889, the second in 1899, and the third in 1910. These tours and the reports he submitted on his return had little discernible impact until the third go-round. His 1910 report, *Education for Industrial Purposes*, was the direct impetus for Ontario’s Industrial Education Act of 1911.
This chapter examines the interactions between the rise of technical education within Ontario’s school system at the turn of the century and the science curriculum that was establishing a permanent place for itself in the province’s high schools. It shows how the changing dynamics, within the sphere of higher education, between pure and applied science and between artisan and engineering education helped to set the patterns of provision for secondary level science and technical education. The incursions of technical education and manual training into the public and high schools prompted educators to establish demarcations between the “academic science” of high schools and the “applied science” of technical schools and to elucidate their respective goals and pedagogy.

Over the course of the nineteenth century, different varieties of “science” were identified, qualified, and differentiated. In the early Victorian period, science was assumed to be an intrinsically useful pursuit. “Educationalists in Victorian Canada firmly believed that in the study of science, theory should be wedded to practice, and that this would contribute to the progress of all sectors of society,” write Trevor Levere and Richard Jarrell.1 This “useful knowledge” tradition saw the founding of schools for farmers and artisans such as the mechanics institutes that multiplied in Britain and Canada. As the century wore on, however, technical education thrived best in its more academic forms—particularly within universities, where engineering education came to find its home. The successes of academic technical education drove a wedge between the education of engineers and the education of artisans. At the same time, the German research tradition was gaining traction in North American universities, and research departments competed with engineering schools for state funding and favour. Research scientists strove to dissociate their work from those doing “applied” science and popularized the notion that pure science served a guide for applied science. Industrial success, they argued, depended above all on the insights provided by abstract research. It is a testament to scientists’ success in disseminating this narrative about pure and applied science that modern science came to be thoroughly conflated with nineteenth-century notions of industrial progress. “The progress of science, in this latter part of the nineteenth century, has revolutionized all our industries,” wrote Minister of Education George Harcourt in 1899.

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“. . . The curriculum of fifty years ago will not do today.”

This narrative about the roles of pure and applied science, popularized among professional scientists, was projected onto secondary level science and technical education.

As the universities broadened their clientele and their mission, welcoming engineers and other incipient professional groups, there was a general impetus to shield the high schools from any kind of vocational education. If universities were becoming a standard pathway to occupational training, high schools were cast as the mainstays of liberal education. If university curriculum was specializing, high schools were to be resolutely generalist – even if they remained feeders to new, diversified university programs.

This redoubled insistence that high schools should be generalist, non-vocational, and non-specialized drove a wedge between academic and technical science. Vocational technical education could find no place in high schools and was confined to separate institutions such as the Toronto Technical School. Students’ future trajectories were an important point of demarcation. Technical schools were oriented toward employment, where high schools were for future studies – or failing that, “general culture.” Technical education was about national development, where public and high schools were about education in the broadest sense. Furthermore, the basic sciences played a clearly defined role within technical education programs. An education in the basic sciences served to “rationalize” manual labour, to “humanize” factory work, to “elevate” the worker, and to confer status on ordinary pursuits such as housework. The notion that pure science served to guide and enlighten applied science, popularized in the sphere of higher education, thoroughly permeated lower technical education.

These starkly drawn distinctions, however, disguise important points of connection between academic science and technical education. In particular, manual training and science as school subjects fought many of the same battles against the stronghold of traditional subjects over the high school curriculum. Proponents of manual training and science educators deployed many of the same kinds of arguments: they emphasized the importance of hand and eye training in the education of the “whole person,” they argued

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for the importance of appealing to the “practically-minded” child, they summoned old-
guard arguments for mental discipline, and they proffered pedagogical objectives that
were steeped in the language of personal morality. They chipped away, in tandem, at the
dominance of the traditional curriculum. Perhaps because of their common cause, late
nineteenth-century educators sometimes conflated the new hands-on high school science
curriculum, manual training, and the science taught in technical schools. Despite the
efforts of educationalists like Seath, who positioned science as a high form of mental
discipline, the “useful knowledge” vision of science had a lot of staying power.

Eventually, however, the purpose of high schools was reconceived. This happened much
more quickly in the United States. Herbert Kliebard argues that the rise of manual
training programs, initially presented as abstract exercises dissociated from any kind of
trade training, quickly opened the floodgates of vocationalism within American public
schools. In Ontario, isolated educators began arguing for the need to give the high
schools – the lower grades especially – an unapologetically vocational thrust. This would
not come to fruition until the 1930s, but calls for change mounted. The idea that schools –
high schools, the bastions of a general liberal education – could also be a place where job
skills were acquired took hold and enduringly revised the established purposes of public
education.

2. Postsecondary Technical Education: Drawing Distinctions and Hierarchies

Throughout the latter half of the nineteenth century and into the beginning of the
twentieth, the distinctions between academic science education and technical education
were blurry and emergent. Gidney and Millar note that until the early 1870s, science
education and technical education were often treated as close to synonymous: “There
were only hazy distinctions between training for the workshop skills practiced by artisans
and training for the so-called scientific professions.” As well, the boundaries between

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3 Herbert M. Kliebard, *Schooled to Work: Vocationalism and the American Curriculum, 1876–

“pure” and “applied science” were themselves in flux. While some developments blurred and contested the boundaries between these categories, others sharpened them.

The most important development that strained these various boundaries was the evolution of engineering education. If there were no clear-cut divisions between artisan and engineering education at mid-century, the distinctions were sharp by the 1890s. Ultimately, at the higher education level, laboratory-based pre-professional engineering education won out over schools offering shop-based instruction to farmers, mechanics, and craftsmen. In growing, industrializing North American cities, schools churned out engineers to meet the rising demand for specialized technical expertise to manage urban electrical, water, and transportation infrastructure. Late nineteenth-century engineers fought to professionalize their trades and established professional societies, journals, and conferences. Wielding these hallmarks of professionalism, they edged out job competition from the skilled craftsmen who had traditionally built these urban systems.5 At Toronto’s School of Practical Science, students enrolled in increasing numbers because it had become clear that innovation in construction and other fields required them to master theoretical knowledge in the basic sciences, which they could not acquire through shop training alone.6 Many North American schools of science established ties to universities, and the education of engineers came to resemble the education of scientists more closely than that of artisans. Engineers were required to become well versed in the basic sciences, and engineering and science students rubbed shoulders in the same laboratory classes, often taught by the same professors. As well, university affiliation gave engineering students the opportunity to take arts electives, which helped to confer the cultural prestige of a classical education. The rising social stature of engineers and the grandiose nature of their projects were such that their contemporaries quite literally lacked the words to adequately describe the social impact of the machinery, infrastructure, and systems that defined the era.7

The rapid industrialization of the late nineteenth century prompted increased state support for higher technical education. In the United States, the Morrill Land Grant Act of 1862 allocated 30,000 acres of federal land to each state for the creation of institutions of higher education that would “promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.”\(^8\) In Ontario, provincial funding for higher education was rarely forthcoming, but Guelph’s College of Agriculture and Toronto’s School of Practical Science fared better than the universities.\(^9\) In the face of these new investment priorities, research scientists were keen to restore clear status lines between pure and applied science. They responded by working to sharpen the definitions of pure and applied science and elucidate the relationship between them. Worried about being passed over by the state in its allocation of funding, scientists touted their role as the guiding lights of industry. Research science was the true fount of industrial innovation, they proclaimed: pure science charted the course for applied science. In promoting this narrative, scientists disseminated the idea of a hierarchical, trickle-down relationship between abstract research and applied science and fought to secure stable financial support of research while preserving the autonomy of their research agendas.

While this battle for status and funding played out primarily in the realm of higher education, it inevitably had an important influence on what happened in high schools. The perceived social roles of pure and applied science, their place within the universities, and the extent to which each was associated with either “professions” or “trades” all shaped how they were received in the high schools. As seen in Chapter 1, high school science educators and policymakers worked hard to deflect assumptions that science was a mere servant of industry. Educators focused on mental discipline rather than usefulness. When “practical” subjects like manual training and domestic science were instituted as options on the official high school curriculum, they too tried to ward off the taint of vocationalism. While scientists and engineers advertised themselves as the men who would guide the nation to prosperity and embraced a vision of abstract science directing

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applied science toward innovation and achievement, late nineteenth century high school educators assiduously tried to unmoor science and technical education from its industrial ties.

Suzanne Zeller has observed that Victorian Canadians “inherited the longstanding conceptual distinction between *ars* (the mode of thought of the philosopher) and *ingenium* (that of the mechanic).” These two conceptual categories, in turn, translated into two separate educational streams: schools devoted to the liberal arts for the “aspiring bourgeoisie” and apprenticeships for tradespeople. But Victorian science strained this distinction by spanning these two educational streams and threatening to superimpose their jurisdictions. Demand for expertise in the basic sciences was markedly transforming higher technical education; secondary educators had to contend with these changes and what they meant for the traditional vision of a general education.

3. Educating Artisans and Engineers

In the late nineteenth century, the status of engineers was on the rise. Imposing engineering projects like railway and telegraph networks – and the visible ways they changed society – gave engineers newfound prestige. Leo Marx argues that nineteenth-century observers were at a loss for a term that adequately encompassed these new grand-scale projects and the social transformations that accompanied them. Existing terms like the *mechanic arts* and the *useful arts* did not suffice. The *mechanic arts* conjured up images of the lone artisan at his workbench, not the university-educated engineer well grounded in the principles of modern science. By mid-century, a full-fledged “semantic void” was in evidence, says Marx. Traditionally, there had been a clear status divide between the *useful arts* – the domain of artisans and the workshop – and their counterpart, the *fine arts*, the realm of culture and erudition. The work of engineers seemed to fall into some undefined middle ground. In short, what was needed was a whole new category – one that was “untainted by the machine’s derogatory legacy of social and intellectual inferiority and hence capable of elevating the *useful arts* to a

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higher plane—a plane closer to that of the fine arts.” Marx contends that the word technology later moved in to fill this semantic void, acquiring new meanings in the process:

Whereas mechanic arts belong to the mundane world of work, physicality, and practicality—of humdrum handicrafts and artisanal skills—technology belongs on the higher social and intellectual plane of book learning, scientific research, and the university.11

By complicating the dichotomy between useful and fine arts, the high-profile work of engineers simultaneously challenged the many concomitant assumptions that were embedded in this dichotomy. As Marx points out, “The stock distinction between the useful and the fine arts had served to ratify an analogous—often invidious—lineup of distinctions between things and ideas, the physical and the mental, the mundane and the ideal, body and soul, making and thinking, the work of slaves and of free people.”12 As both abstract and applied science gained ground in the universities and in high schools, scientist and educators had to constantly navigate fundamental assumptions about the divide between culture and utility, even as this groundwork shifted under their feet.

The fact that engineers were university trained played an important part in straining the old distinctions between useful and fine arts. The structures of technical education changed markedly in the last decades of the nineteenth century. The provision of education both shaped and was shaped by the social status of engineers. In the United States, many schools of science that were established in the nineteenth century came to be integrated with universities. At the beginning of the century, technical education was embedded in what Roger Geiger calls the “useful knowledge tradition.” Technical schools in the useful knowledge tradition aimed to equip artisans, farmers, and shop workers with scientific knowledge that would give them deeper insight into their trades. This tradition made no distinction between pure and applied science: all science was assumed to be inherently useful. But by late century, the useful knowledge tradition had

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been overtaken by an academic model of technical education, as schools of practical science were increasingly affiliated with universities. University-affiliated schools catered not to artisans and farmers, but to future engineers. They could count on the steadier enrolments and institutional security conferred by established universities. With university affiliation, rigorous entrance standards took on new importance. The new technological universities gradually superseded the schools of science that had aimed to offer an accessible education to farmers and mechanics. “The scientifically trained mechanical engineer inexorably displaced the schooled mechanic,” writes Geiger.\(^{13}\) As Robert Kargon and Scott Knowles have shown, when local industries were innovative, technical education followed suit. When schools had strong ties to local, state-of-the-art industries, they transitioned very quickly from shop work to laboratory-based higher scientific education. Where the local industry was more conservative (like the steel industry in Pittsburgh) and where there were fewer ties between schools and industries, the shop-based model of technical education lingered longer (as it did at Pittsburgh’s Carnegie Schools of Technology). By the mid-1920s, however, pre-professional engineering training had carried the day as the dominant model of technical education. Even the Carnegie Schools had become the Carnegie Institute of Technology, which was granting degrees by 1912. “For scientists and for many engineers, the lessons of the last third of the nineteenth century were clear: basic science, applied science, and technology were part of a single spectrum of organized knowledge,” write Kargon and Knowles. “The path ahead led … towards what might be called the new technological university, incorporating teaching, research, and industrial outreach.”\(^{14}\)

In Ontario, the provision of higher technical education followed a similar course. What would eventually become the Faculty of Engineering at the University of Toronto started out as a College of Technology, founded in 1871 as a school for technicians and mechanics. Throughout the 1870s, amid ongoing debate about its mission, it steadily developed closer ties to the University of Toronto. At the same time, Gidney and Millar

\(^{13}\) Geiger, “Rise and Fall of Useful Knowledge,” 59.
\(^{14}\) Kargon and Knowles, “Knowledge for Use,” 19.
recount, it progressively turfed out the artisans in its midst. In 1877, it was renamed the School of Practical Science, and by 1878, it had been relocated to the University of Toronto campus, where many of its science classes were taught by cross-appointed professors. In 1887, it was formally affiliated with the University of Toronto, and finally, became the Faculty of Applied Science and Engineering in 1904. Over the course of 30 years, the work and education of engineers was purposefully differentiated from that of artisans, builders, and craftsmen. Engineers’ education had become thoroughly academic, and engineers were claiming the status of “professionals,” as the traditional “learned professions” gave way to notions of professionalism based above all on merit and expertise.

In postsecondary education, it was the academic model of technical education that turned out to have staying power. In 1871, Deputy Minister of Education John Hodgins had returned from a grand tour of engineering colleges in the United States convinced that “the success of major American scientific schools is in proportion to their practical separation for teaching and other purposes from the other parts of the university.” But the subsequent history of higher scientific education would prove him wrong. Both university science departments and engineering schools thrived by sharing facilities, students, and teaching personnel. Like many American colleges, Ontario schools of science established progressively closer ties with universities. The School of Practical Science and the Ontario College of Agriculture both joined the University of Toronto in 1887. Similarly, Kingston’s School of Mining was affiliated with Queen’s University from its founding in 1893. The academic model of higher technical education put a premium on entrance standards where the earlier mechanics institutes had prized accessibility. All these developments helped bring about what Suzanne Zeller has called the “scientization” of technical education: “Boosters, especially in the universities, had no need to champion technical education as anything other than applied science.”

Through the structures of educational provision, engineers were able to ally themselves

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16 As quoted in McKillop, Matters of Mind, 169–170.
17 Zeller, “Roads Not Taken,” 27.
closely with university science while distancing their work and training from that of artisans and shop workers. These patterns of status and provision would shape the patterns taken up by high schools, both raising demand for science courses as matriculation options and prompting educators to begin drawing distinctions between high school science and the science taught to artisans and workmen.

State demand for technical expertise had profound implications for how scientific practice was conceived of—both by the wider public and by scientists themselves. As nations began to rely on and invest in engineers and technicians, their oversight placed a premium on the civic, practical value of science. Steven Shapin has chronicled how, during the eighteenth and nineteenth centuries, science was increasingly “integrated into the structures of power and profit.” Research scientists—in short, those invested in “pure” rather than “applied science”—feared being overlooked within this new arrangement and pushed for more state support for abstract research. In this climate of competition for funding and recognition, “a range of distinctions and stipulated causal relations between ‘the scientist’ and the ‘the engineer,’ and between ‘pure’ and ‘applied science,’ emerged as argumentative tactics—both as evaluative justifications for social subvention of ‘abstract inquiries’ and as descriptions of their respective characters and bases of authority,” writes Shapin.18

This rivalry was certainly in evidence at the University of Toronto, where the university President, physicist James Loudon, threw himself into raising support for pure research. In his 1899 convocation address, he outlined his vision for technical education in Ontario and stressed that technical education would always remain subordinate to pure research: “I should like to state emphatically… my conviction that no diffusion of technical training will in itself be effective if we do not take care to maintain the higher and highest kind of scientific instruction.”19 As Suzanne Zeller has pointed out, manufacturers also

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19 James Loudon, *Convocation Address, University of Toronto, October 2nd, 1899* (Toronto: Rowsell and Hutchison, 1899), 7.
perceived themselves as dependent on the universities and the “new light which scientific research is constantly throwing upon [technical knowledge].”

Such efforts to define the relationship between abstract and applied science, with a view to their respective claims to state support, had by this time a long lineage. The inaugural issue of Canada’s first scientific journal, the Canadian Journal, had featured Lyon Playfair’s 1851 address, “On the National Importance of Studying Abstract Science with a View to the Healthy Progress of Industry.” Playfair famously stated that researchers, “the cultivators of abstract Science,” were “the horses of the chariot of industry.” Those who applied the truths of science, meanwhile, were the harness. This analogy, of course, laid the groundwork for questioning the state’s investment priorities. “But is the chariot drawn by the horses or the harness?” Playfair asked pointedly. “We honour the harness, but neglect the horses. It is the harness that is gilt, but the hard-working horses too often receive meagre fare.” In Britain, as in Canada, research scientists were keen to demonstrate their indispensable role in industry and national prosperity. T. H. Huxley had similarly argued that “thorough scientific education is an absolutely essential condition of industrial progress,” and that “[neither] nations [nor] individuals will really advance, if their common outfit draws nothing from the stores of physical science.” Such arguments were part of a broader shift in how scientists saw and explained the meaning of their work. Increasingly, they argued that abstract research, even as it pursued its own self-directed ends, yielded a “delayed utilitarianism” – an indefinite promise of fruitfulness and influence in matters of national and industrial development.

Concerns about the government’s investment priorities when it came to education were not baseless rhetoric. In the late nineteenth century, the funding of higher education was indeed skewed toward fields that seemed to promise direct benefits to national development. As mentioned above, the School of Practical Science and the Ontario

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20 As quoted in Zeller, “Roads Not Taken,” 15.
23 See Shapin, The Scientific Life, 43.
College of Agriculture were significantly better financed than the universities. “Science harnessed directly to the needs of the state was encouraged while general university requirements were, by comparison, neglected,” notes McKillop. Until 1901, the provincial government had invested only minimally in the University of Toronto, its primary support coming in emergency reconstruction grants following the disastrous fire at University College in 1892. In 1901, Loudon finally managed to secure over $25,000 in support for the university’s science departments. In 1905, newly elected premier James Whitney instituted numerous government grants, plus a yearly public expenditure of $30,000 to be used for the construction of new buildings and wings.\(^\text{24}\)

The effort to secure state funding for research science compelled scientists to spread the idea of a hierarchical, “trickle-down” relationship between abstract science and industry. As they manoeuvred to publicize their role as beacons of industrial development and technical proficiency, they styled a new account of the relationship between pure and applied science by providing a slippery, dual justification for the importance of abstract science. On the one hand, pure science was portrayed as a guide for applied science; on the other hand, it was simultaneously conceived as a sort of deferred applied science in itself.

The entry of engineers into universities was just one sign that the role of universities was being reconceived. Over the course of the nineteenth century, the location of professional education in Ontario was steadily resituated from worksites to schools, with universities being a prime beneficiary. Gidney and Millar argue that the Georgian idea of the “professional gentleman” – who was classically educated, of independent means, and either a doctor, lawyer, or clergyman – was superseded by the Victorian idea of the “professional.” Being a professional had more to do with merit and specialized expertise – “paying attention to one’s craft and the systematic bodies of knowledge associated with it” – than it did with the reputation, inherited social standing, and general erudition of the Georgian gentleman. “The decline of the notion of ‘gentleman’ as an ascribed status … was accompanied by the rise of a variant, the idea of ‘nature’s gentleman,’” they write.

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“Entrée into an occupation now had to be ‘earned’ by dint of ability and hard work.”

This hard work increasingly took place within the halls of the province’s universities.

In the mid-nineteenth century, the undergraduate curriculum was mostly geared toward the initial education of lawyers, doctors and clergymen. By the turn of the century, however, the universities’ clientele was expanding. From the 1880s to the first decade of the twentieth century, professional associations of doctors, dentists, engineers and high school teachers all built alliances with universities. The latter were more than willing to welcome new professional programs, in part because the influx of new students — aspiring doctors, dentists, and engineers — meant higher enrolments in university science courses. As occupations like dentists, land surveyors, and teachers fought for the status of “professionals” and threw in their lot with universities, the notion of “professions” expanded beyond divinity, law, and medicine. At the same time, universities gained more and more jurisdiction over the educational standards of the province’s professions. Eventually, write Gidney and Millar, a profession would essentially become “what the university said it was.”

In short, a university education was no longer just about the general cultural polishing of gentlemen, but about specialized training for an occupation. The university’s changing identity was especially brought into relief by higher technical education. Universities were increasingly seen as integral to the creation of a skilled industrial labour force. In Industrial Canada, the journal of the Canadian Manufacturers’ Association, contributors argued that universities had always been trade schools of a sort: it was just that they had shifted their ambition from training the leaders of society, such as the clergy, toward nurturing the powers of production more broadly.

4. Science and Technical Education in Elementary and Secondary Schools

The growing acknowledgement that universities were becoming more frankly vocational, more accessible, and more specialized only served to reinforce the notion that high

25 Gidney and Millar, Professional Gentlemen, 381.
26 Ibid., 207–210; 359–361.
27 McKillop, Matters of Mind, 174.
schools were emphatically *not* vocational. As discussed in Chapter 1, until the 1870s, there was much redundancy between high schools and universities. Many students simply skipped high schools and did their preparatory classes at university. But in the last few decades of the nineteenth century, universities and high schools disentangled their roles. The high school system expanded dramatically, and as it did, universities raised their entry standards. Matriculation from a high school became a requirement for university admittance, and high schools – at least the upper grades – settled into their role as feeders to the universities.

As the university’s curriculum and clientele widened, so did high school matriculation options. Science courses were added as matriculation options in 1885.\(^\text{28}\) In the late 1890s, the amount of science required for matriculation increased.\(^\text{29}\) By contrast, in the early 1870s, no high school science courses had been required, nor even allowed, as matriculation subjects for aspiring medical students.\(^\text{30}\)

Even as the high school program evolved to meet the changing demands of university admittance – and in turn, changing notions of what it meant to be a “profession” – educators took pains to insulate high schools from the vocational thrust that had penetrated the universities. In the face of the idea that universities could offer specialized training, high schools were portrayed as the bastion of a general liberal education. This became the crux of the difference between high schools and universities.\(^\text{31}\) The technical education movement, which sought to promote technical education throughout the entire school system, ran headlong into the traditional vision of the high school as the provider and protector of liberal education. James Loudon, for example, argued forcefully that technical education was not part of the high school’s mission:

> It has been suggested that perhaps all the technical instruction required here could be given in the High Schools. It is hardly necessary, I hope, to explain that this is not a practicable plan. … The High School is, or

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\(^{28}\) *Report of the Minister, 1885*, 161.

\(^{29}\) Gidney and Millar, *Professional Gentlemen*, 356.

\(^{30}\) Ibid., 356.

\(^{31}\) Non-specialization as a hallmark value of Ontario high schools is further discussed in chapters 3 and 5.
should be, concerned in general, not technical, training. It has already been complicated and diverted from its object by the introduction of technical and semi-technical subjects, and to proceed further along the same line would be to further impair its usefulness.  

Suzanne Zeller has shown that any talk of integrating technical education into the mainstream school system prompted vocal misgivings and hostility. These efforts to keep the threat of vocationalism at bay from high schools served to sharpen the differences between academic science and technical science.

The last decade of the nineteenth century marked a definitive shift within Canadian society. Worries about industrialization and Canada’s place within the international marketplace continued to add fodder to complaints that the Ontario school curriculum was ill suited to the changing times. In a Labour Day address in Toronto in September 1896, member of parliament John Ross Robertson declared that it was time that technical education received due attention from legislators. “We are sadly behind in this regard,” he admitted. “We want men in this country with energy and muscle, those who, by union with capital, can keep the wheels of manufacture and commerce [turning].” Similarly, in an 1897 letter to Minister of Education George Ross, a concerned citizen insisted that “No nation ever became great or permanently prosperous that was purely agricultural, but required [sic] manufacturing industries to be established to enable them to be so. . . . If [technical schools] are necessary in Great Britain, France, and Germany, they are more so in Canada.” The author of this letter was not alone in suggesting that Canada needed to reinvent its longstanding rural, agrarian image. William Pakenham, principal of the Toronto Technical School, likewise reflected that Canada was “standing at the parting of

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32 Loudon, Convocation Address, 12.
33 Zeller, “Roads Not Taken.”
35 Letter from Chairman of the Civic Celebration Committee for the Queen’s 60th Jubilee to G. W. Ross, 8 February 1897, Department of Education select subject files, RG 2-42-0-6596, Archives of Ontario.
ways, with a growing consciousness that we have other interests than those of the soil.” What the nation needed was “men, trained men, to guide us.”

Over the course of the 1880s and 1890s, a campaign for technical education slowly gathered momentum in Ontario. Isolated calls from a few educators for more in the way of “practical” education soon grew into a full-fledged movement backed by the forceful support of labour groups such as the Trades and Labour Congress, which had been founded in 1883 in an effort to centralize Canada’s labour unions, and the Canadian Manufacturers’ Association. These groups persistently argued that the demise of the apprenticeship system had left a gaping hole in the training of mechanics, industrial workers, and other tradespeople. The 1889 Royal Commission on the Relations of Labour and Capital took up the refrain, recommending significant changes within the school system to meet the educational needs of young workers.

At the same time, the province’s mechanics’ institutes were being roundly condemned as failures. Ontario’s first mechanics institutes had been established in the 1830s. By 1879, there were 84, and they offered evening classes to workers and farmers. In his first year in office, Minister of Education George Ross expressed his hope that mechanics institutes would bring an influx of scientific knowledge into industrial pursuits and acquaint workers “with the branches of science which are of practical application to their various trades.” The institutes, however, struggled to thrive. Enrolments were low, and by the 1880s, they faced a mounting flood of criticism. High school chemistry teacher and textbook author A. P. Knight dismissed them as “complete failures.” It was time for the province to set up secondary schools specifically devoted to the teaching of science, he argued. Like the labour groups, Knight argued that the province needed to provide technical education beyond the enclave of the universities. “Until [schools of science] prove successful,” he wrote, “there will always be cranks and croakers who insist that no

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38 Ibid., 42–44.
39 Report of the Minister, 1884, 205.
education worthy of the name can be outside the four walls of a university.” In the 1890s, mechanics institutes were abolished and many were converted into public libraries.

In 1892, the Toronto City Council opened the first technical secondary school in the province, largely in response to the evident failure of the mechanics institutes. When the Toronto Technical School opened, it ran very much like a mechanics institute, offering free evening science, mathematics, and drawing classes “for artisans, mechanics, and workingmen.” In fact, despite overcrowding and demand for afternoon classes specifically for women, the school’s board resisted instituting daytime classes on the grounds that they were outside the school’s mandate. This response illustrates that the board saw the role of the Technical School as very different from that of public high schools.

The divide would not remain quite so stark. In 1901, the Board finally conceded to demand for day classes. As with regular high schools, admittance was contingent on a high school entrance or public school leaving certificate. But the biggest structural change happened in 1904, when it was transferred to the jurisdiction of the new Toronto Board of Education and renamed the Toronto Technical High School. In 1902, William Pakenham became its principal and steered it through its transition into the academic school system, pushing for more academic course offerings. Even so, the school remained cash-strapped and sidelined, “an appendage to the local and provincial school systems, rather than a ‘rung’ on the educational ‘ladder’ leading from elementary through high school to the university.”

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40 A. P. Knight, *Chemistry for High Schools: Consisting of a Series of Concise Definitions, Short Notes and Chemical Problems . . . for the Teachers’ Examinations of the Education Department, Ontario*, 4th ed. (Toronto: Copp, Clark, 1884), 286.


While Pakenham and the Toronto Technical School sought to address a felt need for secondary-level technical education, other educators set their sights on the elementary schools. Inspired by the manual training movements in Britain and the United States, they argued for the introduction of manual training courses into Ontario elementary schools. Discussions about how to implement technical education at the pre-university level, far and above any other school subject, prompted a remarkable number of foreign educational tours, including two by John Seath, one by Deputy Minister of Education John Millar, one by journalist Bernard McEvoy, one by Kingston collegiate institute principal W. S. Ellis, and one by Inspector of Technical Education Albert Leake.  

Toronto school inspector James Hughes provided the first sustained advocacy for manual training in Ontario. In the mid-1880s, he began drafting a program of studies for a proposed manual training course that continued through all the grades of public school. Hughes’ advocacy for manual training encapsulated the movement’s characteristically diffuse goals: he alternately touted its intellectual, moral, social, and economic benefits, arguing for everything from how it increased pupils’ earning powers, how it fostered industrial prosperity, and how it combated “the vices of drunkenness and lack of thrift.”

In tandem with Hughes’ advocacy for manual training, Adelaide Hoodless mounted a vigorous campaign for domestic science. By 1894 she had opened several training centres for student and prospective teachers, and was later able to leverage the attention and funding bestowed on manual training to expedite the subject’s integration into the school system. By 1904, nine school boards had implemented domestic science courses on their schools’ curricula. Manual training was also considered to be the urban counterpart of agricultural education, which aimed both to bring science to bear on agricultural practices, but also to keep farmers interested in their work and thereby stem the

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44 Ibid., 58.
population flow from the country into the cities, a trend that worried many contemporary observers.

The watershed moment for the Canadian manual training movement came in 1899, when Montreal tobacco manufacturer William C. Macdonald established the Macdonald Manual Training Fund to fund the setup of manual training programs across Canada. Macdonald’s funding provided enough money to build manual training centres in several major Canadian cities and to fund their operation for three years, at which point it was hoped that local school boards would step into to provide the needed financing. Federal agricultural commissioner James Robertson, who had managed to interest Macdonald in the establishing the fund in the first place, was tasked with implementing the fund. In the process, Robertson became a prominent spokesperson for the subject and helped give shape to the particular pedagogical vision for the new subject. By the end of the three years, there were twenty-one centres in place across the country. In tandem with the advent of the Macdonald funding, the Ontario Department of Education decided to give the movement its approval, and manual training and domestic science became optional elementary school subjects in 1899. The subject would also be approved as an option in high schools when new regulations were instituted in 1904. The new regulations allowed students to choose among seven programs: general, commercial, manual training, household science, agriculture, university matriculation, and the teacher’s course. In practice, however, many high schools did not have the staff or facilities to offer the full range of programs, and the new vocational courses were usually limited to large high schools in major centres.

5. Mounting a Common Front: Framing the Pedagogical Objectives of School Science and Manual Training

The strategies employed by science teachers, proponents of manual training, and advocates of technical education to secure broad support for their subjects and disarm the objections of their critics shared some striking points in common. The kinds of arguments that were raised on behalf of the new subjects show how strong the hold of the traditional

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46 See Stamp, “Campaign,” 100-105.
curriculum remained. Like the new, laboratory-based science courses, manual training had to situate itself as a fundamentally moral and intellectual pursuit even as it defended its inherently practical goals. Also like science, it walked an ever shifting line between presenting itself as a *critique* of the traditional curriculum – by combating its overly bookish, academic approach – and positioning itself as a *complement* to traditional subjects, because it proposed to address hitherto neglected aspects of pupils’ mental development. Much like their American counterparts, Canadian promoters of manual training presented the subject as a key component of a general education. Early voices of influence within the American manual training movement, such as Calvin M. Woodward, a professor at O’Fallon Polytechnic Institute in St. Louis who became a vocal champion for manual training in US cities, were careful to avoid presenting manual training as rivalling the traditional curriculum, but rather as completing it. 47 Canadian educators followed suit, and recognizable pieces of Woodward’s rhetoric cropped up nearly word-for-word in pitches by Ontario figures James Hughes, James Robertson, and Albert Leake.

Manual training, however, unlike science education, had to contend more directly with the sticky issue of vocationalism. Proponents of science education were wont to downplay the utilitarian aspects of science to ease its integration into the high schools’ liberal education. Manual training had to go further than this. To succeed in positioning itself as an integral element of a general education, it had to decisively break any supposed ties to occupational training. In this task it ran into markedly contradictory impulses. Even as it sought to dissociate its workshop exercises from preparation for any specific trade, it nevertheless fell sway to the ambitions of the broader technical education movement, namely, to stimulate the forces of innovation, production and national prosperity through the channels of formal education. Manual training might not have aspired to provide direct trade training, but it did seek to stir a deeper respect for manual labour, confer the handiwork skills useful to the child’s later occupation (“whatever that might be”), help workers to be more content with their station in life, and

provide an education particularly suited to children headed to careers in industry rather than university studies.

In an effort to reinforce the notion that manual training offered rewards to all students, not just future workers, its advocates placed a high premium on its moral benefits. Here too, the rhetoric of manual training is strongly reminiscent of rationales for hands-on science teaching. Working with tools at the workbench, much like working with apparatus at the lab bench, was said to cultivate a host of personal virtues including self-discipline, restraint, responsibility, and patience. These arguments were frequently paired with remarks about how manual work provided an outlet for the mischief-making tendencies of youth (almost always male youth in particular). There is nothing particularly surprising about this, considering the deep-rooted Protestant convictions about the honour of labour that held sway in nineteenth-century North America. But in this sphere as well, rationales for manual training diverged in important ways from the moral trappings of science teaching. Manual training in particular was driven by a palpable sense of nostalgia for pre-industrial life and sought to restore a sense of autonomy and honour around manual labour. As well, manual training and its counterpart domestic science were considered to be particularly useful for facilitating the social integration and Canadianization of immigrant children.\footnote{See, for example, Danylewycz, “Domestic Science Education,” 130.}

Finally, as much as proponents of manual training and technical education advertised the moral and intellectual aspects of their mission, they were – far more overtly than the school science movement – inherently practical enterprises. The immediate outcomes of manual training courses were the production of “useful objects” and the acquisition of handiwork skills. Technical education, for its part, was overtly vocational. Its goals were to educate workers for gainful employment. In this respect, both manual training and technical education had to contend with continued resistance to the notion that high and public schools should be engaged in any sort of occupational preparation. The now universal assumption that a central purpose of schools was to prepare people for their life’s work was, at the turn of the twentieth century, still a radical proposition. Accordingly, educators like Pakenham, Leake, and Seath had to tackle this idea head-on.
Challenging the notion that “utility” was somehow opposed to “culture,” they tried to chip away at assumptions and cherished values surrounding liberal education. Just as universities were broadening their curriculum and providing specialized occupational training, so too should high schools embrace a more pragmatic approach to their mission, they argued.

But the differences between the pedagogical rationales for science and manual training become particularly stark when considering how educators conceived of the role of the basic sciences within secondary-level technical education. Manual training focused on workshop exercises and drawing with no real science component, but science did play a key part in technical education. The discourse surrounding the relationship between pure and applied science thoroughly permeated not only higher technical education, but secondary-level technical education as well. The scientific aspects of craftsmanship, factory work, and domestic science conferred status on these pursuits. It was by virtue of education in the basic sciences that manual workers were “enlightened” and “humanized” and that an educated worker could rise to the level of a manager or even a “leader of industry.”

While the incipient manual training and technical education movements shared many of the objectives of the laboratory science movement, some aspects of how the manual training movement was marketed to educators and to the public set it apart from school science. As a university matriculation subject, science was fairly easily able to position itself as an academic subject and to avoid having to navigate the difficulties of vocationalism for many years. As will be discussed in Chapter 5, not until the 1930s would the high school science curriculum be reorganized in order to better serve the interests of students who left high school early to get jobs. Technical education, on the other hand, was specifically geared to employment and had to make the case for schools taking on the task of occupational training. In the case of manual training, there were intrinsic tensions within the movement that pulled it in different directions, reinforcing the traditional mental and moral roles of schooling, on the one hand, while always keeping occupational success in the long view, on the other. Kliebard points out that the
movement’s diffuse objectives likely made it easier for it to gain adherents, allowing supporters to latch onto whichever aspects they liked best:

The ambiguity as to whether manual training should be interpreted primarily as a pedagogical reform or as a necessary avenue to learning job skills for the new industrial age was never resolved. In a sense, this dual justification may have actually added to its appeal. Supporters tended to see in the reform what they wanted to see.49

6. The Value of Hands-On Learning

As shown in Chapter 1, science educators anchored their arguments for laboratory science and specimen collection to the central pedagogical principle of “learning by doing.” The overarching stated goal, of course, was to develop pupils’ reasoning skills, whether by classifying plants or by testing hypotheses. But the development of these intellectual skills was assumed to rest on the more basic foundation of hands-on learning. Through activities such as gathering, mounting, and drawing specimens, working with laboratory equipment such as a balance or a microscope, or rolling a ball across an inclined plane, students experienced the “direct contact” that was the essential first step to independent learning.

These arguments, so prevalent in rationales for science teaching in the 1880s, carried over smoothly into justifications for manual training in public and high schools. As with science, manual training was presented as an exercise in mental discipline. “We need to train more than just the memory and language faculties,” argued James Robertson. The assumption was that these handiwork exercises were themselves a particular form of mental discipline, in which the mind was cultivated by training the hand and the eye. Robertson’s rhetoric evoked the principles of Scottish philosophical idealism, which rejected the notion of mind-body dualism.50 He stressed the importance of training the “whole child” by bringing together “scholarship and practical and manual instruction.” Robertson also drew on the principles popularized by James Hughes’ kindergarten

49 Ibid., 12.
movement. As discussed Chapter 1, the ideals of “self-activity” preached by Friedrich Frobel and enshrined in the kindergarten movement dovetailed neatly with the purported goals of independent work in the science laboratory. Toronto school inspector James Hughes, the leading advocate for kindergartens in Ontario, also began agitating for the introduction of manual training in public schools in the mid-1880s. He believed that manual training was the “natural extension” of Froebel’s principles as children got older and moved from kindergarten through the school system.\(^{51}\) Robertson concurred. “The spirit and the principles of true kindergarten teaching should continue throughout the whole educational course,” he wrote in a 1900 essay on manual training. Public schools needed to maintain continuity with the earlier life of the child by engaging “hand, eye, and mind.” Children’s natural desires needed to be guided toward actions that had educational value: this, argued Robertson, was how “mental growth” occurred.\(^{52}\)

While manual training was unapologetically practical, its practical applications were firmly subordinated to its moral and intellectual rewards. “It really is hand and eye training. . . It really is in the highest sense a recreation for the mental powers of the boys. Its purpose is to train the child with system and care, to observe, to interpret, to construct, and to describe,” insisted Robertson, in language unmistakably reminiscent of that employed by science promoters.\(^{53}\) To reinforce the intellectual nature of the enterprise, manual training advocates took pains to dissociate the lessons of the manual training classroom from any form of occupational or trade training. This was a common feature of the early manual training movements in the United States and Britain. John D. Runkle, an early architect of manual training programs in the United States, had instituted a version of manual training inspired by the “Russian Tool System” in a Massachusetts secondary school. What had particularly drawn him to the Russian system, which he had first encountered at the 1876 Philadelphia Centennial Exhibition, was how its workshop lessons were isolated from the broader manufacturing process. Each workshop skill was taught discretely, as an abstracted exercise, dissociated from the goals of industrial production. For Runkle, this seemed like an inherently democratic approach to the


\(^{53}\) Ibid., 336.
manual arts, because it avoided the assumption that boys were being groomed as future workers. It aimed to instil a deeper appreciation for manual work without pigeonholing students. To reinforce this, Runkle’s school adopted the motto “Arts, not trades; instruction not construction.”

This philosophy became the rule of many nineteenth-century manual training programs. When Ontario’s first Macdonald-funded manual training centre opened in Ottawa in 1900, educators and government officials at the opening ceremony were quick to assure all present that manual training was emphatically not vocational training. “Ladies and Gentlemen, I ask you to understand that manual training is not intended to teach any trade,” declared Lord Minto, the Governor-General of Canada. “…Only as the alphabet and the art of reading are necessary to the literature of all the professions, so manual training fits a boy to begin his apprenticeship to any trade with greater aptitudes and correspondingly better chances to be a skilful, excellent workman.” The Governor-General’s analogy shows that while manual training was clearly intended for boys who would go on to work in industry, it was intended to be several removes from direct trade training. It would provide the rudiments of handiwork skills and craftsmanship that could, in theory, be applied to any occupation. “In the manual training room no attempt is made to teach a trade,” reiterated Albert Leake, the manager of the Manual Training Fund, who would soon be appointed as the first inspector of manual training, technical, and art schools. “Only when manual training has been taken as a factor in a general education has it succeeded.”

Lord Minto and Leake were not merely trying to assuage the worries of traditional educationists. They were also, no doubt, trying to appease labour groups who worried that manual training in public schools would lead to a glut in the labour market and lower the demand for trained workers. The Trades and Labour Congress (TLC) opposed manual training in the public schools, but stood in support of technical education, which purported to offer night classes for adults who were already employed in industry.

54 Kliebard, Schooled to Work, 4–5.
Technical education, as the TLC understood it, strengthened the skills of their base, while manual training threatened to “undercut the apprenticeship system, take work away from properly qualified tradesmen, and produce second-rate workers.”

Another point of commonality shared by manual training and science advocates was their critique of the overly bookish curriculum. Here again, their arguments rested on presuppositions of complementarity with the traditional curriculum. Just as their arguments founded on mental discipline called for training “other faculties” beyond those allegedly favoured by the traditional curriculum, their case for a less bookish curriculum pointed to the need to reach out to other kinds of learners – specifically, “practically minded” children. Pleas on behalf of the practically minded student highlight one of several tensions within the movement. While insisting that manual training was not simply trade training for the future – that it stood to benefit all children, because it engaged the “whole child” – their arguments for reaching out to a specific kind of child betray the very prejudices about manual work that they were ostensibly seeking to redress. The movement commonly elicited categorizations and distinctions among students. H. E. Miles, an American proponent of manual training with the National Association of Manufacturers, divided children into three classes: abstract-minded or imaginative, concrete or hand-minded, and the “great intermediary class” that displayed both tendencies. As much as manual training advocates preached for a more broadly appealing, democratic curriculum, it was clear that aptness for manual work was elided, subtly or overtly, with inferior intellectual ability or academic feebleness.

Manual training and technical education, like science, were said to fill a prominent void in the school system. But unlike science, manual training singled out students who struggled with the traditional curriculum. “All minds are not constituted in the same way,” wrote W. S. Ellis, the Principal of Kingston Collegiate Institute. “For many minds, perhaps the majority, the mere theoretical and abstract offer conditions that are difficult to understand, hence are not educational because not clearly intelligible.” He complained

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57 Stamp, *Schools of Ontario*, 58.
58 Kliebard, *Schooled to Work*, 32.
that no provision was made for the student “whose mind has a practical bent.”\textsuperscript{59}

Similarly, Robertson remarked that “the so-called dull boys, who are not quick at book-studies, have in many cases been found to show great aptness for manual training.”\textsuperscript{60}

7. Schoolroom Lessons in Virtue

These pedagogical precepts were also overlaid with moral benefits. As seen in Chapter 1, educators justified the expanded science offerings not only in terms of the mental training science conferred but also in terms of the moral qualities it fostered. Ambling through nature, handling specimens, and manipulating finicky laboratory equipment cultivated patience, self-discipline, and a reverence for nature. Educators emphasized that these activities disciplined the body as well as the mind, and that they redirected pupils’ energy for mischief into productive channels. If this argument was common among science educators, it was ubiquitous among proponents of manual training and technical education. “Manual training,” declared James Robertson, develops “habits of industry and leads [children] to thoughtfully adjust their acts to desired ends. . . . It gives them self-reliance, hopefulness and courage, all of which react on their mental and physical faculties.” Manual training was a corrective, he continued, for the excitable and over-anxious child.\textsuperscript{61} Albert Leake likewise pointed to the sense of responsibility cultivated by manual training. Describing the manual training centres that were opening in various cities, he wrote,

\begin{quote}
Each boy has his own pigeon-hole in which to keep his work, drawing, apron, etc., and for the neatness and tidiness of this he alone is responsible, and this feeling of responsibility . . . is found to be most beneficial to the character and morale of the boy.\textsuperscript{62}
\end{quote}

The assumption that manual training was a corrective influence had a long lineage. In Victorian times, “industrial schools” had been schools for juvenile delinquents. To give children a few simple tools in the garden or workshop would allow them to use up “much

\begin{footnotes}
\item[59] Ellis, \textit{Report}, 17.
\item[60] Robertson, “Manual Training in Public Schools,” 339.
\item[61] \textit{Ibid.}, 338–339.
\end{footnotes}
of that youthful energy and restless activity which now find expression in the mischief-working so common to irrepressible boyhood and so trying to anxious parents,” wrote one Ontario minister in 1881. Isaac Newton, he submitted, was one example of a “comparatively dull scholar” redeemed by his assiduous use of his “saw, hammer and hatchet.” Likewise, the author reflected, it was doubtful whether John Smeaton (the English civil engineer), James Watt, and George Stephenson, who had been “handy with tools when mere boys,” would have “accomplished so much in their manhood” without such “self-culture” in their youth.63

While manual training was promoted as a correction for children’s personal foibles, it was also held up as an antidote to a deeper moral crisis that faced society. Herbert Kliebard writes that the virtues implicit in the Protestant work ethic had been imagined in the context of the artisan’s workshop, where a workman could see a project from inception to finished product. As factories, assembly lines, and piecework superseded private workshops, the traditional sense of work ethic lost its moorings. This venerable ideal of noble, autonomous, productive labour was at odds with the new industrial order.64 When William Pakenham, Principal of the Toronto Technical School, reflected on the demise of old ways, his nostalgia was palpable: “The apprentice, with the splendidly human and instructive relationship that bound him to his master, has gone from industrial life,” he noted solemnly.65 This sense of crisis precipitated by the dislocation of work ethic, as well as the difficulty of imagining the assembly line as a space for edification or fulfilment, reinforced the perception of an essential antagonism between progress and morality. In the context of these disquieting social changes, both manual training and technical education seemed to be a throwback to an older, more gratifying relationship to physical work. Proponents of manual training emphasized that boys would create complete objects, from beginning to end, and gain the satisfaction of

64 Kliebard, *Schooled to Work*, 1–3.
seeing their finished work.\textsuperscript{66} There was to be no division of labour, no machinery, nor any labour-saving devices, in the manual training room.\textsuperscript{67} The manual training room was envisioned as a foil to the factory floor, and as a place where the dignity of handiwork could be reclaimed. “It is a good thing to let boys and girls become partakers of this divine joy in their own work,” declared James Robertson.\textsuperscript{68} Manual training thus became a “symbolic reassurance that traditional values were not being displaced,” argues Kliebard.

Manual training’s claim to having the power to reinvigorate the ennobling power of work and to correct moral defects was dubious at best…. [But] it was comforting for Americans to believe that the problems associated with the transformation of the workplace could be addressed in schools. Somehow the new, puzzling, impersonal world that the Industrial Revolution had wrought seemed less threatening.\textsuperscript{69}

Of course, this appreciation of work was evidently a lesson that was targeted at some students more than others. Robertson, Leake, and other supporters of manual training pointed to the intrinsic interest of their subject, much as early advocates of science and nature study had. After his tour of English manual training centres, Robertson stressed how absorbed pupils were in their work and how much enjoyment they evidently took in it. While students’ simple enjoyment on the work was often linked to Frobelian ideals of the child’s self-activity and natural interests, it also underscored the movement’s goal to make manual labour more appealing to those who would be engaged with it.

If the supreme desire be that the children and grown people shall be happy and capable in the sphere of life in which they are to live, then the education and educational processes will be directed to attain those ends . . . . Doubtless one of the many causes which have helped to bring


\textsuperscript{67} Leake, “Manual Training in Canada,” 357.

\textsuperscript{68} Robertson, “Manual Training in Public Schools,” 339.

\textsuperscript{69} Kliebard, \textit{Schooled to Work}, 23.
about a distaste for manual and bodily labor has been the too exclusively book and language studies of the common schools.  

8. Secondary-Level Science and Technical Education: Vocationalism in Ontario Schools

At the secondary school level, technical education was frankly vocational. Technical schools such as the Toronto Technical High School were not a gateway to the universities, but rather aspired to offer instruction that would lead directly to jobs. Consequently, its proponents spent less energy trying to assimilate it into the model of a general education and instead made an open case for the need of the useful in secondary education. One of the biggest challenges facing both science educators and advocates of technical education was confronting the worry that the traditional role of high schools as cultural polishing was being subverted by a crass utilitarianism. William Ellis, Principal of the Kingston Collegiate Institute, tried to chip away at this worry by questioning its underlying assumptions. The distinction between mental discipline and usefulness was essentially arbitrary, he argued: “The subjects which we now keep on our curriculum because of the intellectual discipline that their study affords were inherited to us from the programmes of older schools, and … in those schools these subjects were selected for study because of their usefulness in the after life of the student.” In other words, subjects like Latin had originally been put on the curriculum because they were useful to students who were destined for the learned professions like theology and law, where a mastery of Latin played a functional role. Now that its direct relevance had diminished, educators defaulted to the stance that Latin trained the mind. Pakenham, Principal of the Toronto Technical School, made the same case. “Formal education,” Pakenham declared, “has always been more or less utilitarian.” He went on to lament the fact that the methods of formal education always seemed to lag behind its purpose. Pakenham and Ellis’s arguments echoed similar arguments made about the universities – namely, that they had always been occupational in nature but had focused on a very narrow selection of occupations: the learned professions.

71 Ellis, Report, 5.
Science was not an important ingredient of manual training courses in elementary schools. Because, after all, manual training courses were designed for younger boys, they focused on shop work and drawing without pausing on any underlying scientific principles. In secondary-level technical education, the basic sciences were crucial. In a 1902 letter, Pakenham boasted that “the chemical laboratory [of the Toronto Technical High School] has not its superior as a students’ laboratory.” He went on to admit, however, that the situation was different for physics. “The Board did not ask for a physical laboratory last year,” he complained. “It should have one at once. No technical school in the world is without one.” Pakenham unapologetically defended the expense of such facilities: “The methods of technical education are expensive,” he argued, “because it teaches by doing, not telling. It needs large buildings, many teachers, extensive laboratories, and generous supplies.”

While Pakenham stressed the scientific credentials of his institution, he also took pains to distinguish between the science taught in the technical school and the science taught in high schools. “It should not be forgotten that in this connection that the Toronto Technical School is not the duplicate of a collegiate institute,” he wrote.

The technical school does not seek primarily to give general culture or to fit for the learned professions or for the University, but it does seek to rationalize the work of the artisan and the clerk, and to make alert, resourceful manufacturers and merchants. […] The mathematics, the chemistry and physics of the High Schools are general in treatment, and aim solely at the mental development of the pupil. Euclid in the Technical School, becomes practical geometry as needed in drafting; arithmetic becomes practical mensuration, while algebra is taught merely to prepare for the higher calculations in physics and chemistry. In physics and chemistry the difference becomes more marked. The Technical School trains definitely in the application of physics to machinery, to steam, gas and electrical engineering, and in the applications of chemistry to the industries of Toronto,—brewing.

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73 W. Pakenham, letter to the Chairman of the Toronto Technical School Board, 7 May 1902, Department of Education select subject files, RG 2-42-0-6563, Archives of Ontario, 3.
engraving, tanning, dyeing, food-preserving, to paints, oils, glues, ferments, etc.  

With this list, Pakenham very deliberately demarcates the missions of the high schools and the technical schools. In doing so, he reiterates the cultural mission of the high schools and emphasizes that the technical school does not threaten or encroach on this mission, because its ends are different.

In other defences of technical education, the unique goals of the movement highlight the differences between academic science and technical science. As Leake explained in his 1913 report, *Industrial Education*, technical education had the potential to “counteract the narrowing & blighting influence of the … division of labour.” Elsewhere, he noted that technical education aimed to “make the worker a thinker and thinker a worker.” This could be accomplished by rationalizing factory work – for instance, by teaching students the mechanical principles of each tool. Understanding the laws of physics that underlay their tools and tasks, he argued, would make workers more fulfilled, knowledgeable, engaged with their work – and better equipped to climb up the factory ranks. In other words, an education in the basic sciences had the potential to restore individuality and intentionality to the labourer’s work, to bring intelligence to bear on dehumanizing factory work, and to provide opportunities for personal advancement.

Despite these efforts to disambiguate science, manual training, and technical education, it is clear that some educators continued to conflate these categories. In 1907, for example, the Chairman of the Board of Education in London, Ontario wrote to Minister of Education Robert Pyne to complaining about the space crunch at the Collegiate Institute and requesting that a technical school be established in London. His assessment was revealing: “If a technical school were established,” he reasoned, “we could take out the Science Department [from the high school] which would give us three rooms more, and the Household Science department which would give us another room, this would relieve

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74 Ibid., 5.
the pressure for sometime to come.” In other words, this board member viewed science as a pursuit that could be relegated to a separate institution outside the high school.

During this period, laboratory work came with a considerable amount of workshop tasks. This was as true of university-level laboratory work as it was of high school courses: even James Loudon complained of the “drudgery” of shop work that he had been required to do to set up his physics laboratory at the University of Toronto. For high schools, having students build their own apparatus was part of the arrangement, as noted in Chapter 1. The shop work components of experimental science likely contributed to perceptions that science had much in common with manual training. And not everyone was convinced that science was such a disinterested pursuit. Jameson Avenue [Toronto] Collegiate Institute mathematics master I. J. Birchard remarked in the *Canada Educational Monthly* that some teachers regarded science as a “bread and butter subject” whose claim on the high school curriculum was as dubious as its “close relative,” manual training.

9. Conclusion

Proponents of technical education sought to stimulate a broader interest in industrial work at all levels - both in manual labour and in the work of managers and industrial leaders. To make the schools the venue for this new kind of education, they needed to sell the subject both to educationists, to students, and to parents. To make manual training and technical education appealing to educators, they borrowed heavily from strategies that had been used by science educators to bring perceptions of their subject into harmony with the traditional curriculum. But this was a strategy for educationists, not for students. Historians have pointed to the gap between the program offerings as they existed “on paper” and the realities of student enrolment in the early decades of the twentieth century.

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77 Letter from Chairman of London Board of Education to R. A. Pyne, 3 October 1907, Department of Education select subject files, RG 2-42-0-6543, Archives of Ontario. My emphasis.
The reality was that vocational programs were far less available to students than academic options, and that students persistently opted for academic programs even where vocational options were available. “While provincial commissions recommended more vocational training as a means of providing work-oriented education and as a way of creating greater opportunities for working and middle-class youth, potential consumers took academic courses in high schools and pressed for access to higher education,” write Lazerson and Dunn.\(^\text{80}\)

Gidney and Millar propose several reasons for this. First, the comparatively high cost of vocational education meant that the subjects outside the list of required courses were, for the most part, only offered in large centres and at well-provisioned schools.\(^\text{81}\) These courses remained optional until the late 1930s, when the Ontario Department of Education made courses like manual training and domestic science mandatory.\(^\text{82}\) Among these new, mandatory, and more overtly vocational subjects was the new grade 9 general science course, which is the subject of Chapter 5. Second, the matriculation (university entrance) course had prestige and staying power. Parents and students were well aware that a matriculation certificate opened the doors to white-collar jobs, even for matriculants who did not go to university. It also kept students’ options open along the way and gained them access to the universities, the most reliable source of social mobility. While educators kept pushing the general or vocational program, even instituting a “high school leaving” certificate as an alternative to the matriculation certificate, the vast majority of students continued to seek matriculation. “Paradoxically, perhaps, the academic program was pre-eminently practical, in the sense that it led to good jobs,” they write. As they explain,


\(^\text{82}\) Danylewycz, “Domestic Science Education,” 128.
In that respect there was nothing more practical than Latin or algebra. The academic high school was, in its own way, a vocational school – or perhaps better put, the pre-vocational program for the higher echelons of white-collar work.\(^83\)

While there was a major surge in vocational enrolments in the early 1920s, Gidney and Millar’s research into retention rates suggests that this surge was a result of new mandatory attendance legislation that was passed in 1921. Students dropped out of vocational programs at much higher rates than students in academic programs – nearly four times higher.\(^84\) A plausible interpretation of this difference is that those who wanted to be in school chose academic programs, whereas many of those who were passing time until they were legally allowed to leave chose vocational programs, which were easier to get into.\(^85\)

These enrolment patterns suggest that while educators’ elevated moral and intellectual rationales for technical education may have won converts among educationists (and even philanthropists like William Macdonald) and eased their subjects’ integration into the public school system, their arguments seem to have had little resonance for students and parents. The fact that students persistently favoured academic programs highlights the disconnect between educators’ ambitions to mould public perceptions and students’ own reasons for attending school. Parents sent their children to school not to kindle a deeper appreciation for manual labour or farming, nor to achieve contentment with “the sphere of life in which they were to live” (as Robertson had put it), but to set them on the path to a better life.

Science subjects had managed to avoid this disconnect. First of all, upper year science subjects soon became matriculation options (and eventually requirements) in order to meet the demand brought on by the universities’ own diversifying science students, namely, doctors, dentists, and engineers. Moreover, as manual training and technical education sought entry into the schools, science education was better able to position itself.

\(^83\) Gidney and Millar, *How Schools Worked*, 255.

\(^84\) Ibid., 254.

\(^85\) Ibid., 449, note 21.
itself as an academic subject that was more cultural than vocational. Attempts such as Pakenham’s to disambiguate between the science offered in technical schools and the science offered in high schools further drove these differences home. As high school science was aligned with abstract science, thereby juxtaposing it with the applied science of the technical schools, high school science was able to capitalize on the widespread cultural narratives about pure science “guiding” applied science and stimulating industrial success. Not until high schools came to be regarded as fundamentally vocational institutions, a shift borne out in the MacArthur plan in 1936, did high school science intentionally embrace a more applied, vocational thrust.

The result was that even as proponents of technical education strove to rehabilitate manual and industrial labour in the public eye, they widened the divide between the respective clienteles for academic science and technical science. This was a problem that the early reformers encountered head-on. It was in evidence, for example, in Albert Leake’s remarks that “Theoretically [parents] believe thoroughly in industrial education, but so far as it leads to actual work in a shop or factory it is for the son of somebody else and not their own.” As they reinforced the differences between the science education of the high schools and that of the technical schools, they perhaps unwittingly contributed to the group segregation that has been heavily derided by critics of vocational education. In their efforts to carve out a place for technical education within the public school system, technical education marketed manual training as an intellectual pursuit and technical education as a separate enterprise – and in doing so, they reinforced the putative cultural mission of the high schools and drove a wedge between high school science and technical education.

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87 Lazerson and Dunn, “Schools and the Work Crisis,” 298.
Chapter 3

Turf Wars and Curriculum Clashes: Defining the Moral and Pedagogical Role of School Science in Early Twentieth-Century Ontario

1. Mental Discipline in Retreat?

As discussed in Chapter 1, Ontario school officials like high school inspector John Seath and Minister of Education George Ross justified science’s place on the curriculum – and the expense of setting up laboratories and buying apparatus – by arguing that studying science was above all an exercise in mental discipline. Science initiated students into a specific set of skills, they argued: scrupulous observation, adroit drawing and sketching, precision of language when translating observations into words in written reports, methodical hypothesis-testing, manual craftsmanship, dexterity and control in the manipulation of fine instruments, and most importantly, an ability to make inferences and sound generalizations. The work of developing these intellectual and physical skills also awakened moral virtues: patience, self-control, appreciation of nature, perseverance, humility, fair-mindedness, and dispassion.

At the turn of the century, psychologists’ challenges to the scientific legitimacy of mental discipline as a theory of learning led to considerable controversy over the proper ends of education. Educators debated fundamental questions about the nature of teaching, learning, and curriculum-making. Herbert Kliebard has argued that American debates about curriculum reform can be understood as a contest among different interest groups, each with its own distinctive intellectual commitments and visions of the role of education. Some believed that the foremost purpose of education was to develop enhanced reasoning skills. Charles W. Eliot, president of Harvard University, espoused this view, as did others who shared what Kliebard calls a “humanist” philosophy of education. “Developmentalists,” on the other hand, argued that the curriculum should be built to harmonize with the developmental stages of young students. Psychologist G. Stanley Hall was the lead proponent of this conception of education. Others, whom
Kliebard calls the “social meliorists,” emphasized the school’s role in improving society, pointing to the moral and civic functions of schooling. A fourth interest group, with Joseph Mayer Rice at its helm, focused on efficiency and targeted the problem of waste in the education system. Rice and his colleagues set their sights on fiscal misspending and irrelevant curriculum content as forms of waste that needed to be eliminated.1

Ellen Lagemann has framed turn-of-the-century debates among educationists in the United States as a confrontation between Hegelians and Herbartians. A group known as the St. Louis Hegelians was instrumental in promoting Hegelian views of education in the United States. They believed that learning demanded effort and hard work from pupils. In this understanding, education was about earning one’s place in society: schools served to equip students for their role as citizens. The National Herbart Society, founded in 1892 by a group of educators (including John Dewey), embraced a different view modeled after the teachings of German philosopher and educator Johann Friedrich Herbart. Herbartians believed that the curriculum should be geared to pupils’ natural interests. They emphasized the need for interrelatedness among all school subjects. “Correlation,” as they called it, was their catchword. A correlated curriculum could sustain students’ interest because it was coherent, cohesive, and connected to daily life.2

In Ontario, these conflicting theories and ideas unsettled familiar justifications for science as a form of mental discipline at a time when science was still jockeying with other subjects for prominence on the curriculum. Jameson Avenue Collegiate Institute schoolmaster I. J. Birchard remarked that discussion among Ontario teachers as to how to bring “balance” to the curriculum rapidly devolved into a turf war. “The conference degenerates into a contest of factions, each party trying to secure the lion’s share in the programme,” he complained.3 The annual meetings of the Ontario Education Association frequently saw heated exchanges among teachers from the OEA’s different subject sections. The animosity came to a head in what historian Robert Stamp has called “the

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high school debate” of 1901. This dispute arose at a 1901 curriculum conference at Queen’s University and spilled over into the pages of the university journal, *Queen’s Quarterly*. Educators sparred over the merits of introducing “modern” subjects into the high school program as electives. This proposal was a departure from the cherished notion of a common curriculum for all students. Queen’s philosopher John Watson opposed the creation of a differentiated curriculum, arguing that it would prematurely channel students into professional, industrial, commercial and artisanal careers. On the other side, Kingston Collegiate Institute principal William S. Ellis insisted that high schools should stop being regarded as mere feeders to the universities. Electives, he argued, would fill a real need for non-university-bound students. While the high school debate started out as a dispute about the value of electives, it soon followed the pattern observed by I. J. Birchard and devolved into a battle over curricular shares. Nathan Dupuis, Dean of Queen’s new Faculty of Applied Science, chimed in to point out that the common curriculum accorded too little importance to science and kept it in the shadow of literary subjects.4

Ellis’s view won the day – at least in theory – when the 1904 high school curriculum introduced a program of seven strands. This official endorsement of a differentiated program by the Department of Education, which gave vocational subjects like domestic science and manual training a new place on the curriculum, further exacerbated tensions between classicists and scientists. The animosity worsened when the Department of Education proposed substituting science for Latin in the matriculation exam for aspiring teachers. Meanwhile, resentment rippled through the addresses of various members of both the Science and Classics sections at OEA meetings, as speakers traded genteel barbs and open insults.

2. Psychology, Education Research, and New Approaches to Teacher Education

The difficulty of weighing the value of different subjects, the vested interests that teachers had in promoting their chosen specialties, and the open acrimony of curricular

debates prompted some to raise calls for a dispassionate, impartial method of deciding curriculum matters. What was needed, according to I. J. Birchard, was a more scientific approach to education. The question of whether there could be a “science” of education became a matter of vigorous discussion in the 1890s, thanks to Harvard philosopher Josiah Royce. Birchard’s views on the issue were definite: “Education is one of the natural sciences,” he declared, “and as such its foundations must be laid upon the results of observation.”

Patient investigation . . . skilful and intelligent observation of facts, careful classification and study of data . . . are the chief steps by which the foundations of the other natural sciences have been laid. If we are willing to pay the same price for a Science of Education we can obtain it upon the same terms. The laws of mind are surely not less definite than the laws of matter.

The desire among educationists to place the field of education on an equal footing with the natural sciences spoke to the general scientific and technological enthusiasm of the day. The effects of science on an increasingly wide range of human endeavours were evident. “The wonderful strides which science has taken in the last decade or two . . . could not fail to touch the imagination of the most prosaic and awaken the dormant prophetic powers of the least visionary,” reflected one member of the Natural Science section in 1904. “It is a well-known fact that every industry and every material aspect of modern life has been revolutionized and is being daily more and more altered by the application in practical life of recent scientific discoveries and inventions.”

Efforts to create a science of education also emerged from what Lagemann has described as a “reluctant alliance” between psychology and education in the 1890s. Psychologists like G. Stanley Hall and William James recognized the keen public interest in education as an opportunity to demonstrate the relevance of psychology to modern-day concerns. However, they showed perceptible ambivalence, uneasy about allying themselves too

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closely with such a low-status, feminized profession as school teaching. These psychologists were keen to separate psychology from its parent discipline, philosophy, and to distinguish the “objectivity” of their research from the disputatious, open-ended nature of philosophical discourse. Despite its low status, education research was a field in which they could demonstrate the scientific promise of psychology. Proponents of educational psychology sought to show that a quantitative, scientific approach to the study of education could bring much-needed consensus and organization to pedagogical theory. As a result, the language and methods used by educational psychologists borrowed heavily from the rhetoric of the natural sciences, placing a premium on experiment, quantification, and laws. The mental testing movement was perhaps the most prominent instantiation of this emphasis on empiricism, classification, and quantification.\(^8\)

As educational research gained status in American universities, largely due to the ambassadorial work of Hall, James, and Dewey, it also came to occupy a place on the prospective teacher’s program of studies. By 1897, students at the Ontario Normal College were required to take a course in the “science of education” as part of their basic training. In 1915, these principles were formalized in a Department-issued textbook, *Science of Education.*\(^9\) Patrice Milewski has argued that the “scientisation” of education in Ontario was a symptom of the increasing standardization of instructional practice and teacher training. The goal of the so-called science of education was to give teachers a “rational basis” for selecting and organizing their teaching methods.\(^10\)

Such an approach assumed that each school subject required its own distinctive pedagogical strategies. As theories of learning grounded in mental discipline came under attack, all subjects – not just science subjects – needed new social and intellectual moorings in the curriculum. The Ontario Department of Education responded to this by producing a twenty-nine-volume series of teachers’ manuals over the course of the 1910s.

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These books offered advice on pedagogical theory and practice for subjects ranging from household science to English composition. The *Manual of Suggestions for Teachers of Science* was the first to be produced. Published in 1910, it was reissued and formally incorporated into Teachers’ Manual series in 1917. The abovementioned *Science of Education* textbook of 1915 was also part of this series, as were volumes on school management and the history of education. Many were reissued in the 1920s, and they remained in use in normal colleges until the mid-1930s.\(^\text{11}\)

How did these turn-of-the-century efforts to build a science of education influence the teaching of chemistry, physics, botany, and other science subjects? First, psychologists and their adherents proposed new, ostensibly more effective ways of teaching science (and other subjects) that were tailored to children’s mental development. “Science” was not a monolithic subject. Each scientific subject called for different methods and approaches, and educators sought to establish the best order in which to introduce the elements of nature study, physics, chemistry, botany, zoology, and others in such a way as to harmonize with students’ developing interests and minds. Second, many educators were optimistic that the scientific study of education could resolve disputes over the contents of the curriculum and establish proper balance among the different subjects. Birchard’s call for a natural science of the mind, cited above, epitomized this hope. Third, the emergence of a science of education was a testament to the immense cultural prestige of science at the turn of the twentieth century. Notions of “scientific method” held sway over pursuits ranging from psychology to factory management and offered the promise of professional legitimization and authority. “The scientific spirit has permeated all our institutions and influenced our thinking on every subject,” remarked one member of the Natural Science section.\(^\text{12}\) The new prominence of scientific research in the universities and its influence on secondary science teaching meant that the status of scientific subjects on the high school curriculum was never truly in jeopardy after the 1880s. As Birchard

\(^{11}\) Ibid., 341.
declared in an 1894 address, “Whether for good or ill, Science as a Department has come to stay.”

Many science educators enthusiastically embraced the learning theories of leading educational psychologists. In the United States, an association of physics teachers calling themselves the “New Movement among Physics Teachers” invited G. Stanley Hall, John Dewey, and others to contribute essays to a written symposium that appeared in instalments in *School Science and Mathematics* in 1908 and 1909. Hall had previously weighed in on the teaching of physics, having devoted a chapter of his landmark 1904 treatise *Adolescence* to his proposals for a “new education in science.” He blamed the physics curriculum’s disregard for the stages of mental development – its “blindness to genetic laws,” as he put it – for declining high school enrolments in physics. The New Movement physics educators appropriated Hall’s ideas in their efforts to discredit faculty psychology and promote their own ambitions for the physics curriculum. Educational psychology provided a rational, scientific basis for how science should be taught, they argued, while the old ideas about learning based on mental discipline were mere speculation. Significantly, the battle lines were drawn along a professional divide: the New Movement was largely made up of high school teachers who wanted to free physics from the allegedly “college-dominated” approach promoted by university men like Edwin Hall and Charles Eliot. As Kathryn Olesko has argued, the New Movement allowed physics teachers to come together, stake a claim over the physics curriculum by challenging what they saw as its narrow focus on college preparation, and build the foundations of a national professional identity. By allying themselves with the new

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13 Birchard, “Conflict of Studies,” 54.
educational psychology, physics teachers could portray the debate between educationists and college professors as a clash between science and traditionalism.

Like their American counterparts, Ontario science educators also kept an eye to the new learning theories emerging from educational psychology. Norman MacMurchy had pronounced the death of faculty psychology in 1897, endorsing instead a pedagogy rooted in pupils’ “self-activity.” But the finality of MacMurchy’s pronouncement should be read as a rhetorical tactic. Faculty psychology had not died out as an accepted theory of learning – far from it. Controversy over the ultimate aims of education raged on. Charles Eliot remained steadfastly sceptical of learning theories based on child study, despite having hired Hall to deliver his seminal lectures series at Harvard. In Ontario, as the Educational Monthly and OEA addresses make abundantly clear, many educators maintained a thorough allegiance to mental discipline as the true standard of pedagogical value well into the twentieth century. Moreover, even educational psychologists did not completely dispense with the notion of mental discipline, despite their rejection of faculty psychology. Edward L. Thorndike, the noted experimentalist, defended a limited form of transference even as he challenged the empirical validity of faculty psychology.¹⁷

Ontario educators who welcomed developmentalist learning theories often called attention to inherent tensions in the high school’s mission, drawing a dichotomy between its tasks of university preparation and life preparation. Developmentalists believed that high schools had placed too much attention on university matriculation at the expense of their more fundamental role in socialization. William Ellis, the principal who faced off against Watson in the Queen’s debate, took a strong position on this underlying clash of aims. In 1903, amid rumours of an impending overhaul to the curriculum, Ellis published a series of spirited articles disparaging the curriculum, the Minister of Education, and the public’s apathy toward educational matters. He particularly decried the “mischievous domination” of the university matriculation exam over the public and high school programs. The curriculum, he insisted, should be adjusted to the stages of pupils’ mental development “like food and exercise to a growing body.” It was time to dispense with the

¹⁷ Moyer, “Physics Teaching,” 225.
“old pernicious doctrine of study for the sake of discipline.”18 For Ellis, the ultimate role of the schools was to prepare citizens to participate in the social and civil life of the community. In his view, schools had failed in this goal. “The [education] system is unscientific,” he declared,

because its tendency is mainly to substitute knowledge for education, information for power of accomplishment, and scholarship, as measured by examination marks, for trained ability to take part in that struggle for existence and progress which modern conditions impose upon every member of the community. It is thus out of touch with the requirements of the times, especially in a new and progressive land.19

The educational discourse at the turn of the twentieth century highlights the ways in which competing interest groups strategically polarized debates over secondary education. Reformist educators framed the debates in terms of empirical research versus traditionalism, college domination versus life preparation, and pedantry versus relevance and vitality. In some cases, the battle lines were drawn between teachers of different subjects, each side arguing for the special pedagogical value of its own field. But there were also disputes and competitions for status, no less pronounced, among cognate disciplines. Science subjects vied for time and recognition – not only with humanities subjects but also with other science subjects. Olesko argues, for instance, that the New Movement can be seen partly as an effort to bring physics to the centre of the science curriculum. The now established triad of physics, chemistry, and biology was then unknown, and a host of specialties competed for stature. Physics teachers had every interest in ensuring that their subject became both prominent and permanent on the curriculum. Meanwhile, other early contenders, like botany, zoology, physiography and physiology, fell by the wayside.20 Finally, within individual subject areas, educators wrangled over which teaching methods and which content most accurately represented the discipline. In examining the debates at all these different levels, it becomes clear that

19 Ellis, “Proposed Revision,” 53.
pedagogical disputes cannot easily be separated from territorial disputes and the continual effort to gain status and security on a changing curriculum.

3. Reciprocity and Conciliation

In the midst of these many disagreements over the foundations of pedagogy and the curriculum, educators sometimes made attempts at conciliation. Some, like Birchard, pointed to the “science” of education as one possible route to rapprochement, an objective way to mediate between the proponents of different subjects. Others emphasized the underlying similarities between different subjects. Some science educators subscribed to the Hegelian notion that real learning was above all about intellectual effort. Science deserved a place on the curriculum, the argument ran, because mastering science was just as difficult as Latin or Greek. Others argued that a general education was mainly preoccupied with the cultivation of moral virtues and emphasized the laudable character traits that science helped foster. Some science educators even conceded that literary subjects were more culturally enriching than science subjects and better suited to the broadly civilizing aims of a high school education. Accordingly, they proposed “humanizing” the science curriculum by connecting it more explicitly with history and society.

In other words, most of those advocating for school science were not attempting to subvert the accepted functions the high schools. Instead, they reaffirmed the core values of the established educational culture and tried to show how science slotted into those values. Science educators argued for the distinctive educational benefits of science, but they tailored their arguments to the appraisal of their competitors. As Anna-Katherina Mayer has observed, the constant wrangling among proponents of different school subjects led to their adoption of a double strategy: even as teachers advocated the superiority of their own subject relative to others, they borrowed the rhetoric and the rationales favoured by those they were seeking to displace. After the Second World War, this deliberate rhetorical outreach came to be employed by both humanists and science teachers. But these seemingly conciliatory gestures should be taken with a grain of salt, Mayer warns:
Such mutual generosities between scientific and historical educationists are more than just so many pacific gestures. They emerge as hidden colonization-strategies, if considered within their context, that is, a war-like context of constant wrangling, between all school subjects, over curricular shares.  

The effort to build bridges between science and the humanities on the curriculum will be more fully explored in Chapter 5, which considers the rise of general science in Ontario and Quebec. The general science movement was perhaps the most explicit attempt to historicize the science curriculum until the large-scale “humanistic” physics programs of the 1960s.

As science gained an expanded role in the high school curriculum and teacher education, its increased status made it a more vigorous target of criticism by those who felt their territory shrinking. In response, proponents of school science continued to defend and redefine the social functions of science. The task was to situate science as a school subject within the many disparate viewpoints about education and curriculum-making that were competing for stature at the turn of the twentieth century. The Ontario Educational Association, and particularly the Natural Science section, became a forum where ideas were hashed out, rebuttals to critics were issued, and internal disputes were given vent. In making a case for why every student should have some acquaintance with natural science, educationists played an important role in delineating the public functions of science. The high school program was a site where science as a discipline was given significant cultural definition at the turn of the twentieth century. This process meant articulating the moral and intellectual benefits of science education, both for the sake of responding to critics and as a process of self-definition for the community of science educators. But it also meant determining what truly represented the public face of science for young learners. Which aspects of science constituted essential knowledge? Were the

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“methods” of science the crux of its value, or was content knowledge crucial as well? What was the proper balance between experiment and theory? To what extent should school science be modelled on the shape of the scientific disciplines? This chapter focuses on Ontario educators’ efforts to grapple with these different challenges at the turn of the twentieth century, and to delineate the pedagogical and social roles of science for the steadily increasing multitudes of young people entering the province’s high schools.

4. Turf Wars: Moral Justifications for Science, Born of Conflict

Amid the disputes over the appropriate structure of a general education in the early 1900s, several events conspired to exacerbate tensions between science teachers and Latin teachers. The exchange in the pages of the 1901-1902 Queen’s Quarterly was in principle a debate over the advisability of adding elective subjects to the high school curriculum. This debate touched on a variety of hot-button questions. Would allowing students to branch off into different curricular trajectories early in high school effectively steer them into different careers according to their social class? Would it promote premature specialization? Would it jeopardize the cherished principle of a general education? If electives were introduced, what ought to remain the common core for all students? These questions ultimately turned the debate about the consequences of an elective system into a heated exchange about the merits of Latin vis-à-vis science.

The place of Latin on the curriculum was the subject of ongoing controversy in the early twentieth century. As seen in Chapter 1, Egerton Ryerson’s effort in the 1870s to eliminate Latin from the vast majority of Ontario high schools and to limit it to a few elite schools did not succeed. In the view of many parents, Latin was an essential marker of scholarship and culture. Pragmatically, it opened the door to university studies. Latin had come into greater prominence when it was added to the list of required subjects for the teacher’s matriculation certificate in 1894. 23 In the university matriculation

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23 Stamp, Schools of Ontario, 45.
examination, Latin was weighted more heavily than other subjects, which further testified to the prestige it enjoyed.  

Consequently, it is perhaps no surprise that a 1904 proposal by the Department of Education to replace the Latin requirement with nature study on the junior teacher’s examination – the gateway to a second-class teaching certificate – raised a furor among classicists and provoked a strongly worded condemnation by Toronto’s University College Council. It was a move designed to give candidates better preparation for the teaching of nature study classes, but the University College Council reacted angrily. Science was a poor substitute for Latin, the Council charged, not only because familiarity with Latin was highly useful for teaching English, but also because science was “distasteful and repellent” to many future teachers and might even deter them from entering the profession. “The proposal… seems to me almost pathetically unfortunate,” wrote Professor John McFayden, “because it is symptomatic of the tendency of the times to ignore the indefeasible importance of the spiritual element in education.” The response to this outcry from the province’s science teachers was haughty disdain. When the Council report, which had appeared in the Educational Monthly, was mentioned at the Ontario Educational Association meeting, the Natural Science section decided that it was “too contemptible to merit a reply.”

24 George S. Tomkins, A Common Countenance: Stability and Change in the Canadian Curriculum (Scarborough, ON: Prentice-Hall Canada, 1986), 83. The university matriculation exam served as both a high school leaving exam and a university entrance exam.
25 The junior teacher’s examination was typically written after four years of high school and led to a “non-professional” second-class teacher’s certificate. Non-professional certificates constituted the academic component of teacher education and gained students access to a Normal School. There, they completed the professional side of their education (by doing practice teaching and studying subjects such as the history and principles of education, teaching methods, and educational administration). Normal Schools were one route to a professional certificate, which was required for public school teaching. High school teaching required, at minimum, senior matriculation from a high school. Most high school teachers, in fact, had university degrees.
26 Ibid., 135.
27 John E. McFayden, “The Value of Latin to Teachers,” Canada Educational Monthly 27 (1904): 109. McFayden explains that he is “using the word spiritual in the widest sense to cover literature and every other influence that touches the emotional or moral nature of man.”
The proposal was ratified in the 1904 regulations: Latin was reduced to an optional supplement, and foreign languages were excluded entirely from the junior teacher’s examination. Classics and language teachers protested vehemently. The principal of Cobourg Collegiate Institute expressed dismay that the foreign language requirement had been abolished. “Many a young man, fired with the ambition of obtaining a university education, has cursed the day when the Education Department even allowed physics to be taken instead of a foreign language for the old third class certificate,” he claimed. The new rules would surely mean the eventual phasing out of foreign language specialists in high schools, he worried.29 Several university professors, meanwhile, decried the “gradual encroachment of science upon the languages” and the “arbitrary authority” of the new regulations. Language study had not been given a fair chance, protested John Squair, a French professor at the University of Toronto. “Language is the basis of all culture,” added W. S. Milner, a professor of Latin and ancient history.30

The teachers in the Natural Science section refused to issue a formal response to the University College Council’s polemical rebuke. Despite the Science section’s prickly silence on the matter, the rivalry between science and traditional humanities subjects was plain. The discord that flared up at the Queen’s conference resurfaced at subsequent meetings of the OEA. At the 1906 meeting, Richard Lees, a science teacher from Peterborough, summed up the mutual disdain between the two camps. “I feel confident that our friends of the Classical Section will not accuse me of slandering them when I say that they would be quite willing to see the whole science curriculum, with all the laboratories and other appliances for teaching it, consigned to the junk heap, if to no worse place,” he remarked. He then harshly criticized two papers that had been read before the Classics section in 1904 and defended the place of newer, “practical” subjects on the curriculum. Lees’ determination to rebut criticism from opponents that had been delivered two years prior suggests how deep grievance ran. For Lees, the attacks from classicists smacked of ignorance and highlighted the intrinsic lopsidedness of the education system. A trained scientist generally had some acquaintance with the classics,

he claimed, while the classicist knew nothing about science “except the smell that issues from the laboratory door, and that to his refined tastes is bad.”

Lees’ remarks echoed similar contempt voiced by Nathan F. Dupuis, Dean of the Faculty of Applied Science at Queen’s, who had thrown his support behind the reformist camp in the pages of the *Queen’s Quarterly*. Dupuis drew a pointed comparison between the “conservative” and the “liberal” view of education, a contrast that in his view mirrored the divide between ancient theology and modern science. The conservative education was the theologian’s education, he alleged, in which the only science that was tolerated was “the hazy speculations of an ancient people . . . culled from early legend and the Hebrew scriptures and fit only for the childhood of the race.” The Liberal, by contrast, heralded the advent of the scientific age. A liberal-minded educator recognized that the progress of civilization depended on the advancement of science, and that any modern scheme of education needed to make proper room for it. Latin and philosophy, conversely, belonged to the theological age. They were “dead and fossilized”; they expressed “the life of a world that has passed away, that marked a lower stage of development.”

Small wonder, then, that defenders of classical languages and literature were on the defensive. Professor McFayden saw the removal of Latin from the teachers’ matriculation exam as a profound spiritual loss. Science could never address the moral and emotional aspects of humanity as languages and literature could, he contended. “While science can do much, it cannot do everything; nor – and we say this with deliberation – can it do the deepest things,” he wrote. “There are worlds into which we cannot be transported by any electric tramway or motor-car – worlds, too, which it concerns us, as spiritual beings, to inhabit.” Scientific knowledge was useful, he acknowledged, but it could be left to specialists. The spiritual life, on the other hand, concerned everyone.

31 Lees, “Educational Values,” 212.
5. The Morality of Science Education

Science educators responded to allegations of the spiritual and moral deficiencies of science in different ways. In some cases, they readily accepted the idea that there were fundamental differences between science and the humanities. Dupuis was just one such example. Science symbolized the hard-nosed pursuit of progress in a changing world, while languages and classical literature represented nostalgia for a bygone theological age. Others, like many of the educators discussed in Chapter 1, repeated the time-honoured belief that the study of nature inevitably inspired virtue. “No one who has ever felt the strength and beauty of nature [or contemplated] her majesty and sublimity, can avoid some elevation of his moral nature,” asserted one member of the Natural Science section.34

Still others, while granting that science and literature were fundamentally different pursuits, endorsed them as way to bring balance to the curriculum. J. B. Turner of Hamilton Collegiate Institute submitted to his OEA colleagues that biology and literature cultivated totally different attitudes in students. In order to appreciate a work of literature, students needed to exercise their powers of sympathy. They were required to submerge themselves in the thoughts and feelings of the author. Biology students, by contrast, needed to shut off their emotions. They were called to approach their work without bias, to doggedly follow the facts to wherever they might lead, and to reach the truth only by suppressing their feelings and personalities with an “attitude of rigid elimination.” The work of mastering these opposite attitudes could have potentially damaging effects on students’ characters:

The person who confines himself to [literary] studies will, in the course of time, come to be governed and controlled by his emotions. . . . On the other hand, the person who confines himself to the study of biology will become a man of a cold, calculating turn of mind, one who . . . by a repression of his emotions has very largely lost the power to feel – his sympathies have become atrophied.

The study of both humanities and the sciences was necessary, he concluded, to make “a well-rounded and evenly balanced mind, which after all is what is most worth having.”

It is important to note, however, that this emotional self-repression was not universally seen as a sign of moral deficiency. In fact, it was often held up as one of the singular moral virtues of the scientist. As David Hollinger has noted, the growing suspicion that some of science’s truths might be unpleasant was becoming hard to avoid, especially after Darwin. In defending the moral efficacy of science, “it was safer to shift one’s bets quietly from the moral prospects of particular truths to a perhaps less vulnerable source of inspiration: the pursuit of truth.” In other words, scientists and educators shifted the moral onus from the products and theories of science to the process of doing science. Scientists’ resolute pursuit of truth and readiness to face facts even when those facts were uncomfortable or unwelcome was praised as heroic in itself.

Even so, science educators would eventually come to see this emphasis on the depersonalized nature of scientific practice as problematic. In the wake of the First World War, for example, many British educationists sought to distance British science education from what they perceived to be Germany’s rigorous but amoral approach to teaching science. In fact, German science teaching had long been admired for its exacting nature and its commitment to theoretical science. As R. W. Hedley, a mathematics teacher at Strathroy Collegiate Institute, commented in 1906,

> The Anglo-Saxon race in general does not see the importance of gaining knowledge for the purpose of being efficient in the same. We rather pride ourselves for possessing such qualities as vigor, energy, practical capacity, straightforwardness, etc. In Germany there is a stronger love for abstract knowledge, a greater reverence for learning. ‘The love of the thing for its own sake,’ is their motto. This love of knowledge leads to a clearer sense of its value, and this to a greater capacity for skilfully

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applying knowledge and a willingness to submit to severer kinds of educational discipline.  

German teachers were seen as singularly well-trained and skilful, and the German educational system was frequently held up as a model for other nations to emulate.

The War significantly altered this perception. Germans were thought to have emphasized efficiency at the expense of morality in their quest for scientific and technological prowess. As Mayer has shown, this prompted considerable introspection on the part of British scientists and educators, who promoted a “humanized” science curriculum that was consistent with the core values of a liberal education. In particular, they looked to the history of science to fulfill this goal. By integrating history of science, they sought to infuse the science curriculum with moral lessons while dissolving the barrier between literary and scientific studies.  

This effort to moralize science, particularly by connecting it more explicitly with the history of science, became a key component of the general science movement, which is examined in detail in Chapter 5.

6. The Influence of Hegelianism: Science Learning as Intellectual Effort

In the early twentieth century, however, scientists and science educators more often than not turned the debate back towards the intellectual rewards of studying science. Their arguments make it clear how alive and well the theory of mental discipline remained, despite widespread efforts to discredit it as a theory of learning. Even as Richard Lees derided his classics colleagues for being closed-minded and ignorant of science, he corroborated the longstanding assumption that generalized intellectual training was the true measure of a subject’s value. “Mental discipline can be acquired by the systematic and earnest study of any subject, faithfully pursued with a living conviction of its importance,” he insisted. Indeed, the notion that learning science was a necessarily laborious process became central to the natural sciences’ disciplinary identity at the high school level.

As mentioned above, this view was indebted to Hegelian educational philosophy, which held that intellectual effort was a necessary component of any true learning. Historian of education George Tomkins has noted the influence of rational idealist philosophy in Ontario education. Queen’s University philosopher John Watson (the professor who had taken a stand against electives in the Queen’s high school debate) was one eminent representative of rational idealism. Some science educators used very Hegelian-sounding arguments to challenge the doctrine of empirical learning that marked the spread of high school laboratories in the nineteenth century. I. J. Birchard believed that the new emphasis on experiments in high school physics had entailed a drop in academic rigour. “Schools should not be made popular by omitting essential difficulties,” he insisted. Science in particular exhibited this dangerous trend: “Science is everywhere being popularized, which in most cases means that it is shorn of its strength by the omission of Mathematics,” he wrote. “. . . Physics especially, without Mathematics, may furnish amusement for the idle and the indolent, but as an instrument for serious education it is a sham and a fraud.”

Birchard was a graduate of the University of Toronto, having received his BA in 1880 at the age of 30, just as the generational shift among Canadian physicists described in Chapter 1 was underway. He obtained a PhD in mathematics in 1884 from nearby Syracuse University, and went on to author high school textbooks in algebra and trigonometry. Having taught mathematics and physics since 1880, he would have experienced John Seath’s overhaul to the science curriculum firsthand. Given his educational background and mathematical inclinations, his resistance to the new empirical teaching methods is perhaps unsurprising. In his view, the emphasis on experiment came at the expense of mathematics. “Mathematics and physics are the counterparts of each other,” he declared. “What, therefore, nature has joined together let not the Education Department put asunder.” There was little reason to believe that experimental learning was any better than book learning, he claimed.

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40 Tomkins, *Common Countenance*, 36; 102-104.
41 Birchard, “Conflict of Studies,” 58.
42 In his 1898 address “Methods in Physics,” Birchard notes that he has been teaching physics for 18 years. *Proceedings of the Ontario Educational Association* (1898): 191.
For Birchard, the real problem was that devaluing mathematical physics meant lowering the difficulty level of physics and diminishing its educational value. His objections are a typical expression of the Hegelian view of education:

The chief aim of our educational reformers during recent years has been to make everything easy. Difficult subjects have either been removed entirely or the requirements have been reduced and the examinations simplified. . . . The mental discipline which is obtained by attacking a difficulty, wrestling with it and conquering it, has been to a considerable extent lost. . . . The fallacy lies in the tacit assumption that intellectual power and strength of character can be obtained without serious effort on the part of the student and that an educational curriculum can be improved by simply omitting the difficulties.  

Describing an experiment with a marble and an inclined plane designed to illustrate the concept of acceleration to beginners, Birchard noted that students found it amusing but showed no improvement in their understanding of acceleration. “The exercise had just one merit, it was easy— and worthless.” Students were simply not able to make sophisticated connections between experiment and theory. When practical work was introduced into high schools (and theoretical work swept aside), students were supposedly “turned loose into a laboratory to extract the secrets of nature” like Kepler, Newton, or Faraday. Unfortunately, he wrote, it soon became apparent that “not all students are Newtons in embryo,” and the new methods had therefore not been as successful as expected. By eliminating lectures on theory, students were left with the improbable task of working out the theories themselves. Ultimately, they were left to dabble aimlessly with marbles and inclined planes.

In 1904, two years after Birchard delivered his paper on these “educational fallacies” before the mathematics and physics section of the OEA, a young teacher by the name of Norman Ross Carmichael delivered a paper that presented a nuanced defense of

experiments in science teaching. Carmichael had a very different pedigree than Birchard. His educational trajectory had all the markings of the new, research-driven generation of physics graduates. After studying physics at Queen’s, Carmichael had travelled to Johns Hopkins in 1893 to study electrical engineering on an 1851 Exhibition Scholarship, a travel award created in 1890 by the Royal Commission for the Exhibition of 1851 to allow British subjects to pursue research abroad in pure or applied science.\footnote{Yves Gingras, \textit{Physics and the Rise of Scientific Research in Canada} (Montreal: McGill-Queen’s University Press, 1991), 52. On the significance of the 1851 Exhibition Scholarships for the growth of scientific research in Canada, see pp. 40–45.} At the time of his OEA address, Carmichael was employed as an assistant to D. H. Marshall, the physics chair at Queen’s. His laboratory manual, a collection of experiments for a general physics course, would appear that same year.\footnote{N. R. Carmichael, \textit{Physical Experiments: A Manual of Laboratory Experiments to Accompany an Elementary Course in General Physics} (Kingston, ON: R. Uglow, 1904).}

In his paper, Carmichael dismissed several of the widely cited justifications for teaching science by experiment. Most notably, he rejected the idea that experiments allowed students to “rediscover” the laws of physics. He believed that it was an “indefensible sham” to pretend that students were discovering principles that were in fact being read into experiments by the teacher. Rather, experiments illustrated and consolidated physics concepts that students had already encountered in textbooks and lectures.\footnote{N. R. Carmichael, “The Use of Experiments in Teaching Physics,” \textit{Proceedings of the Ontario Educational Association} (1904): 198–206.}

To illustrate his point, Carmichael cited an experiment with a ballistic pendulum. The exercise was intended to allow students to verify conservation of momentum. In the experiment he described, two pendulums hung side by side swing along a path marked by a curved graduated scale. One pendulum is raised to various distances and allowed to strike the other. The respective displacements of the two pendulums are charted, velocities are calculated and compared. Did the pupil, taking stock of the table of data, duly conclude that “momentum is a property that is conserved”? According to Carmichael, the student was likely a draw a much less generalized conclusion, such as: “It makes a good deal of difference how the bodies strike.”
In Carmichael’s view, the lesson on momentum truly began not with the pendulum experiment, but with the definitions and illustrations provided by the teacher, who might draw on the student’s experience of, say, kicking a ball or hammering a nail. But connecting the unconsciously learned feel for kicking a ball with physics equations on the blackboard was hardly an evident step. This was precisely where the experiment came in, argued Carmichael.

The purpose of [the ballistic pendulum] experiment is… to make clearer and fuller the pupil’s conception of momentum, and of the principle of conservation which it obeys. In the familiarity which comes from measuring the property and using the results in calculation its strangeness disappears. What is at first merely a name or a symbol becomes a tangible reality, whose influence can be traced in the occurrences of daily life. The experiment is the link between the mathematical equation and the everyday experience which makes both intelligible.  

Although Carmichael and Birchard differed on the value of experiments in physics, Carmichael clearly shared the assumption that true learning required strenuous intellectual exertion. Accordingly, he took pains to define the exact nature of the mental effort demanded by physics experiments. The effort did not lie in “rediscovering” natural laws. If not generalizing to the law, then what? Carmichael argued that interpreting a scientific experiment, much like deciphering a Latin sentence or rendering a mathematics word problem in algebraic symbols, was fundamentally an exercise in translation.

The intellectual exercise [of doing experiments] is obtained by interpreting and explaining the problem or experiment in terms of physical laws, and thus arriving at a truer conception of those laws; just as similar mental exercise is obtained by the student of Latin in construing a new sentence in the light of the laws of syntax. . . . The scientific laws have been arrived at by studying thousands of experiments, just as the laws of Latin syntax have been arrived at by examination of the works of the authors who have written the best

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Latin. In each case, too, the beginner gets his mental training in the reverse process of interpreting the particular in the light of the general law.  

The analogies to Latin and mathematics were surely deliberate, given the ongoing climate of conflict between science and the classics. For Carmichael, Latin and science engaged in intellectual work that was essentially the same. The inherent difficulty of science was what placed it on par with the classical curriculum. Carmichael closed his paper with an elaborate metaphor steeped in the imagery of classical literature:

Grammatical laws or scientific laws are not apples growing by the roadside to be plucked by the chance wayfarer. They are the golden apples, Earth’s gift to the gods, growing on the slopes of some distant, unknown Atlas, guarded by watchful Hesperides and [an] unsleeping dragon. The Heracles who can win them is trained for the task by ten arduous labors, and even he must patiently search the whole earth and seek advice from Nerens and Prometheus, the wisest of teachers.

In Carmichael’s view, science needed to strive for the “high ideal of culture” that had been established by the classics. His reflections illustrate how notions of what it meant to learn science and to think like a scientist were articulated in the context of territory disputes between science and literary subjects, as well as critiques from an older, more mathematics-oriented generation of science teachers. Scientists and teachers responded by emphasizing the dispassionate and industrious nature of scientific work. Science, they contended, was at once morally complementary and intellectually equivalent to literature and the humanities as a key element of a general education. It carried distinctive moral virtues that brought balance to pupils’ character development and earned its certificate of culture, alongside the classics, by engaging pupils in a laborious mission of truth-seeking. Science, in this vision, became a search for golden apples on a distant hill, an unrelenting intellectual search for the elusive and remote laws of science. It was a venture for the heroic and the few.


Ibid., 206.
Word of impending revisions to the high school curriculum fuelled the already heated debate about which subjects deserved pride of place. “The rumour is afloat that a couple of officers of the Department are busy at a new course of study,” remarked William S. Ellis in an early 1903 issue of the *Educational Monthly*. Principal of Kingston Collegiate Institute, science teacher and an outspoken member of the Natural Science section of the OEA, Ellis emerged as a lively critic of the curriculum and the Department of Education. He was also an outspoken proponent of technical education. Whispers that a new curriculum was underway prompted him to dispatch a series of four articles to the *Educational Monthly*. In them, he lambasted the Department, the Minister of Education, and the current curriculum. For thirty years, he charged, Department officials had been doing “cobbler’s work” at an old and outdated course of studies, to little effect: “[The curriculum] is not being at all libelled now when it is characterized as unscientific, as educationally unsound [and] as ill-arranged.”

Ellis placed the blame squarely on the Department of Education. Mired in partisan politics, the Minister of Education Richard Harcourt could hardly be expected to offer true leadership and vision. Those who had looked to the Department for guidance, Ellis wrote, had had “to turn away weary and heart sick of the barrenness, the beaurocracy [sic], the officialism that has barred the way.”

A close reading of Ellis’s 1903 series shows the extent to which reformist educators in Ontario were keeping a close eye on developments in other countries – in England, Germany, and especially the United States. Ellis picked up many of the themes that were being popularized in American educational circles. Like John Dewey and Joseph Mayer Rice, he highlighted the problem of waste in the current system. The years of children’s lives squandered in useless studies at the province’s behest were tantamount to a crime against civilization, he alleged. The losses were not only in wasted school years but also in “the undeveloped ability, the unused possibilities for industrial and intellectual usefulness . . . [and] the industrial wreckage, of the dollar a day type, that litters every

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53 Ellis, “Proposed Revision,” 53.
manufacturing centre.” Ellis also drew on developmentalist doctrines, emphasizing that the curriculum needs to be better attuned to the stages of children’s mental development. He likewise drew on the discourse of the social meliorists. The schools’ central purpose, he argued, was to fit children for civic and social competency in their future roles as members of the wider community. The insidious notion that education was for the benefit of the individual and not for the state was a “doctrine of evil” in his eyes. One view of education that Ellis eschewed entirely, however, was the humanist tradition. Subjects on the curriculum needed be interesting for pupils, he insisted, not imposed on them out of stubborn devotion to mental discipline. In short, Ellis wielded a variety of different arguments drawn from different ideological camps against a common foe: the humanist, anti-utilitarian view of education that dominated Ontario’s school system. The various philosophies that, in the United States, had coalesced into the distinct interest groups identified by Kliebard emerged in Ontario as a comingled critique designed to provoke the Department of Education into action. The conflict between conservative and reformist educationists in Ontario was essentially a battle between two groups: those who adhered to the theory of mental discipline and those who dismissed it.

In spite of his aggressive tone, Ellis’s own progressivism was cautious. He was exasperated by the lack of transparency in the Department and argued that the task of curriculum reform should be delegated to a committee of educational experts. But even as he demanded a more open process, he cautioned against radicalism. The ideal committee, for Ellis, would be composed of men (it was clear that he did not envision women in the role) who were actively engaged in teaching and who kept abreast with educational developments around the world. It would not, however, be overloaded with “so-called progressive educationists, of the mountebank type.” Nor should it be made up of “semi-literary hacks who get their knowledge from the Ladies’ Home Journal.” It would be

55 Ibid., 114.
56 Ibid., 114.
57 Ellis, “Proposed Revision,” 55. Ellis’s insistence on selecting men, reinforced by his jibe at candidates who might read the Ladies’ Home Journal, falls in line with the considerable handwringing then exhibited among educators over the increasing feminization of the teaching profession. The reason often cited for this concern was that women were unsuited to instruct older boys in character building, which was understood to be a central goal of teaching. “If proper discipline is to be exercised, that force of character which a well trained male teacher should
completely independent from the Department of Education, and finally, it would include a few shrewd businessmen.

Ellis’s 1903 articles illustrate the narrow path between conservatism and change so often chosen by reform-minded Ontario educationists at this time. As mentioned, Ellis believed that Ontario educators needed to study educational movements abroad (he particularly admired the 1893 Committee of Ten, which he credited with causing a revolution in the work of high schools in the United States) and to choose a judicious course of action based on proven successes and failures. “We [Canadians] are not pioneers in curriculum-making,” he declared. “We cannot, without great loss, afford to try [other nations’] experiments again.” He lamented the lack of a true Canadian leader in education. “Such a man, as leader, as guide, as prophet, we must have. Two or three such I know, but they are not in Canada. Our system has never bred a monster of that kind; beaurocracy [sic] would have stifled him ere his weaning time,” he remarked bitterly.

One of the most pressing issues facing the revision committee, in Ellis’s view, was the need to make adequate provision for nature study and technical education. Like many of those advocating for broadened curricular offerings, he believed that a proper balance among different subjects was required to prevent “mental lopsidedness.” As he had done in his efforts to promote technical education, Ellis sought to dismantle the entrenched dichotomy between culture and utility, which split educationists into opposing factions: “The gathering cry of the one camp has been culture, of the other utility,” he wrote. This culture-utility divide distinguished subjects traditionally associated with intellectual and aesthetic pursuits from those seen as practical and material. Technical education and manual training undeniably fell in the latter category; many placed science there too, by association. In the framework of a traditional liberal education, the culture-

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59 Ellis, “Public,” 117.
60 Ellis, “Making of a Curriculum,” 299.
61 Ibid., 296.
62 Queen’s University English professor James Cappon, for instance, contrasted the two reigning educational ideals, the literary and the utilitarian. The former employed “conceptual” methods, while the latter, which included natures study and science, followed “concrete” methods. “If we
utility distinction also implied a clear hierarchy, one that challenged the contributions of “utilitarian” science to a general education. It was for this reason that John Seath and other proponents of high school science took pains to emphasize science’s disciplinary and moral value and to downplay its practical utility. As Seath tersely informed one of his critics, the language subjects had no monopoly on education for cultural purposes. But although Seath had secured the place of science on the curriculum, science’s ties to industry and commerce remained suspect in the eyes of many educationists. Birchard, for instance, remarked in 1894 that

Natural Science, long denied a place as a part of a liberal education, has at length compelled recognition. The question of its value as an instrument of mental discipline is still discussed with varying results. But there is money in it, and that settles the question. Call it a bread-and-butter subject if you will . . . so long as a discovery in chemistry or an ingenious application of electricity can transform the author into a millionaire, the hard names will be forgotten and students of Science will be on the increase.

To avoid being categorized as merely utilitarian, school science needed to do more than simply profess its moral and intellectual qualities. It also needed to dispel allegations of overspecialization, as Mayer and other historians of science education have noted. Premature specialization was certainly considered by many to be anathema to a general education, and veered dangerously on narrow vocationalism. This aversion to specialization in the science curriculum would become especially apparent in the postwar general science movement. At the turn of the twentieth century, however, science educators were not of one accord on the merits of specializing at the high school level, nor were the links between utilitarianism and specialization always evident. In 1904, University of Toronto chemistry lecturer F. J. Smale argued frankly for a more technical,

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63 Quoted in Stamp, *Schools of Ontario*, 81.
64 Birchard, “Conflict of Studies,” 53–54.
“utilitarian” approach to the teaching of chemistry in high schools. At the same time, he scoffed at the notion that “a general superficial knowledge of scientific principles and facts is a magic key to unlock mysteries” – but nevertheless stated that it was a mistake to “specialize” pre-university chemistry teaching.\footnote{F. J. Smale, “Applied Chemistry in Secondary Schools,” \textit{Proceedings of the Ontario Educational Association} (1904): 193–194.} Carmichael likewise criticized the ideal of the scientific generalist. Science teaching, he maintained, should be geared to creating “the scientific scholar, not the man who has a wide acquaintance with the facts of many sciences, but the man who by a patient study of one has entered into the spirit of all.”\footnote{Carmichael, “Use of Experiments,” 206.}

Ellis, as a stalwart defender of the “practical” in education, worked to dissolve what he saw as an artificial boundary between culture and utility. Culture, he proposed, was about understanding and addressing the problems of modern civilization, while utility was about performing one’s duties as a member of the community. Such duties included earning a livelihood, but they also encompassed all the wider responsibilities of citizenship. The latter, Ellis noted pointedly, meant doing one’s part to encourage civil and moral – but also industrial – progress. Culture and utility were surely not opposites, but rather “two points of emphasis in a unity,” he wrote.\footnote{Ellis, “Making of a Curriculum,” 296–297.} Accordingly, he sought to defuse the bitter conflict between proponents of different school subjects by portraying these subjects as co-participants in the overarching social mission of the schools. “The question is not whether Latin, or Moderns, or Science, shall form an essential part of [the high school] course;” wrote Ellis,

but it is, what shall be the quantity and what the quality of the entire school training and learning that children may best be fitted . . . for carrying out their parts in that great social system into which humanity in this western world has woven itself, and which we call civilization.\footnote{Ibid., 296.}

In August of 1904, the new program of studies became official. Inspector John Seath presided over its release. The most remarkable new feature of the curriculum was its formal provision for vocational options. Students (in larger cities, at least) could choose
from among seven programs: general, commercial, manual training, household science, agriculture, university matriculation, and the teacher’s course. The general course was the default program. The many caveats and provisos in the regulations testify to the difficulty of standardizing the curriculum across the province’s far-flung network of high schools.

The 1904 regulations significantly reconceived the place of science on the curriculum, and as a result, placed it under renewed scrutiny. The science program was designed as a continuous progression, beginning with nature study in the public schools, proceeding to elementary science in the lower school (the first two years of high school) and then to more specialized courses (chemistry, physics, botany, zoology, and mineralogy) in the middle school and upper school. Most important, the elementary science of the lower school became a mandatory component of both the general course and the junior teacher’s certificate course, which was typically the first step to becoming qualified as a public school teacher. Candidates for the junior teacher’s examination also had to take middle school chemistry and physics. Because so many students enrolled in the junior teacher’s matriculation program, lower and middle school science effectively became mandatory for the vast majority of high school students. (The junior teacher’s certificate was such a common program choice that, as one principal put it, “it [could be] frankly admitted that our high schools are simply schools for the non-professional training of public school teachers.”)

Because elementary science was part of the common core for most students, Seath took pains to explain its function on the curriculum. It had to carefully negotiate a dual role: it should provide a broad acquaintance with science to the many students who would leave high school after one or two years of study while also laying the foundation for those who would take further science courses in the middle and upper school. The regulations proposed an outline for a two-year course, where botany and zoology were studied in the fall and spring, while chemistry and physics were taken up from November to April. But it was meant to be relatively flexible, and teachers were encouraged to adapt it in accordance with their pupils’ abilities and the major industries in the area. The order of

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71 Report of the Minister, 1904, 149-152.
the topics in the program was just a suggestion, Seath reminded teachers. Pupils were emphatically not to use a textbook. The course was intended to be observational and experimental, and Seath emphasized that teachers should never dictate notes to students. While it was mandatory for students in the general course and those seeking to become teachers, Seath pointed out that “Many principals . . . advise all the Entrance Class to take the subject for one year at least, as a useful means of culture, and until their future course has been settled.”

As mentioned, the requirements for the teacher’s certificate raised a storm of controversy. Students seeking to become teachers had previously been able to choose from among a variety of course options; now, the teacher’s program was set. Accordingly, even as the program allowed new vocational options, it effectively narrowed the options available to the many students doing the junior teacher’s certificate. As a concession to the classicists’ vehement opposition to the draft program, the Department allowed students to study Latin as an optional supplement. The foreign language requirement was removed outright. “In abolishing options [the Education Department] has simply abolished the study of foreign languages,” wrote one principal disapprovingly. Queen’s professor James Cappon, meanwhile, castigated Seath for ignoring the voice of the OEA, where teachers had voted in 1904 to retain Latin as a compulsory subject. “Mr. Seath’s courage is certainly of an adamantine quality,” he observed sardonically. “He must know that his contemptuous disregard of the vote of the last meeting of the Teachers Association has increased considerably his responsibility for the future of education in Ontario.”

Seeking to allay the censure of language and classics teachers, Pyne and Seath continued to affirm the program’s central commitment to “culture.” In discussing the new Elementary Science course, Seath stressed that “Culture is the great object of both the High and the Public School course.” Critics had failed to understand the course’s intended character, he said. For Seath, the “cultural” nature of the science course dictated

that the methods of science should take precedence over the subject matter. This placed a premium on the teacher’s pedagogical approach, just as it had when laboratory science was being introduced across the province. “Both method and matter are important; but the method is always the more important,” wrote Seath. In high school science, the balance shifted somewhat: the matter (content) gained importance and the course became less adaptable, because “the necessities of the future citizen and of the public school teacher must now be borne in mind.” In evaluating students, teachers should test not only their retention of facts but also their power to reason, he noted further.

In the end, Ellis was very pleased with the new regulations. In his final Educational Monthly piece, he dropped his polemical tone entirely to praise the new program of studies, which had been pre-circulated among the province’s teachers. (In the meantime, he had been appointed as the science representative on a standing committee organized within the OEA to join the Minister’s Educational Council, which no doubt gave him a voice in the Department’s consultation process.) Ellis commended the progressive impulse he saw in the new program – most notably, its recognition that that the school played an essential role in the life of the community. In his view the new regulations were mindful of child development and learners’ interest and they represented a clear move toward increased emancipation from university control.

The accent on method coincided with a new era of prescriptive pedagogy and concerted efforts to train teachers in “rational” teaching methods, as a result of the fledgling science of education. Indeed, while Ellis was full of praise for the values enshrined in the new course of studies, he worried that teachers were desperately ill equipped to put the new ideals into practice. Teacher training, he argued, was stultifying and deficient; moreover, once teachers had done their brief stint in a normal or model school, they were apt to see their training as complete, rather than as a process of ongoing self-improvement. A backlash against the new regulations was “exceedingly imminent,” Ellis believed. It was necessary to launch a “vigorous campaign of instruction” to help teachers and inspectors

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76 Ibid., 14.
77 Ibid., 17.
carry out the new program – or possibly even to delay the most “radical” parts of the new regulations until teachers were better prepared. “Active hostility is not so much to be dreaded, in this case, as the dead weight of a listless, passive resistance to progress,” he warned.  

The Department evidently shared his concern. In his memo to high school principals and teachers following the release of the new program, Seath gave teachers detailed instructions on how to approach the elementary science course in particular, emphasizing the need for extensive knowledge and judicious restraint in their classroom guidance. He also provided a long list of reference books in science, many of them American. In subsequent years, the University of Toronto offered summer courses for teachers on a variety of subjects, taught by professors and university lecturers. Within a few years, a subcommittee of the OEA’s Natural Science section set to work on a textbook on the teaching of elementary science, the Manual of Suggestions to Teachers of Science, which was published in 1910 – the first volume of the Ontario Teachers Manuals series. The Manual of Suggestions acknowledged that many teachers had felt at a loss in dealing effectively with the comprehensive elementary science course, and offered advice on everything from acquiring botanical supplies to classroom management, as well as detailed lesson plans on topics like “the grasshopper” and a general schedule for the course’s two year duration.

In the context of the severe teacher shortages, exacerbated by low salaries, that plagued the province at this time, the gap between the ideal of teacher autonomy and creativity in the science classroom and teachers’ inadequate preparation quickly became evident. It mitigated the extent to which high schools could really move out from under the thumb of the universities. Seath had declared that the new program would relieve some of the “pressure of the Departmental and the University examinations, with its train of evils.” In fact, the University’s influence over the high schools remained tangible, both in the University of Toronto’s summer courses for teachers and in its authority over the curriculum itself, where professors (rather than high school teachers) were often assumed

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80 Seath, Suggestions, 6.
to be the best experts on the contents of the curriculum. Yet this balance of power was beginning to change. The controversy over the place of the atomic theory on the middle school chemistry course, which escalated upon the release of the new regulations, prompted an outright challenge to the authority of university scientists over the curriculum and exposed the competing visions for the high school science program that coexisted in early twentieth-century Ontario.

8. Conclusion

Fifteen years after Seath’s big push to implement practical and experiment-based science teaching in Ontario’s high schools, the expansion of the science curriculum was still a matter of contention. Debates over the curricular status of science in Ontario’s high schools played an important role in articulating the social role of science in the grooming of young citizens. Appealing to self-reinforcing rationales that rested on the growing cultural prestige of science, science educators argued that high school leavers needed an acquaintance with the central theories and processes of natural science in order to be in tune with progress and modernity, while simultaneously further raising the social stature of science by establishing it as one of the pillars of a general education.

In the United States, as presented at the outset of the chapter, a variety of educationist interest groups competed among each other to promote their respective visions of curriculum-making and their diagnoses of the problems facing American schools. In Ontario, the debate was more polarized. In particular, curricular disputes pitted scientists and science teachers against classicists and teachers of languages and literature, who defended the centrality of a common humanistic high school curriculum. David Hollinger has noted that in Great Britain, unlike the United States, “the effort to define science morally took place in a setting of much sharper rivalries between a new, scientific elite and the older, established elites of religion and education.” In Ontario, similar schisms were in evidence. The curricular expansion of science took place against vociferous objections from defenders of the classics. It triggered disputes, at times acrimonious, between the natural science and classics sections of the Ontario Education Association.

81 Hollinger, “Inquiry and Uplift,” 152.
When Arthur Smith, president of the Natural Science section in 1919, looked back over the history of the science curriculum, he described it as an extended battle in which science had emerged victorious, a “long struggle between the scientists and the humanists which [had] terminated in the present prominent position of science in the curricula of all countries.” 82 Although reformist educationists like Ellis and Cornish drew heavily on ideas emerging from American educational circles, they did not fit clearly into any one of the camps identified by Herbert Kliebard. Rather, they wielded developmentalist arguments in tandem with calls for less “waste” in education (like the efficiency movement) as well as a broadly social vision of the high school curriculum (like the social meliorists). The common foe was the universities and their tight grip on the high school curriculum – and their attendant overemphasis on the intellectual, disciplinary functions of schooling.

As outlined in Chapter 1, the crowded curriculum was an ongoing concern among principals, teachers and parents. Because the program was overburdened, efforts to expand offerings in science came at the expense of other subjects’ time allotments. Not surprisingly, this fuelled controversy. The 1904 regulations instated options as a solution to the longstanding problem of the crowded curriculum. Significantly, science was mandatory in the general program. The move made it all the more apparent that adding science courses meant paring down the shares of Latin and the classics. This controversial trade-off meant that proponents of science remained on the defensive and were compelled to justify their expanded role in the high schools. In the context of these timetable disputes, justifications for science were two-pronged: first, science provided moral lessons that were distinctive, an essential counterpart to the sort of moral lessons instilled by the classics, and second, it imparted intellectual benefits that were equivalent to those of the classics.

Given the polarized nature of curriculum debates in early twentieth-century Ontario, the social role of school science was by and large defined in opposition to the functions traditionally assigned to the classics. Proponents of science education frequently focused

their arguments on the importance of balance: science prevented “mental lopsidedness” and counteracted the emotional excess of an overly literary curriculum. For others, like Nathan Fellowes Dupuis, the forward-looking, progressive outlook of science modernized a curriculum weighed down by the chronic nostalgia and traditionalism of the humanities disciplines. Of course, for defenders of the classical curriculum like University of Toronto professor John McFayden, modernity was the very thing to be feared. As historian Anna Katherina Mayer has noted, the conviction of a deep-seated “antithesis between progress and morality” was so pervasive in Anglo-Saxon society that science’s acknowledged usefulness and efficiency in modern life were precisely what made it pedagogically suspect in an educational tradition that championed the cultivation of culture and virtue.⁸³

Those seeking to carve out a distinctive moral role for science implicitly accepted the notion that there were fundamental differences between science and the humanities. The discipline and restraint said to characterize scientific work were set apart from the spiritual sensibilities aroused by languages and literature. Others, in contrast, argued that science had a rightful place on the curriculum because of the inherent similarities between science and the classics. This line of argument focused on the intellectual rather than the moral attributes of school science. Thus, Norman Ross Carmichael claimed that science and the classics engaged in the same kind of intellectual work: they were both, at root, exercises in translation. Others, like teacher Richard Lees, repeated common claims that mental discipline resulted from honest effort in any subject, while Superintendent John Seath continued to refute the notion that the classics were the exclusive route to culture. This continued focus on the intellectual benefits of science education helps explain the lasting attraction of arguments founded on mental discipline, even though recent psychological research was challenging faculty psychology.

In the midst of the ferment of educational philosophies, the pedagogical role of experiments came under renewed scrutiny. In the 1880s, Seath had consistently emphasized the “practicality” of hands-on, experimental work in science. Laboratory exercises and fieldwork were proposed as a revitalizing antidote to the scourge of rote

learning. The experimental method also inducted students into the scientist’s way of reasoning, and honed critical thinking skills that were useful in many aspects of life. It was the methods, not the content, of science that really mattered pedagogically. Seath’s commentary on the 1904 curriculum shows that he continued to regard the unique methods of science as the crux of its “cultural” value.

In the United States, the first decade of the twentieth century saw the beginnings of a reaction action against the laboratory method that had defined the late nineteenth-century growth of the science curriculum. Experimental work had itself succumbed to the pitfalls of rote learning, charged the leaders of the New Movement in Physics Teaching. The laboratory exercises that prevailed in schools promoted a mechanical, unreflective adherence to the inductive method – an overly academic approach to science teaching that had little connection to students’ everyday experience. In Ontario, discussion about experiments focused on their intellectual merits. I. J. Birchard’s complaints showed that laboratory science still faced criticism for being anti-intellectual and sacrificing rigour for popular appeal. Carmichael, meanwhile, argued that it was the esoteric nature of science, its very abstruseness, that made science pedagogically valuable and assured it a place alongside the classics. He warned, contra Seath, that experiments should not be misrepresented as exercises in generalization or “working up to the law.” Experiments were simply pedagogical illustrations. They provided the conceptual link between the law and the phenomenon.

The model of science education promoted by John Seath in the nineteenth century was undergoing subtle shifts. Seath had assumed that laboratory science let students immerse themselves in the practices and mental habits of scientists. Teachers like A. P. Knight had even encouraged students to do original research. This collective, participatory vision of science of the late nineteenth century, wherein dabblers, hobbyists and even students were invited to make their own contributions, was giving way to a more specialized, expert-driven conception of science. Discussions about science pedagogy are suggestive of this shift. The notion that a dedicated novice could in some small way be an active

participant in the scientific enterprise was mitigated by the increasingly common view that high school students were not really equipped to generalize to the law. In Carmichael’s estimation, it was false to claim that students gleaned laws by interpreting experiments. Birchard expressed similar scepticism about students’ abilities, noting that most high school students were hardly “Newtons in embryo.” Rather, generalizing to the law was the preserve of specialists.

As late as 1908, another controversy erupted at the OEA when Maurice Hutton, classics professor and principal of Toronto’s University College, moved that science be eliminated as a matriculation option. At the time, matriculating students were required to take three of four options, namely, Greek, French, German, and science. Hutton ultimately wanted to get rid of science and require students to study all three languages. The Natural Science section strenuously objected. Such a move would obviate any incentive to take the honours matriculation course in science, they protested. It would force bright students into other fields, and it would suggest to the general public that the province’s university did not consider science important enough for higher study. They swung into action, listing off the various people and committees they planned to lobby. At the following meeting, in 1909, Hutton and W. S. Ellis faced off about the proposal, and the members voted to keep the matriculation options as they were, while raising the standard of the science course.85

Although the proposal was quickly squelched and was far from being put into practise (curriculum changes remained at the discretion of the Department, not the OEA), the episode shows that opposition to science’s expanded place on the curriculum was protracted and persistent. It also shows that the Natural Science section was highly aware of the stakes of these curricular disputes in the public’s esteem for science. The First World War would play an important role in bringing science into the public eye. The president of the Natural Science section declared in 1918 that the waste caused by war

85 “Minutes of the College and High School Section,” and “Minutes of the Natural Science Section,” Proceedings of the Ontario Educational Association (1908): 19; 23–24; “Minutes of the College and High School Section,” Proceedings of the Ontario Educational Association (1909): 13–14. Hutton initially proposed that students should choose two of the three languages; in 1909, his preferred plan was to make all three languages mandatory.
would lead to “great competition” in society, and that it would be the “more scientific”
members of society who would succeed in this competition. The school, in turn, would
become a real preparation for life. His comments reveal a new confidence resulting
from the recognized role of science and technology in the long campaign against
Germany. Indeed, after the War, opposition to school science significantly subsided,
replaced by a more pressing concern for infusing science education with ethical values
and humanistic culture. School science, just as I. J. Birchard had declared, had come to
stay. The question was no longer how to rival the humanities, but how to “humanize” the
teaching of science.

86 “Minutes of the Natural Science Section,” Proceedings of the Ontario Educational Association
(1918): 45.
Chapter 4

Convenient Fictions: The Dispute over Atoms and Molecules in Ontario’s High School Chemistry Course, 1904-1909

1. Introduction

In the years immediately following the release of the 1904 regulations, a debate sprang up within the Natural Science section of the OEA about the merits of teaching the atomic theory in the high school chemistry physics course. It was a debate that pitted professors from the University of Toronto’s chemistry department against a high school science teacher by the name of George Cornish. At the April 1907 OEA meeting of the OEA, Cornish addressed his colleagues in the Natural Science section with a talk entitled “Should the atomic and molecular theories be abolished from the high schools?” In it, he accused a conclave of Toronto chemistry professors of engaging in a zealous crusade against the teaching of the atomic theory in Ontario’s high schools. In particular, he singled out Prof. William Lash Miller, who had recently circulated a pamphlet denouncing the atomic theory among the province’s high school teachers. Cornish’s harshest criticism was reserved for a new chemistry textbook, published in 1906 and edited by Lash Miller and two of his Toronto colleagues, Frank B. Kenrick and Francis Barclay Allan, both lecturers in the chemistry department. The new textbook, aimed at high schools, avoided all mention of atoms and molecules save a critical two-page appendix on the “atomic hypothesis.” Cornish accused the new textbook of “outlandish terminology” and “narrow-minded quibbling” and alleged that teaching chemistry without reference to the atomic theory gave students a narrow and distorted view of chemistry that would take years to rectify.1 Professor Lash Miller himself was in the audience, and the Association minutes note mildly that the address was followed by “very interesting discussions.”2

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The atomic theory debate in the first decade of the twentieth century highlights several key points about the teaching of high school science. First, it shows that a contest was underway for authority over the science curriculum. Despite Seath’s assertions that the course of studies had been moved out from under the thumb of the university entrance exam and its “train of evils,” the province’s university professors clearly retained vested interests in the high school program that they were not eager to relinquish.

Second, in examining such pedagogical disputes, it is clear that the “methods” and the “matter” of instruction were necessarily intertwined. In the atomic theory debate, arguments challenging the value of the atomic theory – both as a scientific theory and as a component of the curriculum – were founded on claims about the kinds of mental habits and lazy assumptions it promoted. In his arguments condemning the atomic theory, Lash Miller moved his case smoothly from the inadequate scientific evidence for the theory to its pedagogical shortcomings. The debate effectively thrust the Department of Education into the role of arbitrating what was not only a pedagogical but also a scientific controversy.

Third, Lash Miller’s efforts to introduce a new approach to teaching chemistry are an example of the sometimes heavy-handed systems of prescriptive pedagogy that flourished at this time. While the 1904 regulations paid lip service to the teacher’s creative freedom and the adaptability of the curriculum, Seath and Ellis worried openly that teachers lacked sufficient pedagogical competency and subject knowledge to interact creatively with the program. With the release of the new regulations, Lash Miller saw an opportunity to bring his distinctive vision of chemistry teaching to the province at large. Along with Kenrick and Allan, he launched an intensive campaign, creating and distributing a pedagogical handbook, assembling a new textbook, and delivering their message to the science teachers of the OEA.

Finally, the atomic theory debate brought to the fore competing visions of the role of the high school: on the one hand, an overriding commitment to university preparation, and on the other, a sense of duty to prepare students who were not university bound for their roles as scientifically informed citizens.
2. William Lash Miller’s Anti-Atomism

Lash Miller’s opposition to the atomic theory earned him some rather harsh judgments in the historical record. “Much has been made,” noted one obituary writer, “of Miller’s antipathy toward those who, prior to the substantiation of a great deal of our present-day knowledge of matter in its most distinguished forms, were content to use a language and a nomenclature that lacked experimental proof, but which gave a kind of scientific standing to fairy story thinking.” A historian of the University of Toronto chemistry department has said that Lash Miller’s scepticism about the atomic theory and his isolation from the mainstream distorted chemistry education at Toronto – and in high schools throughout the province – for half a century. But Lash Miller was hardly a disenfranchised detractor cut off from the wider chemistry community. A fourth-generation Canadian of Ulster descent, Lash Miller earned his undergraduate degree in science at the University of Toronto, graduating in 1887 at the top of his class. He then spent three years in Germany conducting research in Berlin, Gottingen, and finally Munich, where he earned a PhD under Adolf von Baeyer. In 1890, he returned to the University of Toronto and was hired as a demonstrator. He continued to spend his summers in Germany, working in Leipzig under the renowned German physical chemist Wilhelm Ostwald. He earned his second PhD under Ostwald in 1892. At the University of Toronto, he gradually rose from lecturer in 1894 to assistant professor in 1900, and was de facto head of the department from 1914 until his retirement in 1937.

Lash Miller remained well-connected throughout his career. He headed the review staff of the Journal of Physical Chemistry, which was founded by his friend Wilder Bancroft, a fellow student of Ostwald. Among other credentials, at different points in his career he was associate editor of the Journal of the American Chemical Society, president of the American Electrochemical Society in 1912, vice president of the both the British and

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4 Adrian G. Brook and W. A. E. Peter McBryde, Historical Distillates: Chemistry at the University of Toronto Since 1843 (Toronto: Dundurn Group, 2007), 85.
5 Frank Kenrick followed a similar path, graduating from University of Toronto with both a BA and an MA (in 1894) and then doing a PhD under Ostwald at Leipzig. Following Lash Miller, he moved his way up through the departmental ranks from demonstrator to professor, becoming department head upon Lash Miller’s retirement in 1937.
American Associations, and became president of the Royal Society of Canada in 1935, having been an elected member since 1900. In April 1923, Yale University named him one of the world’s seven greatest chemists and asked him to speak at the opening of its new Sterling Chemical Laboratory.\(^6\)

In 1905, Lash Miller was part of a small but steadfast group of detractors of physical atomism. Although Cornish contended that the atomic theory was the lynchpin of modern chemistry and accused Lash Miller of “narrow-minded quibbling,” the physical reality of physical atoms was in fact still very much open to debate. Evidential support for the atomic theory had mounted over the course of the nineteenth century – but as Alan Chalmers has argued, the case for atomism remained one of inference to the best explanation. Decisive evidence for the atomic theory would come only with Jean Perrin’s 1908 experiments on Brownian motion. As of the 1911 Solvay Conference, Perrin’s experiments were widely acknowledged as a persuasive confirmation of the particulate theory of matter.\(^7\)

Prior to Perrin’s experiments, a variety of phenomena could be fairly tidily explained by atomism, including stereochemistry, studies of the effects of solutes on solutions, electromagnetic radiation, and Thomson’s cathode ray tube experiments. Nevertheless, as Chalmers points out, there were plausible reasons to remain sceptical about atomism. Kinetic theory, for example, treated the behaviour of gases as motions of particles but encountered difficulties when it came to explaining specific heats and time reversibility. Moreover, in the 1870s, the work of J. Willard Gibbs helped to establish thermodynamics as a rival theory to atomism. Thermodynamics could help explain some things that had been problematic for atomic theory, such as chemical affinity and thermal dissociation. Nevertheless, thermodynamics and atomism were not mutually exclusive: in fact, atomists welcomed and assimilated thermodynamic explanations by interpreting them in terms of the actions of atoms. But the fact remained that one did not need to postulate the existence of atoms at all to make these exciting new thermodynamic predictions.

\(^6\) Ibid., 90.

Accordingly, even if it was increasingly difficult to dismiss the atomic theory out of hand, one could reasonably confine one’s position on atomism to a limited, operational acceptance. One could allow that atomic formulas and stereo-chemical models were useful tools without necessarily assuming that they referred to actual, physical arrangements of atoms. Ostwald, who was one of the most prominent sceptics of the atomic theory, took this approach. Lash Miller was introduced to the field of thermodynamics during his time in Leipzig with Ostwald, and his views on the atomic theory were no doubt shaped during his time there. As a major proponent of physical chemistry in North America, Lash Miller had company in high places in his reluctance to rely on atomistic explanations – mostly notably Ostwald, but also French chemist Marcellin Berthelot and the American chemist and educator Alexander Smith.

3. Advocacy in the Ontario Educational Association

The Toronto chemists’ first major showing at the OEA came at the 1905 meeting, when Lash Miller, Kenrick and Allan addressed the Natural Science section about the newly revised regulations in chemistry. Lash Miller spoke on the dangers of introducing the atomic theory too early and demonstrated some experiments using a simple balance. Kenrick described some of the common errors made by students arriving at university fresh from the high schools. One especially bad habit, he said, was their tendency to record observations that had not really been observed, such as noting that there was no residue from evaporation of distilled water when it fact it usually gives a slight residue. Finally, Allan showed how to teach chemical arithmetic without making reference to the atomic theory. The speakers were evidently very well-received: the minutes note that their talks evoked a “very hearty and profitable discussion” and that attendees felt that it had been “one of the best sessions that the Association has ever held.”

Lash Miller also distributed copies of a small teacher’s manual he had prepared, entitled *The New Requirements in Chemistry* (1905). The booklet was created in response to the

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revised high school regulations of 1904. Lash Miller and his colleagues had succeeded in convincing the Minister of Education to omit the atomic theory from the chemistry course of the first two years of high school. The booklet sought to provide high school chemistry teachers with some experiments to use in their lessons, as well as to clear up some “loose ways of speaking and thinking that ought to be avoided.” In short, this meant eradicating all reference to the atomic theory and strictly adhering to “laboratory terms” only.

To facilitate this, Lash Miller introduced a new nomenclature, one that was firmly grounded in physical chemistry. *Substances* were renamed *chemical individuals*; *solutions* were called *physical compounds*; *atomic weights* and *combining weights* became *reacting weights* and *formula weights*, respectively. The chapter on chemical compounds, in particular, was the springboard for Lash Miller’s attack on the atomic theory. For Lash Miller, explanations that invoked the atomic theory smacked of hand waving: they were speculative and naïve, not unlike seventeenth-century mechanistic accounts of acids and alkalis in terms of pointy and porous particles. Moreover, they begged the question. To describe a reaction of hydrogen and chlorine as the atoms of hydrogen’s attraction to the chlorine atom, he wrote, was like a doctor explaining that chloroform acts as an anaesthetic because of its “soporific qualities.”

From the days of Galileo, scientists had advanced their work through a strict adherence to empirical observations – not by “inventing ‘explanations’ . . . [but] by observing facts, describing them accurately and simply in mathematical language, and collecting the results of their work in the form of a few unexplained generalizations, or ‘laws.’” Lash Miller further alleged that the atomic theory could not even claim to be a fruitful theory in opening up new fields of research (unlike the analogous theory of the luminiferous ether, he noted!) and that in some areas of chemistry it had been more of a hindrance than a help. “It is not surprising,” he concluded, “that much of the early enthusiasm for [the atomic theory] has cooled, and the present tendency is to keep the facts of the science sharply distinguished

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11 Ibid., 25.
from the hypothetical explanation, with great resultant gain in clearness of thought and expression.”¹²

4. The Politics of Textbooks in Ontario

Having introduced their pedagogical handbook, the professors’ next move was to develop a new textbook for high school teachers’ use. *Chemistry for Schools* was published in 1906, with its official author listed as school inspector G. K. Mills, and Miller, Kenrick and Allan listed as editors. The new textbook relegated the atomic “hypothesis” to a two-page appendix at the back. Much as in the *New Requirements*, the atomic theory is described as overly imaginative speculation, a “mental picture” unduly presumed to be a reality. In closing, the writer states,

> At the present day . . . there is a tendency among chemists to abandon these cumbrous hypotheses: not only on account of the greater simplicity of the facts themselves, but also because it is now recognized that such hypotheses, although of great service in the past, have often led to unclear expression of the facts and one-sided development of the science.”¹³

These were politically charged times when it came to Ontario’s school textbooks: in fact, textbooks had emerged as an important issue in the 1905 provincial election campaign. The Conservative candidate, James Whitney, had accused the incumbent Liberal government of being involved in a textbook ring and promised to lower the costs of textbooks if his party were elected.¹⁴ Over the previous twenty years, several successive Ministers of Education had been mired in accusations of collusion with publishing houses and cronyism with commissioned authors. In the end, Whitney succeeded in ousting the Liberals, and his newly appointed Minister of Education, Robert Allan Pyne, immediately set out to address the textbook issue. Pyne issued assurances that his Department would not be pressured by publishers or authors and promptly appointed an investigative

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¹² Ibid., 25.
commission. The Textbook Commission took two years to perform an extensive study of the Province’s practices; in the meantime, all changes to the authorized list were put on hold. In 1907, the commissioners finally issued their lengthy report,\(^\text{15}\) and over the next few years, Pyne embarked on a general revision of the province’s lists of authorized textbooks.

One thing that was not revised was Ontario’s longstanding policy of approving only one textbook per subject. (Indeed, this generally popular policy remained in place until the mid-1930s.) The one-textbook rule meant that the single approved book carried tremendous influence: as Minister Ross had put it, the authorized textbook effectively contained the whole course.\(^\text{16}\) The one-textbook policy was seen as a testament to the duly cautious nature of Ontario’s education system. According to Samuel B. McCready, a botany professor at the Ontario Agricultural College, Ontario’s textbook policy had provided stability and moderation to the province’s science curriculum in particular:

> Science, of all school studies, has been perhaps in most rapid pedagogic development; in Britain and the United States this has found expression in outpourings of new texts. We have shut ourselves off largely from this by our exclusive texts. May be, of course, it is a blessing in disguise. We may have escaped turmoil and confusion and be ready now for a calm conservative adoption of the best product and practice.\(^\text{17}\)

Naturally, the key position of the authorized textbooks – as both exemplars of officially sanctioned pedagogy and safeguards against educational fads – made the Department’s selections especially subject to scrutiny and controversy.

The appearance of Lash Miller’s new chemistry textbook in 1906, then, came at a juncture when the stakes were known to be high. The new regulations had just come out, the old textbook by A. P. Knight was roundly criticized, Pyne’s textbook commission was underway, and a general revision of the list of approved textbooks was imminent.

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5. George Cornish’s Counterattack

At the April 1907 meeting of the Ontario Educational Association, Lindsay Collegiate Institute science master George Cornish faced off against Lash Miller and his colleagues. He conceded that the quality of chemistry teaching in the province was indeed problematic, but argued that blame should not be placed on the atomic theory, but rather on other systematic problems. The issue was not the atomic theory itself; it was the “unpedagogical” ways in which the theory was taught. Pointing the finger at the currently authorized textbook (which was A. P. Knight’s *High School Chemistry*), Cornish accused it of overemphasizing the atomic theory – and, what was more harmful, presenting the theory before any experiments had been performed. In his view, this was an offence against proper teaching, and he cited in his support the Report on the Requirements for College Entrance issued by the National Educational Association in 1899. The NEA report (which was to his mind “one of the most important educational documents ever issued”) had emphasized that theories should not be stated as dogmas but rather presented inductively, “held in reserve until some accumulated facts demand explanation and correlation.” Accordingly, Cornish argued, the atomic theory could be restored to its proper purpose by introducing it after Charles’ Law, Boyle’s Law, and the laws of definite, multiple and reciprocal proportions. When introduced after all these lessons, the theory would become a “concrete mechanism that unifies all these laws.” Cornish was prepared to admit that the atomic theory had been “grossly abused” in Ontario, but to get rid of it, he said, was like “curing the tooth-ache by cutting off the head.”

Next, Cornish countered Lash Miller’s claim that scientific hypotheses were pedagogically harmful. In should be noted that Lash Miller’s strong aversion to hypotheses, particularly in teaching, was not unusual. As discussed in Chapter 1, the rise of laboratory teaching in high schools was characterized by a hard-line commitment to the inductive method. Both doing and learning science, in the scientific credo of the late nineteenth and early twentieth century, demanded above all a strict devotion to facts – and only a cautious, gradual expansion to theories. The core principles of direct contact and disciplined empiricism that characterized science education in this period meant that

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many educators repudiated anything that veered on theoretical conjecture. At the high school level in particular, many felt that theorizing was decidedly out of place.\textsuperscript{19}

In his 1907 address, Cornish, by contrast, argued that hypotheses were indeed useful in pedagogy, perhaps especially for beginners. The human mind had a natural tendency to try to correlate facts, he noted. To reinforce his defense of theories, he quoted British physicist Arthur W. Rücker’s address to the British Association in 1901:

> Even if [theories are] convenient fictions they are not useless. From the practical point of view it is a matter of secondary importance whether our theories and assumptions are correct, if only they guide us to results which are in accord with the facts. The whole fabric of scientific theory may be regarded as a gigantic ‘aid to memory,’ as a means of producing apparent order out of disorder. . . . The simplification introduced by a scheme which, however imperfect it may be, enables us to argue from a few first principles, makes theories of practical use. By means of them we can foresee the results of combinations of causes which would otherwise elude us.\textsuperscript{20}

Theory was essential in all branches of science, Cornish continued, whether it be the theory of evolution in biology, ether theory in physics, or Laplace’s nebular theory in astronomy. Moreover, the theory of atoms and molecules had been just as fertile as those of other fields.

Clearly, the debate over the teaching of the atomic theory touched on fundamental conceptions about how good science operated. Cornish was, in a sense, standing in opposition to a widespread wariness of theoretical speculation that regarded hypothesizing as out-of-bounds for young learners. As Rücker’s remarks show, however, the value of hypotheses was also under debate within the scientific community, as prominent scientists sought to dislodge what they perceived as an overly rigid dogma of empiricism.


\textsuperscript{20} Cornish, “Atomic and Molecular Theories,” 202–203.
Cornish’s defense of hypotheses can be seen as a sign of a slow change of the tides. His emphasis on the important role that theories played in unifying facts and tying together different parts of the course was no doubt indebted to the Herbartians’ guiding principle of the correlation of the curriculum. It also drew on the burgeoning opposition to the rigidity and formalism that had crept into high school laboratory teaching. The New Movement in Physics Teaching was just beginning to gather momentum and disseminating its ideas in *School Science and Mathematics*, a publication familiar to members of the Natural Science section. Cornish was certainly not calling into question the value of the inductive method (as his first argument makes clear), but his arguments for the importance of correlation suggest that he supported a more thematic, interconnected approach to science teaching. It is no coincidence that Cornish would later present the first major entreaty for a general science course in Ontario.

Cornish’s third main counterargument appealed to the fundamental purpose of a high school education. Eradicating the atomic theory from the program of studies undermined the true mandate of the high school: the provision of a general education. The high schools were not primarily intended to prepare students for college, he reminded his audience. Rather, high schools should equip citizens with sufficient scientific knowledge to meet the demands of everyday life. Students should leave with a working knowledge of the subject, a general grasp of its main principles, and the ability to read and understand a magazine article or an ordinary book in chemistry. The new textbook proposed by Lash Miller and his colleagues would severely compromise that purpose, Cornish alleged, because its editors had eschewed “all the terms which have formed the vocabulary of chemistry for the last fifty years” and elected instead to introduce their own unique terminology. High school graduates groomed in this idiosyncratic language would find themselves entirely at sea in attempting to decipher any popular literature touching on chemistry.

Finally, Cornish cast Lash Miller and his colleagues as an isolated faction, dissociated from the views of leading chemists and educationists around the world. The atomic theory should not be abolished until a majority of chemists support it, he declared. As mentioned, Lash Miller had claimed in the *New Regulations* that enthusiasm for the
atomic theory had cooled. In response, Cornish challenged this claim by surveying an array existing textbooks and respected chemists. Having carefully read several dozen recent textbooks, he reported finding only three that did not make regular use of the atomic theory, all traceable to the same small group of authors: *Chemistry for Schools*, Kenrick’s undergraduate lab manual, and Miller’s “New Regulations.” His survey of school programmes from Britain, France, Germany and the United States (including Harvard’s entrance requirements, which were the *de facto* national standard) similarly showed that the atomic theory was a staple component, he claimed.

Taking his point even further, Cornish cited a series of high-profile chemists in his support. Making a pointed reference to Ostwald’s own *Conversations on Chemistry* (which had been translated into English in 1905), he remarked, “I believe Oswald [sic] is held in very high esteem by the chemists of the university, yet he does not see fit to abolish it even from his most elementary text-book.”²¹ Cornish similarly quoted a long passage from Mendeleev defending the atomic theory and emphasizing the indispensability of hypotheses to science. As a final blow, Cornish reported that he had gone so far as to mail a copy of the latest Ontario high school chemistry course to William Ramsay and James Dewar, two prominent British chemists known for their interest in education, to ask if they approved of the omission of the atomic theory. He quoted both their replies. Ramsay’s was particularly damning:

²¹ Ibid., 204–205. To drive the point home, Cornish reads a long excerpt of the dialog between Ostwald’s fictional master and pupil in the *Conversations*. In the quoted passage, the master briefly introduces the concept of atomic weights. The pupil (P.) asks, “Then it is all true?” The master (M.) replies:

No one has ever seen the atoms or weighed such a minute quantity as a single one. It is thus a hypothesis to suppose the existence of atoms. But if we do so, *it affords a convenient method of observing the various applications of the law of combining weights, because the atomic theory is very simple and clear.*

P: But yet we can also get on without it.

M.: Certainly. But you remember that when you learned to do sums you used your fingers as a help, and that was more convenient than keeping the numbers in your head. So it is more convenient to adopt the atomic theory, so far as it applies to the abstract and universal law of combining weights.

P.: Well, this law does not seem to me so fearfully difficult.

M.: Nor to me either; but, to carry out his work, man rightly makes use of every faculty which yields a quicker and quite as accurate a result. (Emphasis in original.)
I don’t think you can possibly teach anything useful in chemistry without introducing the atomic and molecular theories. Surely the omission is pure inadvertence. An ‘engineer’ trained with no reference to theory is called an artisan, and is a poor one at that. Does the department wish you to turn out analytical operators? Such a course as you suggest might suit for an analyst who was required to estimate iron in iron ore and nothing else – in fact, a chemical labourer. But you state that the view is that chemistry taught as you quote from the syllabus is intended to from part of a general education.22

Ramsay’s comments were surely Cornish’s trump card. The chemist’s biting assessment would no doubt have cut deeply in the climate of dissent over the goals of Ontario’s high school curriculum. While some educators, like Ellis, had been campaigning for more practical, vocational course options and less university control, nobody questioned the implicit belief that the high school program, even in its more technical iterations, remained tasked with imparting a general education. In fact, the notion of “general education” was often strategically held up in contrast with an overly academic, university-oriented curriculum by educators who were pushing for reform. Ramsay’s implication that an aversion to theory was more characteristic of a narrow-minded, mechanical training than a liberal education stood in contrast to the staunch commitment to empiricism discussed in Chapter 1.

The controversy in Ontario over the appropriateness of teaching the atomic theory once again raised the question of how much students should be engaging in scientific hypothesizing – a question that recurs throughout the period covered by this dissertation. In the strict inductive methods that characterized the expansion of laboratory teaching in the high schools, generalization was the assumed pinnacle of the process. Yet this generalization stage was rare, halting, and hard-earned. It was assumed to be beyond the reach of students in the lower grades, who were to be trained above all in collecting, drawing, scrupulous examining and observing, classifying, and note-taking. Indeed, pupils’ competence in moving restrainedly and sequentially through the stages of the inductive method was thought to epitomize the mental discipline of science, while a

22 Cornish, “Atomic and Molecular Theories,” 206.
general wariness of generalizations – a sense of self-control against jumping to conclusions too quickly – represented its key moral lesson.

Only in the upper years of high school, once students had been thoroughly trained in the plodding skills of collecting, observing and drawing, was generalization warranted. Seath and other late nineteenth-century proponents of the laboratory method such as A. P. Knight had tacitly assumed that students themselves should do the mental work of “generalizing to the law” when called to. Knight even believed that students should undertake original research. In the laboratory, students became proto-scientists. But others, like science teacher D. F. H. Wilkins of Beamsville High School, publicly wondered if this ambition were not perpetrating myths about pupils’ abilities and about the learning process. In the early years of the twentieth century, the pedagogical role of hypotheses came under renewed scrutiny. N. R. Carmichael argued that it was a “sham” to assert that students could work up to the law on their own steam. High school experiments were at best illustrative examples of previously taught concepts; they provided the link between learned laws and the real world. Lash Miller and his colleagues, in turn, maintained that high school students should “stick to the facts” and that hypothesizing was entirely out of bounds.

Although Lash Miller preached a message about sticking to the “simple” facts and avoiding the “encumbrance” of hypotheses, it is clear that his objections to the atomic theory stemmed from its lack of robustness, not from a general aversion to teaching laws and theories in the high schools. The physicist Arthur Rücker, on the other hand, thought that it was beside the point whether the theory was correct or not; theories served an instrumental purpose, both in science and in pedagogy, as memory aids and consolidators. Cornish likewise advocated the instrumental role of theories in connecting scientific concepts and correlating the curriculum. Moreover, and perhaps most significantly, Cornish’s reply to Miller reflects his belief that key theories represented the public face of science. Informed citizens needed to be duly acquainted with these theories in order to grasp the state of contemporary science. To remove all reference to the atomic theory was to short-change future citizens. Such a move deprived them not only of a true
vision of the scientific enterprise but also robbed their education of its liberalizing purpose, by narrowing it to the training of “mere” artisans and engineers.

Finally, the debate highlights the power struggle over the high school program that persisted amid Seath’s unconcealed efforts to wrest curricular control away from the universities. Even as new regulations sought to mitigate the influence of the departmental exam on the high school program, they granted significant authority to Lash Miller, who purged them of the atomic theory. Given this allowance, he no doubt felt justified in his endeavour to train teachers in the new methods and introduce a textbook that matched the new program. But his project had struck at the core of the controversy about the primary mission of the high schools. Cornish regarded their efforts as another instance of the universities’ heavy-handed incursions into the high school program. Moreover, he compellingly portrayed Lash Miller, Kenrick and Allan as an isolated faction with pedantic and esoteric aims. “All the educational institutions of a province,” he concluded, should not have a radical change thrust upon them, simply because a small group of chemists has a rather vague, unsettled feeling in regard to the value of the atomic theory. Before rushing headlong upon such a course, schools should wait until a vague tendency amongst a few chemists becomes crystallised into a definite opinion among the majority of chemists.23

His remarks illustrate again the fluid boundaries of the debate, which moved in turn from the state of the scientific consensus, to the proper relations between the high schools and the universities, to the pedagogical value of hypotheses.

Cornish, however, had overstated the extent of both the scientific and the educational consensus surrounding the atomic theory. The University of Chicago chemist Alexander Smith, co-author with Edwin H. Hall of the popular manual *The Teaching of Chemistry and Physics in the Secondary School* (1902), was an influential figure in American science education who, like Lash Miller, advised great caution in teaching the atomic theory. He had devoted a section to the atomic theory in *The Teaching of Chemistry and

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23 Ibid., 207.
Physics in which he challenged both the evidence for the theory and laid out its pedagogical pitfalls. “The atomic theory is not a fact,” he emphasized.

It would be better to avoid the term atom as much as possible in the every-day language of the classroom, and to substitute atomic weight or combining weight for it. These terms at once recall the experimental method which is the true basis of every statement.24

Smith’s aversion to the atomic theory stemmed partly from his conviction that the high school chemistry course should act as a microcosm of the science of chemistry – reduced in scale and detail but true in scope and outline. It should “represent the main features of the science in petto, and show it, as it were, viewed through the wrong end of a looking-glass,” he wrote.25 The disproportionate emphasis on the atomic theory fed pupils a totally distorted image of chemistry. An extended exchange in the 1907 volume of School Science and Mathematics between Smith and other chemistry teachers shows that debate over atomic theory in the schools was not unique to Ontario, but was alive in American educational circles as well.26 Furthermore, the place of the atomic theory had long been an object of contention in French secondary schools, where the looming authority of the chemist and politician Marcellin Berthelot, a firm foe of atomism, over France’s centralized education system effectively barred all reference to atoms from French textbooks until Berthelot’s death in 1906.27 Finally, despite Cornish’s appeal to the authority of Ostwald’s Conversations, Ostwald was in fact widely known as a detractor to

25 Ibid., 161.
atomism, who believed that any pedagogical reference to the atomic theory should be delayed as long as reasonably possible.

6. Aftermath of the OEA debate

The next few years of proceedings of the Ontario Educational Association are silent on the topic of the atomic theory or the chemistry curriculum. From 1907 to 1911, Minister of Education Robert A. Pyne gradually revised the list of approved textbooks. Among the science textbooks, the chemistry manual was the first to be replaced, in 1909. Significantly, the new textbook edited by Lash Miller and his colleagues was not selected. A. P. Knight’s manual, which had been approved for the past twenty-one years, was replaced by an anonymous textbook, The Ontario High School Chemistry, which would remain on the list for the next twelve years. In it, the atomic theory is unambiguously presented (although not until Chapter 13, following the law of definite proportions). The educational records hold few clues as to the book’s authorship, although the Natural Science Section minutes of 1910 indicate that a small committee of teachers that had convened to make recommendations about the province’s science textbooks “claimed responsibility” for the new chemistry textbook and laboratory manual. It is not clear whether this means they had a hand in the books’ authorship or just in their selection as the authorized texts. Kenrick made his objections to the new book known, highlighting several “inaccuracies and inconsistencies” and even presented a formal report to the Department of Education, but found the latter indisposed to make any changes to its authorization. He believed that his position on the atomic theory remained poorly understood by the province’s high school teachers.

The new book’s preface does not explicitly invoke the debate that had played out in the OEA over the previous four years, but nevertheless renders a clear verdict on the matter.

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28 *Ontario High School Chemistry* (Toronto: Macmillan, 1909). This textbook was authorized from 1909 to 1917 and reissued in 1913 and 1916.


Middle school chemistry, it notes, serves two functions: on the one hand to develop in students a scientific habit of mind, and on the other, to provide them with enough knowledge to serve as a foundation for further learning. While there is some overlap between these two goals, they are different enough that it is sometimes necessary to choose between them. Faced with this decision,

there must be some compromise between what is best and what is possible . . . It has been thought best to treat the subject in accordance with modern theory, and to introduce from the first the ideas and the terminology needed for that purpose, in order that the student may not have to discard, at a latter period, what he learns regarding chemistry in the High School.  

In short, Lash Miller’s unorthodox nomenclature was rejected in favour of the common parlance of atoms and molecules. The sections of the book dealing with the atomic theory are cautiously worded and attempt to enforce a distinction between facts and theory: the text emphasizes that the term atom does not signify a particle but rather a “unit mass,” and that the atomic theory “does not, in any way, serve as an explanation of the chemical facts” but is “simply a ready way of expressing a theory regarding them.”

In 1908, meanwhile, the course of studies had undergone minor revisions. Although the atomic theory does not appear in the chemistry course, the molecular theory is listed among the topics to be covered in the lower school physics course.

Lash Miller’s campaign nevertheless had lasting effects. In 1910, Jarvis Street Collegiate Institute chemistry teacher Carl Lehmann addressed the OEA about how to teach chemical notation without reference to the atomic theory.

The Science teachers of this Province, whether they admit it or not, owe a great deal to that little book of Dr. Lash Miller’s, “The Requirements,” and to subsequent books that have come from the Chemical Department of the University. To most of us the mere idea that the atomic theory did not have anything new to do with the facts or the laws of chemistry was so entirely new . . . that many, I fear,

31 “Preface,” in Ontario High School Chemistry, iii.
rejected it without even considering it. . . . Yet, it required but a few
moments’ reflection to show that this was perfectly sound, and those
who had been taught in the old way marveled how this theory had
blinded them so long.³³

In the speaker’s view, the atomic theory should only be mentioned as a concession to its widespread popularity, so that students were not entirely ignorant of it upon leaving high school. Pedagogically, he saw no value in it. In his own classroom, he introduced the idea of atomic weights and symbols as a shorthand only after an exhaustive study of the quantitative laws of combination. The minutes note that considerable discussion followed Lehmann’s “very able” paper.

It is difficult to assess how deeply Lash Miller’s campaign influenced the teaching of chemistry in Ontario. His “New Requirements” was evidently widely distributed, but his textbook was not authorized, and he had earned admiration from some teachers and hostility from others. The 1908 course of studies included the atomic theory in physics, as did the 1910 Manual of Suggestions for Teachers of Science.³⁴ Although Ostwald had publicly changed his view on atoms in 1908, Lash Miller was still expressing strong scepticism about the physical reality of atoms in 1911, and he strongly condemned high school textbooks’ imprecise definitions of terms such as atom, molecule, and chemical compound. Such definitions, in his view, deliberately misled students and perpetuated “systematic mystification as an aid to teaching.”³⁵

Frank Kenrick, who succeeded Lash Miller as department head in 1937, similarly maintained a strict adherence to laboratory terminology throughout his teaching career. His own 1932 textbook, Introduction to Chemistry, insisted on the use of “laboratory terms,” steadfastly avoided reference to the atomic theory, and referred to atoms as “fictive constituents” (an expression borrowed from Lash Miller). Significantly, he

maintained that there was value in the inherent difficulty of chemistry, when approached with exacting empiricism. “This will not be found to be a ‘teachable’ book,” Kenrick admitted in the textbook’s preface. “Chemistry is not a teachable subject; it is a thing to be struggled with.”

Cornish’s career, meanwhile, was on the rise. In 1910, he was appointed as a professor at the Faculty of Education of the University of Toronto. He authored multiple textbooks, and was in fact commissioned to prepare the province’s high school chemistry textbook in the next major textbook revisions, in 1917. His textbook, *The Ontario High School Chemistry*, and accompanying laboratory manual were used widely across Canada until the mid-1930s. Cornish would later emerge as a campaigner for new approaches to teaching lower school science that were particularly geared to students not headed to university. By the end of his career, he had “trained at least five-sixths of the teachers of Science and Geography teachers in the Secondary Schools of Ontario, and a good many Normal School teachers.”

7. Conclusion

The controversy over the teaching of the atomic theory in Ontario was just one facet of a wider scientific dispute about the validity of physical atomism. Lash Miller’s involvement in the high school science curriculum emerged from his own tenacious theoretical commitments, particularly his endorsement of thermodynamics as a viable alternative to atomism. It also emerged, understandably, out of a vested interest in high school graduates’ proper preparation for the university chemistry courses taught by himself and his colleagues. However, the atomic theory debate within the OEA also reveals differences of opinion about the relationship between high school science teaching and scientific practice. Was a high school science course a replica model of the

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corresponding scientific discipline – a miniature representation of the field as a whole, as Alexander Smith described it? Or should high school science serve completely different ends, choosing selectively among the features of the field, even distorting them as needed, in order to impart lessons more relevant to non-specialists? Lash Miller’s arguments revealed his assumption that there should be a correspondence between the teaching of novices and work of professional scientists. Scientists did not “invent explanations” but “stuck to the facts”; consequently, speculative theories should be banned from the high school curriculum.

Increasingly, though, some educators were beginning to raise questions about whether the disciplinary structures of science – the scientist’s view of science, so to speak – should be the model for the high school curriculum. In the first decade of the twentieth century, a small group of science educators in Chicago began advocating a new approach to beginner science teaching that downplayed the prominence of the separate scientific disciplines and instead took a broadly thematic, technology-oriented approach.38 This group, the Central Association of Science and Mathematics Teachers, helped initiate the general science movement, which is considered in Chapter 5. The atomic theory debate in the OEA shows that related tensions were present in Ontario. Cornish opposed Lash Miller’s censorship on the grounds that the curriculum owed as much to early leavers and non-specialists (who ought to at least be conversant in the broad strokes of chemistry) as to students who would study chemistry at university. Efforts to reduce the influence of professional scientists over the beginner science courses came in tandem with ongoing calls to lessen the universities’ grip on the high school program.

In the midst of these debates, the inductive method remained the undisputed basis of school science. It was the common ground Cornish appealed to in arguing that the atomic theory should stay: so long as it was presented in the correct sequence, he reasoned, how could it be harmful? Indeed, Lash Miller was trying to instil a more radical inductivism, both in Ontario’s classrooms and among his peers. Kenrick’s and Lash Miller’s insistence on strict experiment-based terminology and explanations outlasted their scepticism about

the atomic theory itself. “One misunderstanding,” wrote Kenrick in a 1935 profile of his colleague, “. . . is that Miller is thought to be opposed to the atomic hypothesis; he is only opposed to those who use the language of the hypothesis without understanding it.”

Perhaps partly in reaction to the more uncompromising variety of empiricism advocated by Lash Miller, Kenrick, and Smith, the inductive method in science teaching came to be associated with pedantry and rigidity, and provided fodder for proponents of major curriculum reform in the sciences.

In Seath’s initial push to overhaul the high school science program, he had campaigned for his new approach by drawing a sharp divide between the methods and the content of science. Method was the core of science; content was secondary. The methods and content of school science should mirror this divide. The atomic theory debate, however, suggests that the relationship between scientific method and content was much more complicated. Both Lash Miller and Cornish purported to evaluate the atomic theory in terms how well it stood up to the methods of science. Lash Miller argued that proponents of atomism failed to follow the proper method: they had resorted to speculation. Attempts to teach the atomic theory in high schools was therefore effectively teaching improper methods to students. However, it is apparent that Lash Miller was deeply opposed to atomism itself, and his methodological arguments served that conviction. There was a reciprocal, self-reinforcing relationship between his position on atomism and the particular variety of method that he took pains to defend.

In Cornish’s case, the elision between theory and content is less pronounced. Cornish was an educator, not a scientist, and he did not claim a strong theoretical commitment to the atomic theory. His stance was, at best, an acceptance by proxy: atomism had credence because it was supported by prominent chemists. Cornish also went so far as to imply that it did not particularly matter whether the atomic theory was “correct.” Theories, even tentative ones, were fruitful both in science and science teaching. But he clearly believed that the atomic theory belonged on the curriculum because it was part of the common parlance of chemistry: in short, the chemistry course should reflect the majority views of

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chemists. However, another of his key arguments is that the atomic theory is compatible with the inductive method, the core value of science pedagogy. The version of inductivism that he used to endorse the atomic theory, not surprisingly, differs from Lash Miller’s, which had banned all speculation. Instead, Cornish focused on the sequence of the inductive method – the progression from facts to laws to general theories – and ignored the question of when theorizing was warranted, a question that was of crucial importance to Lash Miller. For both Cornish and Lash Miller, then, it is difficult to tease apart their respective standards for what constituted valid content from their decision to apply specific features of the scientific method over others.

Such methodological debates would fade in importance as educators began to question whether science pedagogy, especially in the case of beginners, ought to mirror the practices of scientists. In the end, with the general science movement of the 1920s, the focus on strict empiricism and inductivism fell by the wayside. Providing young students with a bird’s-eye view of science or a reduced-scale model of the individual disciplines was considered less important than engaging them with concrete applications, life stories of scientists, and socially relevant aspects of science and technology. In Quebec, where laboratory-based science teaching movement was just getting started, educators looked to the general science movement as one route to a modernized science curriculum and a possible remedy to the pressing problem of teacher education in science.
Chapter 5
Shunning the Bird’s-Eye View: General Science in the Schools of Ontario and Quebec

1. Separating School Science from Scientists’ Science

While there can be no room for dispute in saying that a knowledge of the “laws” of physics and chemistry give a unity and perspective otherwise impossible, to include youngsters with a few months’ training among those who perceive this unity and benefit by this perspective, is to be rather optimistic. Here is a generalization, the reward of a long tedious journey, the endpoint possibly of a considerable amount of accurate quantitative work, generously presented to scientific babes and sucklings still toddling pathetically from chair to chair.¹

So wrote Henry Bowers, principal of Ottawa Normal School and author of a 1938 science textbook, General Science: An Introductory Study of Our Environment, that would soon be introduced in Ontario high school classrooms.² The textbook was created for a new course in general science that was piloted in Ontario’s grade 9 classrooms in 1936. General science was by this time a movement with international reach, with proponents in the United States, Britain, and Australia as well as other Canadian provinces. In all these places, general science courses marked a departure from the customary disciplinary organization of high school science program into courses like physics, chemistry, botany and zoology. Instead, general science courses introduced topics that were intended to cut across scientific disciplines. They drew on examples such as municipal water supply, the work of the meteorological service, and “the relationship of plants to man.” In doing so, these courses embraced applied science, which was held to be far more suited to students’

natural interests than the abstract laws and theorems of the separate disciplines. As Bowers’ remarks indicate, the scientific significance of abstract laws was assumed to lie beyond the grasp of young students, mere “scientific babes” that they were. John Rudolph has observed that this departure from the disciplinary canon of science made general science unique among high school science courses: it was the only science course that did not correspond to an academic field of study.\(^3\) While university scientists had been instrumental in shaping the high school physics and chemistry courses of the late nineteenth century, the impetus behind the early American general science movement came from professional educators, not scientists.

General science curricula attracted support in a variety of locales for distinctive reasons. In the United States, the general science movement emerged in Chicago, where it was closely allied with the work of educational psychologists, in particular John Dewey. It was in part a reaction against the perceived over-regimentation of the laboratory exercises that had become a defining aspect of the science curriculum in the last decades of the nineteenth century. Armed with the arguments of thinkers like Karl Pearson (\textit{The Grammar of Science}, 1892), the American educational reformers promoted scientific reasoning as a skill that could be applied to all areas of inquiry. In the 1910s and 1920s, they increasingly embraced the idea that training in the methods of scientific thought could be transferred to other fields. Indeed, scientific reasoning was regarded as the ultimate exemplar of sound thinking.\(^4\) However, as the project method became the backbone of general science teaching, the program veered away from pure science towards civic engineering.\(^5\)

In Britain, general science was first advocated in 1916 by the Association of Public School Science Masters (APSSM), which protested the dominance of the classics in the public schools and pushed for mandatory science teaching. World War I had brought to light Germany’s dominance in industrial research and development, and the


schoolmasters of the APSSM blamed the inefficiency of British scientific training and recruitment. Though the British general science movement emerged from a set of concerns that were different from those of its American counterpart, its mission was expressed in very similar terms. Efforts to promote general science reflected an ambition to give science broader appeal, to make course content more relevant to young pupils, and to increase science’s stake on the curriculum. However, due to the conservative nature of British boards of examination, who only gradually adopted general science as a matriculation exam option, the general science course was much slower to spread in Britain than in the United States.\(^6\)

According to Rod Fawns, general science was exported to British colonies in Asia and Africa by Frederick Daniel in the mid-1930s. Daniel was a science master at a prominent British secondary school in Kuala Lumpur and had close ties to British promoters of general science. Here, general science was presented as a way to equip colonial students for careers in agriculture and industry. Daniel envisioned his textbook, *General Science for Colonial Schools* (1940), as “a practical contribution (within the existing fabric of English education) towards the solution of the problem of productive labour.”\(^7\) Daniel’s textbook was then adapted to become Australia’s first general science textbook.\(^8\)

In the mid-1930s, general science courses were introduced in both Quebec and Ontario. This chapter looks at both of these episodes, in Quebec focusing exclusively on francophone schools, in order to contrast the ways in which pedagogical discourse in Britain and the United States was taken up in two different cultural, linguistic, and educational contexts. In Ontario, science educators closely monitored educational writings and practices in the United States and Britain. In matters of curriculum-making and textbook production, however, Ontario had been keenly committed to self-

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sufficiency since the late nineteenth century and was determined to produce and adopt Canadian rather than British or American textbooks in its public schools. In francophone Quebec, the historical roots of the education system lay with the Jesuit missionaries to New France. Even following the Conquest of 1759, after which France ceded all its Canadian territories to Great Britain, educational ties to France remained strong.

The 1867 British North America Act, Canada’s first constitution, established a carefully negotiated division of powers between the federal and provincial governments in an effort to manage the significant cultural differences among the provinces. Education, which played an obvious role in cultural transmission, was placed almost exclusively within the jurisdiction of the provinces. Ontario moved towards two parallel systems, one denominational and one non-denominational, over the course of the nineteenth century, while Quebec’s education system was sharply divided along both religious and linguistic lines. Quebec’s French-language schools fell under the authority of the Catholic clergy, who fought to keep the provincial government out of the educational sphere. The Church repeatedly warded off efforts to create a provincial Ministry of Education in the late nineteenth century. Education was not turned over to the province until the Quiet Revolution of the 1960s, a period of intense social transformation during which Quebec society underwent rapid secularization.

In the distinct school systems of Ontario and francophone Quebec, educators often measured their own systems against those of other nations, vacillating between self-satisfaction and self-deprecation. When calling for reform, they denounced their schools, curricula and textbooks as backwards and out of step. When defending the status quo, they portrayed their customs as the envy of other nations. Science educators in particular, who frequently associated science teaching with national economic success and technological superiority, were especially prone to drawing pointed cross-national comparisons. In Ontario, the general science movements in the United States and Britain were conflated and held up against the Ontario curriculum to highlight its “retrograde” emphasis on laws and theorems and its demand for memorization rather than problem-solving. In Quebec, professional scientists pointed to the failings of science education in
the province as the source of French Canadians’ poor showings in manufacturing and industrial pursuits, which were dominated by the province’s anglophone minority.

This chapter considers how the pedagogical ethos of general science was filtered and taken up by educationists in Quebec and Ontario, where distinct pressures were prompting a new outlook on the purposes and goals of a secondary school education. In Ontario, the ways in which science educators engaged with the themes of general science bring into relief the wide range of ambitions that were attached to the science curriculum – ambitions that were intellectual, moral, and social. In terms of its intellectual goals, there was a pointed turn away from using the laws of science as the organizing principle of a high school course. This choice reflected the belief that the laws of science were not an appropriate point of entry into a beginners’ high school science course. The point was not to induct students into the scientist’s vantage point on science (which purportedly focused on laws and concepts), but to adapt the content to the student’s perspective, which was assumed to be technology and the “science of everyday life.” If the centrality of the organizing principles of science was relinquished, the emphasis on the scientist’s supposedly uniquely rigorous thought processes was not. The intellectual ambitions of the science course centred on instilling in students the “scientific habit of mind” by training them in proficient reasoning skills that could then be applied to other domains. However, this goal was undercut by problematic results of empirical testing. In spite of this, educators like Bowers continued to hold out hope that transference would result from improved pedagogical strategies. In this respect, the far-reaching intellectual ambitions of the science curriculum remained strong.

In the nineteenth century, the moral ambitions of the science course had been correlated with the actual practices of scientific research: working with a sensitive balance instilled patience; time spent outdoors in nature collecting specimens inspired virtue; carefully tabulating results developed self-discipline; and so on. In the 1920s and 30s, there was instead a tendency among educators to reach outside the traditional domains of the science classroom and draw on the humanities to inject moral values into the science program. Specifically, educators looked to the history of science to fulfill this moral role. Developing an acquaintance with the life and works of eminent scientists was thought to
inject a “warm,” human element into “cold” systematism of the science curriculum.
Science educators’ ready acceptance of the idea that moral values had to be imported into the science course from other fields suggests that the perceived distinction between the pedagogical roles of science and the humanities had, if anything, grown more pronounced than it had been at the turn of the century.

Finally, the comparison between the delayed but wholesale adoption of general science in Ontario with its much more selective adoption in Quebec raises interesting questions about local receptivity to the course’s pedagogical ideals. The most significant difference between the two provinces was who led the reform effort. In Ontario it was educators, whose role was increasingly separate from that of research scientists. In Quebec, however, a core community of scientists appointed to newly established research institutions launched the campaign to reform science teaching in the province. In his analysis of the origins of the general science movement, Rudolph asks why American scientists did not move to oppose the rising tide of the general science movement, as its disregard for the separate disciplines might well have been perceived as a threat to their professional identities. He concludes that in the prewar years, the stakes were not yet high enough for scientists to get involved – and that the stakes rose considerably in the Cold War era once research dollars and political status more plainly hung in the balance.

The Quebec and Ontario cases invite similar questions. Ontario educators had long kept an eye on American pedagogical practices, even if they often rejected them. Quebec clergypersons and educationists were likewise guarded in their views about curriculum developments abroad, both in France and in the United States, and were particularly wary of the dangers of secularism. Schools were safeguarded as bastions of French-Canadian, Catholic mores. But perhaps more instrumental to the reception of general science in each province were the very different perceptions at play about the social role of science. In Ontario, it was a question of raising support for research and equipping young people with the skills to apply “scientific” methods to all kinds of social problems. General science seemed especially well suited to these missions. In Quebec, the overarching goal of the province’s emerging scientific community was to establish the cultural authority of science in a traditionalist society and to assure the survival of their departments by
expanding science offerings in what was, according to them, an outdated education system. In the climate of this campaign, the general science curriculum could be welcomed as an ingredient of modern scientific instruction, but its purposeful interdisciplinarity was only appropriated insofar as it could be deployed as a tool to ease the expansion of science offerings in Quebec’s Catholic schools.

To the extent that general science found a place in each province, it was closely allied to vocational education. In Ontario, despite initial advocacy from individual educators, general science found little institutional support until the late 1930s, when it was introduced as a universal science course for grades 9 and 10, explicitly uniting students in both technical and vocational streams. The general science course, designed for broad appeal, was a key ingredient of this harmonization of vocational and academic science education. In Quebec, meanwhile, general science found a minor niche in the mid-1930s in the world of adult vocational education with the publication of a French translation of a popular American textbook by Otis Caldwell and William Eikenberry, key players in the American general science movement. This chapter examines the educational ideals that underlay the general science curriculum as it took shape in both Britain and the United States, and how these ideas alternately harmonized and clashed with educational priorities in Ontario and Quebec.

2. General Science in Ontario

2.1 Early Appeals for General Science in Ontario

Ontario educators could read about the ideas of the Chicago reformers in the journal of the Central Association of Science and Mathematics Teachers, School Science and Mathematics. The journal’s business manager travelled to Toronto in 1905 for the annual meeting of the Ontario Educational Association. The journal earned warm endorsements and an interested readership among Ontario science teachers. American science reformers found occasional sympathizers in Ontario science educators. One member of the OEA’s Natural Science section, wielding a 1905 School Science article by physics

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educator John Woodhull, warned his colleagues about enrolment declines in physics and chemistry signaled by American educators. Canadian teachers could not afford complacency, he urged: the curriculum needed more popular and applied science and less pure science and dry quantitative exercises. In short, it needed to start from the perspective of the student rather than the “science specialist.”

While the ideals of the nascent general science movement garnered notice in Ontario, they apparently did not cause much of a stir. The Department of Education certainly had other concerns. As mentioned in Chapter 4, a new provincial government came into power in 1905 and was busy cleaning house, amending textbook policies that had long been mired in allegations of cronyism and conflict of interest and managing the introduction of a new program of studies. If some OEA members harboured hopes for reform, others held up the province’s conservatism as a point of pride. Ontario Agricultural College botany professor S. B. McCready had argued that the best course of action was to wait and choose cautiously from among the plethora of new textbooks produced by the United States and Britain rather than flit from trend to trend.

During the second decade of the twentieth century, general science gained prominence in both Britain and the United States. In the United States, two education professors, Otis Caldwell and William Eikenberry, inspired by the ideas of John Dewey, developed a new course in general science that was founded on exercises in problem-solving. In 1914, the new course was published as a textbook, *Elements of General Science*, which would be issued in at least four more editions over the following two decades. In each chapter, students were presented with a problem (e.g., “How does water flow through pipes?”) and guided through its solution (which they were presumably only supposed to consult after having attempted to solve it on their own). By the mid-1920s, every American state offered a course in general science, and between 1910 and 1925, more than thirty general science textbooks were published in the United States. Caldwell went on to chair the

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science subcommittee of the Commission on the Reorganization of Secondary Schools, whose 1920 report provided valuable sanction for general science.¹¹

In Britain, meanwhile, the neglect-of-science campaign succeeded in getting the attention of the Prime Minister, who commissioned an enquiry into the state of science education. While this enquiry was underway, a committee of science masters wrote the pamphlet “Science for All,” which would provide the framework for the British general science movement well into the 1930s. The report of the Prime Minister’s commission, released in 1918, also drew heavily on the ideas articulated in “Science for All.” Much like the American general science movement, the British movement emphasized the importance of responding to the natural interests of the student and taking a cross-disciplinary approach to the curriculum.¹²

Ontario educators, who kept a close eye on educational developments in Britain and the United States, noted the growing attention garnered by general science. The first major apology for general science came from George Cornish in 1921 in the pages of The School. Cornish, as discussed in Chapter 4, was a prominent and outspoken member of the Natural Science section of the OEA. By this time he had been a faculty member at the Ontario College of Education (previously the University of Toronto’s Faculty of Education) for over a decade, and his chemistry textbook had been in use in Ontario’s high schools for over three years. His two-part article in The School represents a moment of taking stock. A course of elementary science that covered physics, chemistry, botany and zoology had been in place for fifteen years. Its defects, however, had become apparent, Cornish wrote. His critique of the curriculum was sweeping: it was disconnected; its topics were uninteresting to students; it was overloaded and burdensome (largely because there was no authorized textbook and students were compelled to take detailed class notes); and for lack of sufficient time, teachers ended up neglecting experiments.

When Cornish issued his appeal for general science, he pointed to the findings of foreign educational commissions. A general science course had been on trial in different parts of the United States for five to ten years, he noted. “[I]f we wish to progress, it is necessary to see what is being done in other parts of the world where opportunities for experimenting are more numerous. Probably no better field for the trial of new courses exists than in the United States.”\(^{13}\) Quoting extensively from both Caldwell’s report and the British Prime Minister’s commission, Cornish made a comprehensive case for introducing general science into Ontario high schools. Following the British and American movements, Cornish focused on the importance of cultivating students’ natural interests. As he saw it, the disciplinary breakdown of science, central though it was to the identities of professional scientists, held little meaning to beginners:

> To the skilled scientist, the chief interest of a fact is that it affords additional evidence of a fine co-ordination of the facts of that science, but the pupil does not see that beautifully co-ordinated cosmos of facts and is not interested from that standpoint at all.\(^{14}\)

Emphasis on the laws and theories of the special sciences should be reduced, he argued. General science operated from the student’s perspective, not the lofty “bird’s-eye view” enjoyed by the accomplished scientist. Moreover, the age for mandatory school attendance would be raised from 14 to 16 in the fall of 1921 with the advent of the Adolescent Compulsory Attendance Act, he pointed out. General science seemed to have more to offer to the new influx of students who would stay in high school for only a year or two before leaving for industrial jobs. The course in general science, in Cornish’s view, was the urban counterpart to the agriculture course in Ontario’s rural schools. “Does a course in botany, zoology, or even physics properly equip the boy who is going into the factory?” he asked. “For him especially the course in general science is almost a necessity.”\(^{15}\)


\(^{14}\) Cornish, “Elementary Science,” 494.

\(^{15}\) Ibid., 495.
2.2 Challenging Scientists’ Role as Curriculum-Makers

It is worth noting that the arguments like Cornish’s, which emphasized the stark differences between the student’s and the scientist’s respective standpoints, implied that scientists were not the best candidates for designing a beginners’ science course. Indeed, the key figures in the early general science movement in Chicago were not scientists but educationists – people who occupied “an ambiguous position between the science research community and the lay public.”  

In Ontario, the professional divide between high school science teachers and university scientists had widened considerably since the nineteenth century. In 1920, for instance, high school teachers’ efforts to have their research recognized by Canada’s National Research Council (NRC) fell flat. Having learned that the NRC was planning to establish a national laboratory in Ottawa, a group of science teachers in the OEA petitioned to be involved as key contributors. They emphasized their qualifications, pointing out that the training of science masters was often “in no wise different from that of those at present engaged in [NRC] work.” The teachers hoped that they would be given “every encouragement” to engage in research, asking the Council to provide them with a list of unsolved research problems and to cover the expenses of their investigations. They wanted similar support from the universities and from the Department of Education. The Department, they noted, needed to make it known to school boards that science teachers had a right to use school laboratories for their own research. These extensive recommendations were unanimously approved by the assembled members of the natural science section. But their demands evidently met with a lukewarm reception in Ottawa: by the following year’s OEA meeting, enthusiasm for this plan had fizzled out. The committee dropped its list of demands and noted that “while appreciating the value of Research Work among teachers. . . . [involvement will]

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be left to the initiative of individual members.” In 1920, then, many science teachers still saw themselves – in their moonlighting at least – as independent research scientists. But this vision of their professional identity lacked institutional support and collective momentum. Original research was no longer an assumed part of high school science teachers’ occupation; rather, their skills were to be directed towards judiciously selecting content and making it engaging for young students.

Significantly, science teachers were expected to be generalists. General science, both in Britain and the United States, was just one manifestation of a pervasive aversion to specialization in secondary schools. In Ontario, likewise, educators continually emphasized that the high schools’ mandate was to provide general, liberal education. Some argued that professional scientists, unlike educators, were inevitably specialists – and that the narrowness of their expertise was handicap when it came to grasping a new learner’s needs. Queen’s University principal William H. Fyfe, a British émigré, went so far as to express nostalgia for the heyday of Victorian science:

A generation ago there were men who were scientists without being scientific specialists…. As an instrument of education that Victorian type of scientist held an immeasurable advantage over the botanist or biologist or chemist of to-day, whose attention is too often narrowed to one sub-division of one sub-branch of science.

Just as teachers were losing their identity as scientists, scientists were being subtly nudged out of the realm of pre-university education.

2.3. Education Research and the Problem of Transfer

While science teachers’ professional identities gradually shifted, educational psychologists were steadily gaining influence in matters of pre-university education. The rise of educational research in the United States and its origins in the emerging science of

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20 For example, Cornish, “Elementary Science,” 494.
psychology are well documented. Canada’s first department of educational research was founded at the University of Toronto in 1913 by Peter Sandiford, who had earned his PhD under Edward Thorndike at Teachers College Columbia. The Ontario College of Education, established in 1920 and affiliated with the University of Toronto, offered opportunities for graduate studies and doctorates in pedagogy and catered primarily to a clientele of headmasters and normal school principals seeking to advance their careers in the education system.

Henry Bowers, the science teacher cited at the opening of this article, was one example. After spending a few years as principal of a high school in Fergus, Ontario, he enrolled at the OCE in 1925 to earn a doctor of pedagogy degree. On the strength of this research project, he would be granted a doctor of pedagogy degree from the University of Toronto in 1927, and soon thereafter gain a position at the Ottawa Normal College. More significant for this story, Bowers would eventually be commissioned to prepare one of Ontario’s two authorized textbooks in general science. His two-part textbook, *General Science: An Introductory Study of Our Environment* (1938), remained on the province’s authorized list until the mid-1960s.

Bowers’ doctoral thesis tackled the pressing question of transfer of training, a topic that interested Sandiford at the time and that Thorndike had repeatedly investigated. Educational psychologists had been probing the longstanding dogma of mental discipline since the 1890s, seeking empirical proof that studying any one subject could provide intellectual skills that were transferrable to other fields. In his research, Bowers tried to isolate the intellectual effects of individual subjects on Ontario’s middle and upper school program (grades 10 to 13). His particular goal was to determine whether middle or upper school chemistry and physics yielded any discernible transfer of training in students, as determined by students’ performance on standardized tests of his own devising. To ascertain this, he compared sets of students who had followed an identical program but for the presence or absence of one subject. By isolating the role of individual subjects, he

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hoped to determine the effects of studying physics and chemistry, as well as English, algebra, geometry, history, Latin and French, on students’ reasoning abilities and observation skills. He sought to confront what he called “a curious lack of scepticism” among educators about the aims of science teaching. “Assumptions pass unchallenged; unfounded theory becomes vested with authority by usage,” he wrote.24

Although hampered (as he admitted) by participant attrition and the impossibility of controlling for other variables, Bowers’ research did not support transfer. “There is no evidence of either transfer or hindrance from Middle or Upper School Physics or Chemistry,” he reported.25 Performance differences were equally insignificant for the other school subjects he had examined. Moreover, Bowers assiduously surveyed the extant experimental research on transfer, reaching back to William James’s pioneering investigation of memory skills in 1890. Finding fault with nearly all the studies (with the exception of a 1924 study by Thorndike on the mental discipline value of various high school subjects), Bowers concluded that “at present, claims for the existence or non-existence of a generic transfer are without basis.”26

The qualifier “generic” is significant. While many of the early studies on transfer yielded negligible or weak evidence for its effects, psychologists and educationists had not given up on transfer entirely. Researchers continually questioned and qualified the conditions under which transfer might occur. “Experiments in transfer show that the transfer is greatest when common elements are involved,” wrote Sandiford in his 1928 review of the research on the topic.27 The acknowledged limitations of transfer seemed to hold clear implications for curriculum-making and for the disciplinary basis of school subjects in particular. “The more technical a subject, the fewer common elements it provides for thinking to work with,” noted John Dewey in the revised 1933 edition of his influential treatise How We Think.28 Sandiford similarly argued that the paltry successes of transfer meant that school subjects could not be justified on disciplinary grounds. “If transfer

25 Ibid., 16.
26 Ibid., 37. Emphasis in the original.
27 Sandiford, Educational Psychology, 299.
proves to be a broken reed, then studies whose content is socially useful must be emphasized,” he concluded.\footnote{Sandiford, \textit{Educational Psychology}, 298.} In Britain, the Science Master’s Association (SMA) remarked in its 1936 report on general science that appeals to disciplinary value seemed to be unfounded: “The \textit{experimental} evidence has shown quite definitely that the possibilities of transfer of training are much smaller than had formerly been supposed.” It was more productive to foster a positive \textit{emotional} experience of science and to ensure that the beginner’s first encounter with science was not boring, but stimulating and engaging, the SMA proposed.\footnote{Science Masters’ Association, \textit{The Teaching of General Science} (London, England: John Murray, 1936), 13–14.}

Naturally, Bowers’ research on transference shaped his views of science teaching in Ontario. In a 1936 essay in \textit{The School}, Ontario’s leading education journal, he argued that in light of the “pitifully few, and possibly feeble, experimental efforts” showing that science effected any real changes in pupils’ attitudes or thought processes, it had become clear that the science program needed revising. Above all, science courses needed to provide students with “valuable information” – content that offered some perceptible application, whether ethical, aesthetic or utilitarian. “Do we not, in a fantastically unreal atmosphere to which custom has dulled our sensibility, teach facts no more useful or ornamental than the incorrect telephone numbers of fictitious citizens?” he asked.\footnote{Bowers, “Academic Secondary School,” 463.} The “ordinary” physics and chemistry courses were too fact-based, too ambitious in scope and too regimented to foster transference or to provide wider social value. Rather, an effective physics and chemistry course would need to provide “genuine research problems.” It would need to reduce its fact-based content and stimulate the independent exercise of reason. Finally, it would need to relinquish its emphasis on laws and the supposed unity of perspective that they offered. As the opening passage demonstrates, he saw this as far too idealistic a pedagogical starting-point.

Nevertheless, it is clear that Bowers had not given up on the possibility of transfer. He took pains to define the “scientific attitudes and method” that science courses sought to
Scientific attitudes and methods, for Bowers, encompassed a wide range of intellectual skills and proper behaviours, including:

- the ability to perceive similarity and to form generalizations, to detect anomalies in the field of interest, and to be impatient in the presence of these anomalies but patient, concentrated and persistent in their resolution;
- the capacity to suspend judgment, and to frame hypotheses;
- distrust of the unaided senses; objectivity; resistance to suggestion;
- familiarity with the general principles of attacking problems, for instance the elimination or control of variables; intellectual honesty. 32

Clearly, Bowers considered this idealistic mix of intellectual and behavioural habits a goal that was still worth pursuing. For Bowers, transference – particularly its role in promoting desirable attitudes, like a love of precision and accuracy and an inquisitive spirit – remained a compelling pedagogical goal for the science curriculum, but one that could not be accomplished without a new approach that presented students with compelling, real-life problems.

2.4 Humanizing the Science Curriculum

If one motivation for interdisciplinarity and non-specialization in the science curriculum came from critiques of transfer of training, a second impetus came from concerns for moral education. A central preoccupation within the general science movements both in Ontario and abroad was the need to “humanize” the teaching of science – to broaden science’s appeal by, as one educator put it, “[clothing its] lifeless skeleton with living flesh and blood.”33 This concern found expression in several ways, but particularly in efforts to integrate the history of science. Scientists of the past were held up as models of noble resolve and selfless diligence. Cornish wrote in 1921 that students should become “hero-worshippers” of scientists like Watt, Faraday, Pasteur and Cavendish and be “filled with enthusiasm to follow in their steps as much as in the steps of great soldiers or statesmen.”34 More than twenty years later, this idea seemed to hold similar promise.

32 Ibid., 461.
34 Cornish, “Elementary Science,” 449.
Toronto’s Harbord Collegiate Institute teacher C. G. Fraser reflected that students needed to become acquainted with the lives of past scientists, the majority of whom were “noble citizens, with whom it is distinctly beneficial for us to associate.”35 James Donnelly has suggested that general science was just one iteration of the time-honoured project to “humanize” the teaching of science, an endeavour that reached back to the nineteenth century.36

Calls to inject human values into the science curriculum revealed the entrenched dichotomies between science and the humanities – dichotomies between objectivity and emotion, utility and aesthetics, materialism and spirituality – that persisted in the public imagination. One Ontario university professor, for instance, declared in 1918 that while science had ushered in great material progress, it had simultaneously inhibited the emergence of a body of great Canadian literature.37 Fyfe, the principal of Queen’s University, claimed that science education, despite promising beginnings, had sacrificed its moorings in a liberal education by giving way to the demands of industry. The education system could churn out students who could “measure and analyze and organize” but who had lost a sense of human values, he warned. The overly factual teaching of science had created a society whose citizens were “morally unprepared for the mastery of nature which machinery has given us.”38

This duality was reinforced by many educators who assumed that the humanities and the sciences were competing influences on the moral, intellectual and emotional development of students. “The study of ‘the humanities’ gives sympathy, emotional refinement and a sense of values, but on that diet alone pupils are apt to grow passionate and pale,” Fyfe continued. “They need also the corrective astringent of science.”39 Science students likewise needed the counteractive ministrations of the arts. Fraser, meanwhile, reported that “A number [of students] told me that the science seemed to them what they described

35 Fraser, “Humanistic Approach,” 435.
as ‘too cold’ to make them feel as much at home as in history, poetry, and some other subjects which have more of the ‘milk of human kindness’ in them.” History of science, Fraser believed, was a “magic wand” that could be wielded to give the science course new vitality.  

Yet even as educators turned to history of science as an antidote to the cold rationalism of science, they regarded the singularly dispassionate nature of scientific thinking as a crucial stabilizing influence in society. In the mid-1930s, Canada, like many other nations, was gripped by economic crisis and growing apprehension toward the steady expansion of fascism in Europe. Sound scientific reasoning, it was hoped, offered protection against suggestibility, bigotry, and credulity. Science was held up as the archetype of critical thinking and cautious judgment. For Fyfe, objective thinking and the uncompromising pursuit of truth, cultivated by the study of science, were sorely needed by a society that was ever more enslaved to advertising and propaganda. “If the eyes of the rising generation are to be cleansed, they must apply themselves properly to science,” he wrote. Well-trained intelligence was not only an intellectual asset but also a moral virtue:

The active study of science is the best of all possible antidotes against
the prejudice of mass suggestion and the lethargy of ready-made ideas.
It breeds a healthy scepticism, a disinterested attitude of mind and an
unrelenting passion for truth.  

Bowers too, hoped that “scientific habits of mind” could be applied to wider society. He developed a keen interest in teaching students how to appraise propaganda and address social problems with clear thinking, particularly after the outbreak of the Second World War. He wrote a textbook for teenagers that dealt with how to critically evaluate propaganda (Thinking for Yourself, 1947) and he believed that a course on rational thinking would soon become a staple of the school curriculum. Both Bowers and Fyfe contended that school science had failed in its mission to teach better thinking. Despite

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Fyfe’s optimism about science’s ability to foster objective thinking, he thought the curriculum did not require students to reason things through independently. For both, a general science course offered a way to overcome these problems and fulfill the social promise of school science: to foster sound thinking and to build a more cool-headed, rational society.

2.5 Science for All: General Science in Ontario High Schools

Despite Cornish’s call for change in 1921, there were no changes to the science curriculum until the mid-1930s. The chemistry and physics textbooks that had been introduced in the 1910s were reissued with minor revisions in the 1920s, while 1921 saw the appearance of new textbooks in botany and zoology.\(^{43}\) The approval of these two new textbooks meant that it was unlikely that the science curriculum would be overhauled anytime soon, given the rate at which new textbooks were authorized by the Department of Education (generally no sooner than every seven years – often more rarely).

Meanwhile, the curriculum as a whole entered a period of general quiescence, and the high school program maintained its academic character, remaining best suited for the small proportion of students (approximately 15%) who would go on to university or a normal school.\(^{44}\) In North America, the epicentre of the progressive education movement was Teachers College, Columbia. In Ontario educational policy remained mostly immune to the influences of progressivism in the 1920s. As historian Robert Stamp reports, F. W. Merchant, Ontario’s Chief Director of Education from 1923 to 1930, refused to hire Teachers College graduates on the grounds that Canadian teachers should be “trained in institutions permeated with British and Canadian sentiment.”\(^{45}\) While individual educators like Cornish might have had their eye on developments abroad and called for reforms, the OEA ultimately had insufficient clout to present a powerful challenge to Department of Education policy.\(^{46}\)

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\(^{44}\) Stamp, *Schools of Ontario*, 117.

\(^{45}\) Stamp, *Schools of Ontario*, 120.

\(^{46}\) On the fragmented state of the Ontario Educational Association in the 1920s, see Stamp, *Schools of Ontario*, 120.
In the 1930s, resistance to progressive education began to abate. The Depression had brought an influx of students into the high schools as the need for unskilled labour dropped. The surge in enrolment, in turn, prompted greater attention to the social role of the high school and a new openness to progressive education. By the mid-1930s, Toronto hosted the largest Canadian chapter of the Progressive Education Association. “What had seemed somewhat idealistic in the individualism of the 1920s now appeared eminently practical in the depths of the depression,” notes Robert Stamp. The interwar years saw the rise of composite high schools offering both academic and vocational programs in response to the diversified student body. Even where the two programs were housed in the same buildings, however, they typically had little to do with one another. This changed in 1937, when Deputy Minister of Education Duncan McArthur introduced a plan that called for a new, more flexible grade 9 program. The McArthur Plan required all first-year high school students to follow a common curriculum in grade 9 before deciding, the following year, whether to enter the matriculation (university preparation) program, the vocational program, or the commercial program.

A new general science course was piloted in the 1935-1936 school year and introduced into Ontario high schools in 1937. The new course comprised the first two years of high school science, and the first year of the course was a staple of the newly integrated grade nine program. The practice of printing the minutes of the individual sections of the OEA had ended in 1925, so it is difficult to determine the extent to which the members of the Natural Science and Physics and Mathematics sections had played a role in its development. Furthermore, Depression cost-cutting measures meant that the printing of the OEA’s annual proceedings was suspended from 1936 until 1942, making the role and views of teachers even more difficult to ascertain. Nevertheless, articles in The School provide some insights regarding its reception. The new course of study listed five main objectives for general science:

(a) To arouse, encourage and utilize curiosity in natural objects and phenomena, in order to develop an understanding of the elementary

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48 Stamp, Schools of Ontario, 159.
facts of nature;
(b) to cultivate discriminating observation, and the ability to carry
observation to a logical conclusion;
(c) to cultivate precise and orderly expression;
(d) to develop and appreciation of nature; [and]
(e) to help toward rational and healthy living.

In general, the program followed the standard mould of general science courses – however, it did recognize what it called the “natural division” between biology on the one hand and physics and chemistry on the other; in other words, its merging of the various separate sciences was not absolute. “Indeed,” the curriculum noted, “the Ontario climate practically forces such an arrangement on the teacher, even if he were inclined to break through the boundaries between the special sciences.”

The new course also required new facilities. In 1937, Bertram Tolton, a teacher at Humberside Collegiate Institute in Toronto, provided suggestions for how schools might adapt existing laboratories for use in general science courses. He recommended a combination laboratory in geography and general science, but estimated that the cost of adapting a specialized laboratory for general science could entail apparatus costs of at least $1,000 – a sum that included visual aids, one microscope per eight students, microscope slides, and other equipment. This would be a challenge for cash-strapped school boards who were emerging from the worst years of the Depression. This concern, however, would be blown aside by the outbreak of war, which led to a strong backlash against the ideals of the progressive movement.

Significantly, general science was introduced as a common course for all first-year (grade 9) high school students, which represented a significant departure from earlier practice. The course gave “to all pupils the practical training available formerly only in the technical department,” observed one principal who piloted it in a composite high

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51 Stamp, Schools of Ontario, 171–182.
The McArthur Plan represented an important shift in the mandate of the high school, making it considerably more open to the “utilitarian” training that had long been anathema to the ideal of a broadly cultural education. According to one high school inspector, the program’s goal was to “make our academic schools less academic and our vocational schools less vocational, in other words to provide in all secondary schools a kind of general education which will fit our adolescents for life – as individuals, as citizens and as workers.” In McArthur’s view, however, the idea was not to steer students towards vocational education but rather to give first-year high school students a taste for school in the hopes of retaining them longer. The general science course, designed to appeal to students’ “natural interests” and replete with concrete applications and examples of modern technology, dovetailed perfectly with the broad mission of the McArthur Plan.

Henry Bowers’ 1938 textbook, *General Science: An Introductory Study of Our Environment*, issued in two parts for grades 9 and 10, was one of two new textbooks written to match the new curriculum guidelines and authorized by the Minister of Education for teaching general science. In the acknowledgments, Bowers thanked George Cornish for his help and encouragement. For Cornish, who had first advocated for general science seventeen years prior, the new course was a long-awaited achievement. It represented a pragmatic acknowledgement that most students would never go beyond grade 10 nor take another science class. More important, it embraced a proper grasp of adolescent psychology. It recognized that students’ minds were not suited to broad generalizations, but tended rather to focus on “very small concrete units of knowledge.” It presented problems that would spring up naturally in pupils’ minds – problems such as “Why do steel ships float?” or “How did plants and animals get their names?” Finally, it brought Ontario’s science curriculum in line with prevailing practice. “We are two decades late entering the field of general science,” he wrote.

Let us not begin where others were a decade ago, but let us launch forth into this promising sea, of which modern educators in every field

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approve, but unto which only a few have had the courage to plunge.
Ontario is too virile to be hanging on to the coat-tails of any man,
whether he is the American author of a text-book in general science, or
the maker of a British course of study. It is time she was in the
van[guard].\textsuperscript{54}

Even as Bowers’ textbook drew interest in other provinces and secured official
authorization in New Brunswick, others lamented the inferiority of Canadian general
science textbooks. A chagrined reviewer of an American textbook series, writing in \textit{The
School}, noted grimly, “A careful study of this set of books covering a three-years’ course
in general science makes a Canadian teacher almost sick with envy to think what
stimulating and attractive books are put into the hands of pupils in the United States.”\textsuperscript{55}
Such remarks, however, should be taken with a grain of salt. As W. H. Brock has pointed
out, drawing comparisons with foreign education systems was a ubiquitous strategy
among educationists looking to spur change in their own countries.\textsuperscript{56} Such comparative
arguments were often “relative and rhetorical,” he notes. As will be shown below,
Quebec educators were painting similar comparisons to underscore the urgency for
reform in that province.

But while some educators castigated Canada’s backwardness, others defended its
prudence. In 1938, Peter Sandiford surveyed the new curricula instituted in several
Canadian provinces in the late 1930s and remarked with satisfaction that Canadian
educational systems had avoided the pitfalls of American excess. While Teachers
College, Columbia had more than 30,000 curriculum revisions on file, Canadians could
be “thankful … that we have been spared these frequent upheavals.” Canadian
conservatism, he argued, was not knee-jerk traditionalism, but rather was the product of a
deliberate educational philosophy – a philosophy that placed trust in the opinions of
educational experts and school inspectors and saw value in uniform textbooks and
examinations as tests of pupils’ achievements.

\textsuperscript{54} G. A. Cornish, “The Course in General Science for Grades IX and X,” \textit{The School: Secondary
Olby et al. (London, England: Routledge, 1990), 948.
Our neighbours to the south, distracted by the restlessness and continuous change in every department of educational work, envied us our stability. It is a feature of our education that we should cherish.\textsuperscript{57}

On the force of such cross-national comparisons, educationists like Cornish and Sandiford heralded the school reforms of the late 1930s – including the new general science course – as the culmination of decades of caution and (sometimes plodding) deliberation and the beginning of a new progressive era in Ontario education.

Some science educators in the Ontario Educational Association had followed the development of the general science movement in the United States and Britain since the early 1900s. Given this, it can be tempting to see Ontario’s eventual adoption of a general science course as a historical inevitability – a modernization that came “two decades late,” as Cornish put it. Certainly, by the 1930s, general science had come to be associated with specific educational outcomes both in Ontario and abroad. It was considered especially suited to students headed towards jobs in industry; its emphasis on technological applications was assumed to hold immediate relevance and appeal to young students; and finally, its emphasis on problem-solving promised to develop reasoning skills in students that could help them become rational, judicious citizens. These expectations of general science as a school subject had solidified partly due to the work of Ontario educators like Bowers and Cornish, but also due to the advocacy of educators in Britain and the United States.

In 1930s Ontario, several factors conspired to make the educational goals linked to general science particularly desirable. The Depression placed enrolment pressures on the high schools and prompted increased support for vocational education. A growing scepticism about transfer of training placed a new premium on concrete, “useful” curriculum content. Concerns about mass irrationality, caused in part by the rise of dictatorships in Europe, prompted some educators to look to school science as a training ground in sound thinking. Finally, the changing professional boundaries between high school science teachers and university scientists, compounded by psychological research

that differentiated the scientist’s perspective from the student’s needs as a learner, loosened the ties between school science and the disciplinary organization of science in the universities. Many of these developments were absent in the francophone school system of Quebec in the 1930s. Accordingly, even though a translated version of Caldwell and Eikenberry’s general science textbook came on the market in 1934, general science had minimal influence in the province’s French-language public and private secondary schools during this period.

3. General Science in Quebec

3.1 Education in French Quebec

In Quebec, French- and English-language public schools operated under the jurisdiction of two separate confessional school committees, Catholic and Protestant, which had operated fully independently of one another since the late nineteenth century. The As Roger Magnuson argues, the Protestant system was by necessity non-sectarian, and perhaps as a result less overtly religious.\(^{58}\) In the Catholic system, by contrast, the influence of the clergy pervaded all levels of schooling, both public and private, from the university boardroom, where senior clerics presided over administrative decisions, to the primary school classroom, which was often led by a brother and priest or teaching sister. The linguistic, religious and administrative dichotomy that defined these two systems had profound consequences for secondary education in the province. The Protestant system, which encompassed the vast majority of English schools, followed the reigning North American model of secondary education by establishing free, uniform, public high schools. The French Catholic secondary school system, for its part, comprised a mix of disparate institutions administered by separate bodies. This comparison focuses exclusively on Quebec’s French Catholic schools.

Among Catholic secondary schools, there was a particularly sharp demarcation between the public and private sector. Until the late 1920s, there was little opportunity for students to move from one to the other. Model schools (écoles modèles) and academies (écoles

académiques) came under the public system, and covered the four primary grades along with two to four years of supérieur, or secondary education. These public schools were not, however, a direct gateway to the universities. The structure of public secondary education was the subject of an ongoing dispute among Catholic educators. Priests and brothers in the teaching orders advocated for a system analogous to North American high schools, while the bishops on the Catholic committee of the Council of Public Instruction sought to preserve the élite classical model of secondary education. Over the course of the 1920s, the modèle and the académique were replaced by a two-year cours complémentaire (complementary course) and a three-year cours primaire supérieur (advanced primary course) akin to the public secondary courses instituted in France in the 1880s. Notably, no mandatory attendance laws were passed in Quebec until 1943. Such measures were proposed several times starting in the late nineteenth century, but were persistently resisted by the clergy as state encroachment into education.

In the private sector, the province’s Catholic classical colleges offered an élite secondary education in the form of an eight-year cours classique (classical course) rooted in the Jesuit tradition. These colleges were privately run by religious orders, and they represented the standard avenue to the priesthood, the liberal professions, and university studies. Students entered around the age of twelve and graduated at twenty, progressing stepwise through yearlong courses in “Latin elements,” Syntax, Method, Versification, Literature, Rhetoric, and Philosophy I and II. The classical course was an exclusively male domain until 1908, when the Congregation of Notre Dame finally got approval to open the first classical college for girls in Montreal. The colleges’ program was overseen by the Université Laval and the Université de Montréal, which administered the final examination and conferred its prestigious degree, the baccalauréat ès arts. Although

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60 V. Troger and J.-C. Ruano-Borbalan, Histoire du système éducatif (Paris: PUF, 2005), 16–35. The teaching brothers pressured the Catholic committee by running the primaire supérieur course independently until the committee ceded and welcomed it under its auspices in 1928.
62 One exception was the colleges run by the Compagnie de Jésus, which were independent. Claude Corbo, Les jésuites québécois et le cours classique après 1945 (Sillery: Septentrion, 2004), 12.
Quebec’s classical colleges preserved many of the traditional features of French Ancien Régime era classical education, they also introduced modern elements such as commercial programs: by 1900, for instance, fifteen of the nineteen extant colleges offered commercial programs. Like the French lycées, classical colleges remained highly selective well into the twentieth century. Unlike the secular lycées, however, they were emphatically Catholic institutions: they were fundamentally committed to religious education and remained gateways to the priesthood (among other professions). Indeed, Quebec’s colleges were safeguarded as bastions of Catholic, French-Canadian national identity. Indeed, Charland suggests that many of the first colleges were established to protect Catholic children from the influence of English schools.

As gatekeepers of the liberal professions in French Canadian society, the classical colleges were heavily invested in a traditional liberal education. Their professed goal was the provision of culture générale, or well-rounded knowledge. Unlike secondary schools in France, where a science program leading to the baccalauréat ès sciences had been offered (on and off) since the early nineteenth century, Quebec colleges resisted instituting an alternate baccalaureate until 1953, when the Latin-science option was created. Nevertheless, as of the mid-nineteenth century the baccalaureate exam typically required some basic knowledge of physics, chemistry, mathematics, chemistry, mineralogy, geology and botany. Science courses were usually confined to the Philosophy courses of the final two years. Science teaching remained abstract and theoretical, a complement to the humanities in the college students’ general cultural polishing. Science’s role within the classical course was not seriously challenged until the 1920s.

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63 Charland, L’ombre du clocher, 104.
64 According to Troger and Ruano-Borbalan, enrolments in French lycées represented less than 15% of age group. In Quebec, in 1946, fewer than 25% went beyond 8 years of total schooling, and only about 2% finished secondary school. Troger and Ruano-Borbalan, Histoire du système éducatif, chap. 1, pt. VII; Corbo, Jésuites québécois, 14.
65 Charland, L’ombre du clocher, 103.
Following a pattern previously exhibited in many other places, school science in Quebec came under close scrutiny with the creation of a community of research scientists within the province’s universities. The provincial government had proposed setting up a faculty of science at the Université Laval in the 1870s, but the clergy strongly resisted this as unwanted government intrusion into the realm of French-language higher education, which had long been the preserve of the Church. The watershed moment came in 1919, when the Montreal branch of the Université Laval finally managed to gain independence from its Quebec City headquarters, and the Université de Montréal was founded. One of the first orders of business of the new university was to establish a faculty of science. In response to the stimulus of competition, Laval quickly followed suit and established its Faculty of Chemistry in 1921.

The professors who were appointed to run these science faculties were hired on the basis of their credentials as research scientists. Most had studied abroad in European research universities. These newly appointed scientists emerged as an influential group of activists who took up the cause of promoting science in Quebec. This became all the more pressing in the 1930s, when the Depression hit the universities hard. With the survival of science laboratories in jeopardy, Quebec’s francophone scientists became convinced of the need to raise popular support for science in the province.

The scientists decided to focus their promotional efforts on two main targets. The first was secondary education. Indeed, the primary function of the science faculty at Montréal was the training of secondary school teachers, who constituted the bulk of the faculty’s enrolment. The reformers were particularly concerned with the teaching of science in the classical colleges. The colleges were the training grounds for the intellectual and social élite of francophone Quebec, and the reformers insisted that the colleges’ role should be expanded to include the training of top scientists. The professors launched their campaign

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68 Université Laval was established in 1852, when the Séminaire de Québec was granted university status by a Royal Charter. It fell under the authority of the Vatican’s Congregation for Catholic Education until 1971, when it acquired a new charter and became a fully independent, secular university. The clergy’s authority over higher education extended only to the French-language universities. The English, Protestant McGill College (later University) was a public institution.

in the journal of the province’s classical colleges, where they sometimes drew heated rebuttals from defenders of the traditional curriculum who believed that the reformers’ attacks opened the door to state education and secularisation.\textsuperscript{70} The reformers’ second major project focused on popularization, including an extremely successful movement known as the \textit{Cercles des jeunes naturalistes} (Young Naturalists’ Clubs). The \textit{Cercles des jeunes naturalistes} (CJNs) were clubs for children and teenagers modelled after the Scouts, and their central theme was scientific fieldwork and specimen collection. The tremendous success of the CJNs was widely acclaimed in educational journals, and even led to spinoffs such as the \textit{Cercles des jeunes agriculteurs} (Young Agriculturalists’ Clubs).

\textit{3.2 School Science and the Advancement of Scientific Disciplines}

In Ontario, educationists were the driving force behind science education reform in the 1920s and 1930s, but in Quebec it was professional scientists who led the push for school science reform. In an effort to improve the lot of science both in the classical colleges and the public schools, they emphasized recruitment in their arguments. Adrien Pouliot, a mathematics professor at Université Laval, issued an earnest plea for science teaching in a series of six articles in \textit{L’enseignement secondaire}, the journal of the classical colleges.\textsuperscript{71} In his opening piece, he charted the professional occupations of classical college alumni in order to highlight the dearth of students who had chosen scientific careers. For Pouliot, as for many of his colleagues, the welfare of science education in the province was central to the prosperity and self-determination of the French Canadian people. The acknowledged purpose of the classical colleges was to train an intellectual and social elite. The reformers did not try to undercut this mission; rather, they argued that it should be expanded to include the training of top scientists – not just priests, lawyers and other traditional professions.\textsuperscript{72} Famously, Pouliot threatened that unless

French Canadians stepped up their participation in industry and commerce, “we will be conquered a second time.”

It is not surprising that these reformers, speaking out as professional scientists, maintained strong disciplinary allegiances. They frequently made cases for the specific contributions of their respective fields, publishing essays with such titles as “The place of chemistry in secondary education” and “The teaching of biology and the training of the mind.” As they pushed for more science in francophone secondary schools, they were galvanized by a sense that the contents of a revised science program were still up for grabs. Scientists no doubt had an interest in promoting their own fields, since a steady demand for courses at the secondary level helped ensure the wider institutional success of their discipline.

In this climate of advocacy and campaigning, when the stakes were institutional security, professional prestige, and the promise of national economic success, key aspects of the educational philosophy of general science were unlikely to find much traction. General science proponents abroad had called into question scientists’ role in pre-college education and downplayed the disciplinary value of science. In Quebec, scientists were at the helm of education reform, and disciplines were in competition with one another for resources, time, and recognition in the province’s schools.

This disciplinary approach to science was reflected in the province’s textbooks. The standard science textbook was a primer of elementary science (sciences usuelles). Co-authored by Victor-Alphonse Huard, editor of Le naturaliste canadien, and Université Laval professor Henri Simard, the Manuel des sciences usuelles was first published in

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73 Pouliot, “Sciences,” 466.
1907 and reissued five times until 1924.\textsuperscript{75} Its content was divided into distinct categories, namely, zoology, botany, mineralogy, physics, cosmography and “industry.” In this respect it was similar to Ontario’s elementary science curriculum of the early decades of the twentieth century – though the latter intentionally eschewed any textbook. The Sisters of Saint-Anne produced a parallel series of science textbooks for girls, the \textit{manuels de connaissances scientifiques} (textbooks of scientific knowledge), closely modeled on Huard and Simard’s textbook. These books remained in wide use well into the 1950s.

Certain elements of the ethos of general science also clashed with the pedagogical principles of Quebec’s eight-year classical course. The classical colleges remained rooted in a highly structured, stepwise progression through the eight years of the course. A methodical, Baconian understanding of science underpinned the student’s progress through the eight-year program. Science learning was conceived as a strictly inductive process, guiding the student from object lessons in the program’s early years, to “philosophy” (i.e., generalizations and laws) at its culmination. For instance, Léon Lortie, a professor of chemistry at Université de Montréal, argued that chemistry contributed to general knowledge “only insofar as it follows the logical method”:

observing, learning and collecting facts; comparing them, grasping the relationships between them and classifying them. Then, by means of analysis and reasoning moving from the known to the unknown, generalizing . . . ; becoming initiated to scientific induction in order to establish for oneself the laws of nature; passing thereby from the concrete to the abstract, drawing conclusions from premises based on experience; synthesizing all this knowledge in a harmonious whole.\textsuperscript{76}

The student’s gradual advance from empirical facts to laws and structures demonstrates a deliberate emphasis on laws and theories – an emphasis that general science had jettisoned. Likewise, Université de Montréal geology professor Léo Morin would argue in \textit{L’enseignement secondaire} that the practice of science, which drew on skills of


\textsuperscript{76} Lortie, “La place de la chimie,” 256.
observation, classification, comparison and synthesis, represented “the complete cycle of
human thought.” Morin further argued that science should not be taught by considering
each branch in isolation, but rather by emphasizing the connections among its branches.
Despite their distinctive techniques and methods, the various fields of science culminated
in a common end-point, namely, the general principles of physics and chemistry:

And this is how botany, biology, and geology, beyond their specific
techniques, will on the one hand draw their general principles and their
methods of experimentation from physics and chemistry, and on the
other hand will provide multiple applications of these same principles
and experimental verifications on a large scale.  

Morin’s reflections on the reductionist unity of science highlight just how far removed
the reformers’ aspirations for secondary science education in Quebec were from the
educational philosophy of the general science movement as it found expression in
Ontario. Cornish had stressed that students’ minds thrived on small bits of concrete
knowledge and that the laws of science were too remote to be a relevant pedagogical
endpoint. In the United States, the general science movement had embraced Dewey’s
account of a “complete act of thought” in How We Think (1910, revised 1933). For
Dewey, thinking was fundamentally a process of problem solving, and the steps of
thought included identifying the problem, proposing solutions, testing them, and drawing
conclusions. Dewey did not intend this to be understood as a strictly inductive process.
Morin’s pedagogical arguments, rooted as they were in interdisciplinarity and the unity of
science, were therefore put to a very different purpose than similar arguments raised by
general science proponents. For Morin, the connections among the branches of science
pointed to a fundamentally reductive understanding of science. This bird’s-eye view of
science’s disciplinary structure, gleaned from the vantage point of the mature scientist,
was just what the general science movement held to be largely irrelevant to the young
pupil.

3.3 An American Textbook in Quebec

Despite these pedagogical differences, general science nevertheless made one notable appearance in Quebec. In 1934, a French translation of Caldwell and Eikenberry’s *Elements of General Science*, the iconic American general science textbook first published in 1914, was issued by the Quebec publishing house Garden City Press. The press was owned by James John Harpell, an enterprising businessman who was strongly influenced by the workers’ cooperative movement. The translation and adaptations were done by Louis Even, an employee of the press, and W. L. Goodwin, former Dean of the Faculty of Applied Sciences at Queen’s University in Kingston. Revisions were overseen by two Trappist monks at the Institut Agricole d’Oka, Brother Léopold (Ortiz), Director of the Oka school, and Father Louis-Marie, botany professor at Oka and author of a celebrated Quebec flora.78

The translation project was likely undertaken first and foremost for the benefit of the press’s own employees. Harpell was an autodidact and a firm supporter of adult education. He had expanded his Kingston-based publishing business to the small francophone community of Ste.-Anne-de-Bellevue, near Montreal, in 1918. Inspired by Sir Ebenezer Howard’s garden city movement in Britain, Harpell decided to create a workers’ community, which he named Gardenvale, where his employees could live and take night classes. One of Harpell’s guiding purposes as a businessman was to promote workers’ education through “self-study.” In 1922, he established the Institute of Industrial Arts as the educational wing of Garden City Press. Employees were strongly encouraged to take courses and were given a raise for every course they completed. “Learn More, Earn More,” was the motto printed on the cover of every course.79 Goodwin and Even, the translation-adaptation team for the general science textbook, were both instructors for night classes at Garden City Press.

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Whatever his primary motivations for commissioning the textbook’s translation, Harpell would have wanted to turn a profit with the initiative. This would plausibly explain why he sought the endorsement of the monks at the Institut Agricole d’Oka, whose only tangible contribution seems to have been writing the book’s preface. In the preface, Léopold positions the textbook within the recent popularisation movement initiated by French Canadian scientists:

The publication of this book . . . brings timely encouragement and support to the wonderful movement launched here a few years ago for the study of the natural sciences – for the study of the laws of nature. The creation of the *Cercles de Jeunes Naturalistes*, whose numbers continue to grow from year to year, was inspired by the innate fondness of young people for the things of nature.\(^{80}\)

Léopold makes no mention of the textbook’s fundamentally interdisciplinary approach, except to note that the student of nature required at least a smattering of knowledge from various scientific disciplines:

[T]he study of nature itself cannot go far without at least introducing the most elementary notions of physics, chemistry and mechanics. This book will initiate the student who has not had the advantage during his school years of broaching these subjects, whose applications turn up frequently in daily life.\(^{81}\)

In Léopold’s view, the new textbook was particularly well suited to the self-taught learner. He notes that the material is presented simply enough that anyone able to read could make progress, if they were willing to sacrifice a little leisure time to study. Clearly, Léopold assumed the book’s niche was for autodidact adults who had had little exposure to science during their formal schooling.

There is no apparent evidence that the new textbook was used in any classes at the Institut Agricole d’Oka, nor even that it was acquired by their library. Nevertheless,

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\(^{81}\) Ibid., iv.
Léopold and Louis-Marie’s commendation may have helped the textbook’s bid for authorization by the Catholic committee of the Council of Public Instruction. In 1935, the translated textbook was approved for used in primary schools – not for student use, but rather as a teachers’ manual and as a reference book for school libraries. Marketed as a primer, it remained unlikely to find a foothold within the private classical colleges, where science courses were still confined to years 7 and 8, Philosophy I & II, and heavily focused on laws and synthesis.

The official sanction of an American textbook in translation was the exception rather than the rule in Quebec’s francophone schools. Paul Aubin notes that less than 5% of Quebec textbooks were imported or translated. The vast majority of these imported books came from France. Indeed, the Caldwell and Eikenberry textbook appears to be the only American textbook to be approved by the Catholic Committee of the Council of Public Instruction. Textbooks were a lucrative industry in francophone Quebec. Home-grown textbooks were also an important symbol of self-sufficiency in matters of education, as they were in Ontario. The burgeoning francophone research community in the 1920s and 30s celebrated the publication of new science textbooks that could replace imported French ones, and they chronicled the history of science in Quebec by publicizing the legacies of influential scientists of the past. Yet the impact of “attractive” American general science textbooks – which was lamented by the Ontario reviewer quoted above – had been felt as far away as Australia. This was apparently just as true in Quebec. Andrée Dufour has observed that the French edition of *Elements of General Science* featured layout and content that were noticeably more modern than those of contemporary Quebec science textbooks.

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In Quebec, where educators were increasingly making allegations about Quebec’s alleged deficiencies in comparison to other places and looking outwards in order to modernize school programs, general science was granted limited approbation, but only insofar as it matched the prevailing purposes of Quebec’s educational traditions. Divorced from its original mandate and subsumed instead within vocational education and the pressing efforts of popularization, general science in Quebec served as an instrument of science reform in a way that its creators, the original Chicago reformers, would not have envisioned.

5. Conclusion

The strong networks of communication between the educational communities in Ontario and the United States, via educational journals and other published materials, meant that Ontario educators were keenly aware of the incipient general science movement emerging from Chicago. While a few expressed admiration for the American reforms, this was not sufficient impetus for adopting general science wholesale in a strongly centralized school system where caution and conservatism were cherished values. Rather, several concurrent developments combined to prompt its adoption. A growing skepticism about the extent of transfer of training meant that educators were ready to relinquish the idea that studying science necessarily conferred general intellectual skills. If transferrable mental competencies were not a viable pedagogical goal, it became more imperative that content of science courses be directly applicable to students’ lives. General science, which was rooted in practical problem solving and concrete applications from everyday life, seemed to offer a promising way forward. Its approach was all the more appealing given the efforts during the late 1930s to harmonize vocational and academic science education in the early years of high school.

Francophone Quebec had few ties with American or British educators. Rather, it looked to France, albeit often critically. Quebec educators compared their classical course to France’s secondary programs to underscore the need for an expanded science curriculum. In the 1920s and 30s, Quebec scientists fought for cultural and institutional support for science by arguing that scientific excellence was essential for French Canadian society to
compete in a global economy. In fact, many of the scientists who spearheaded this
movement would later become involved in nationalist politics. Galvanized by the
possibilities of an expanded science curriculum, scientists were keen to promote their
own disciplines, so the interdisciplinary nature of general science would have held little
appeal. Where general science was adopted, it was by an Anglophone business owner
concerned with the vocational education of his employees. There is little evidence that
French Canadian educators engaged with the general science movements in English-
speaking countries. Their attentions lay elsewhere.

Examining the ways in which educators in Ontario and Quebec interacted with the ideals
of general science brings into relief the different priorities that were at play in their
respective social contexts. In drawing such comparisons, apparent indifference can be as
revealing as direct responses. Comparative analysis can make silences conspicuous where
they might otherwise seem unremarkable. The absence of a general science movement in
Quebec becomes noticeable only when science education in the province is contrasted
with that in the neighboring province of Ontario. In the historiography of Quebec science
education, it has not previously been asked why Quebec did not interact with the general
science movement. Such a question remains invisible to those pursuing internal histories.
By searching for general science in Quebec, attention is drawn away from the established
historical narratives of science education to a seemingly minor incident on the margins,
the publication of Harpell’s translated textbook. The production of this textbook, which
ended up being approved for use in public schools, indicates that general science was a
genuine alternative for Quebec educators and not a moot point. Cross-national
comparisons bring into evidence a range of historical contingencies that would otherwise
escape our notice.
Conclusion

Competition for curricular time and resources in the late nineteenth century Ontario high schools meant that educators and science boosters grappled with how to identify and defend the unique moral and intellectual contributions that science courses made to a general education. The implementation and expansion of laboratory-based science courses came with expenses to school boards and trade-offs in the curriculum. The reactions of high school teachers and university professors to changes in the curriculum show that they perceived the stature and repute of their various disciplines to be deeply intertwined with the shape of the high school curriculum.

The fact that the high school curriculum – particularly, the university matriculation requirements – was a clear avenue to academic prestige and public regard elicited forceful pedagogical arguments on behalf of high school science. In the 1880s, when John Seath worked to implement and standardize laboratory-based science teaching, these pedagogical arguments hinged on loose appeals to mental discipline. A central thrust of these arguments was to stress what science was not: science was not mere facts; it was not merely utilitarian; it was not merely materialistic. Rather, it conferred culture, discipline, and mental acuity, broadly speaking.

Educators’ incentive to imbue high school science with deeper cultural and intellectual value was powerful and enduring. Chapter 1 considered how, less than a decade after Minister of Education George Ross framed the value of science exclusively in terms of mental discipline, the theory of mental discipline was called into question by the psychological experiments of Edward Thorndike. Psychologists were staking their own claims to authority over the curriculum, which rested on alternate conceptions of learning and child development, such as G. Stanley Hall’s theory of developmentalism. Despite such challenges – as well as pronouncements by some reform-minded educators that the “doctrine” of mental discipline had been debunked – hope in the promise of general, transferrable intellectual skills had enormous staying power. Chapter 5 showed how in 1936, almost forty years after the emphatic critiques of mental discipline theory were first voiced within the Ontario Educational Association, teacher and textbook author Henry
Bowers grappled openly with the same issues. The dubious evidence for transfer of training, he believed, meant that high school science courses should focus instead on providing “valuable information.” Nevertheless, he remained optimistic that science courses could lead to “sound habits of mind” and rational thinking in the spheres of politics and society. Even he, despite his stark appraisal, did not relinquish the hope that a well-designed science curriculum could create wiser and more judicious citizens.

These intellectual ideals had staying power in part because they served important underlying objectives. In 1880s, as the Ontario Department of Education pushed for sweeping pedagogical changes in high school science classrooms, it underscored the pedagogical importance of hands-on learning. Its insistence on “practical” science teaching in the 1880s helped secure province-wide standardization of high school curricula and teaching practices and imposed the Department’s authority on local boards. Putting laboratories in high schools also served the interests of university research scientists, bringing university-level reforms full circle. The spread of laboratories reinforced the idea that research-driven science was the way of the future. Laboratory-based teaching in high schools also created a need for laboratory-trained science teachers, who ensured steady enrolments in university science classrooms.

Placing a premium on the intellectual and moral rather than the practical value of science also served to demarcate high school science from technical education and to confirm its academic credentials. Educators’ emphasis on the importance of experiments appealed to the instrumental, hands-on nature of science. The application of the inductive method, however, provided a bridge from the concrete to the abstract. It validated experimental science as a path to abstract truths. By insisting on the abstract reasoning skills that they argued were intrinsic to the scientific method, educators justified science’s position in the upper years of the high schools and secured its role as a purveyor of social mobility via the matriculation examination.

At stake also was the public image of science. In the realm of education, this image was shaped by vocal clashes with educators of languages and literature. Proponents of science justified its value by reasserting its inherent difficulty, which, they insisted, rivaled and
even surpassed that of studying classical languages and literature. As members of the Ontario Educational Association squared off and engaged in open conflict about the place and weight of different subjects in the matriculation requirements, their clashes drew on and endorsed popular dichotomies between sciences and the humanities, particularly when it came to their roles in the cultivation of morals and emotions. Even as some educators, like Nathan F. Dupuis, embraced the notion of a fundamental opposition between science and the arts as a rhetorical tool for his polemical science-boosting, others embraced the very same notions as an attempt toward conciliation, emphasizing the complementary roles of science and the arts in students’ emotional maturation and learning. Their arguments on behalf of student learning reinforced cultural wider narratives about the role of science as a path to wise citizenship and personal discipline.

The shape of science on the curriculum also served, at times, the professional ambitions of educators who sought to wrest control of the curriculum away from the universities and establish their own credentials as researchers and educationists. The showdown between high school teacher George Cornish and university professor William Lash Miller examined in Chapter 4 illustrates this clearly. While Lash Miller framed his arguments in terms of the pedagogical rigour of precise nomenclature and strict empiricism, he also insisted that high schools needed to lay the proper groundwork for university studies and complained that he found himself having to undo the fuzzy thinking around atomism perpetuated by the high school chemistry course. Cornish, meanwhile, framed his arguments in terms of the non university-bound students, insisting that they needed to be initiated into the common parlance of chemistry. The fact that Cornish’s view won the day, and that Lash Miller’s published textbook was passed over, suggests that the university’s grip on the curriculum was loosening.

The Cornish-Lash Miller episode also highlights the distinctive interaction between textbooks and scientific controversies. The high stakes created by Ontario’s one-textbook policy, the charged political atmosphere surrounding textbook production, and the strategic rhetorical focus on the distinctive needs of young learners all set the terms of the OEA debate. The Department of Education’s decision to pass over the textbook that represented Lash Miller’s dissenting views suggests that a Kuhnian view of textbooks as
canonized scientific knowledge, the verdict on the conflict stage of a scientific revolution, might well have particular merit when it comes to high school level textbooks. The proselytic nature of Lash Miller’s commentary about atomism in his textbook illustrates Kuhn’s claim that science textbooks are fundamentally “persuasive and pedagogic” in purpose. Contra Kuhn, however, Lash Miller’s textbook did not merely propose to initiate a new generation into accepted scientific doctrine, but had the potential to enlist that generation into a live, ongoing scientific debate. Finally, this episode highlights the importance of examining the conflicts surrounding the production and selection of textbooks, particularly when a higher authority (in this case, the Department of Education) that does not have a special claim to scientific expertise is compelled to arbitrate a scientific debate. In this instance, the mission of the high schools was thrust into the foreground, with Cornish presumably convincing the Department that it should teach a “safe,” majority view (as he compellingly portrayed his own position) rather than require students to inhabit the frontiers of a live scientific controversy.

The history of the teaching of high school science in Ontario also highlights fundamental changes in educators’ conceptions of scientific research and expertise. In the late nineteenth century, scientific investigation and classification were perceived as a collective cause – an endeavor that every interested hobbyist could contribute to the great store of scientific knowledge in his or her own small way. This view of science as the shared enterprise of enquiring minds was reflected in the pedagogical aspirations of the high schools. Students could head out into the fields and collect specimens of the local flora and fauna – and infer from their observations wider principles of morphology and classification. However, by the 1920s and 30s, science educators increasingly took up the refrain that students’ minds were ill equipped to make generalizations or to grapple with abstract laws of science. Scientific laws were the preserve of specialists, and specialization was anathema to the mission of the high schools. Given research scientists’ preoccupation with the “bird’s-eye view” of science, they made poor educators. It was educators – those who aimed to be generalists – who had real insight into students’ minds and abilities, and therefore, into how the curriculum should be constructed.
In the 1880s, as science offerings were being expanded and laboratories being built in high schools across Ontario, conceptions of school science were crafted to harmonize within the traditional, cultural mission of the high school. Once its prominence on the curriculum was established, school science was used as a lever to broaden the mission of the high school: to address the needs of non university-bound students, to appeal to students’ natural interests, to carve out inroads for progressive education, and to assert high schools' greater independence from universities. During the period covered by this dissertation, school science continually negotiated a balance between conforming to the established mandate of high schools and acting as a tool for changing that mandate. Science’s success and prominence in the high schools, in turn, reinforced its rising status in society at large and helped cement the notion, virtually unquestioned today, that science was an indispensable building block of every citizen’s basic education.
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