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Articulation Between High School and CEGEP Science Post- Reform: Understanding the Gap

Heather McPherson and Maggie McDonnell

Abstract

Reforms in K-12 science education are global. New national science curricula were introduced in the United States (NRC, 1996), in Canada (CEMC, 1997), and in Europe (European Commission 2007). In this article, the impact of these reforms on college students in Quebec is studied. Articulation between high school and college sectors is viewed through the lens of STEM (Science, Technology, Engineering, Math) high school and college faculty. Faculty of both communities experienced stress

HEATHER MCPHERSON

Heather McPherson is a doctoral student in McGill University's Department of Integrated Studies in Education, and she is a full time high school science teacher. Her doctoral research focuses on teacher engagement with inquiry-based

as the first education reform curricula cohorts entered college. Results of a diagnostic test developed by CEGEP faculty to assess college preparedness found no difference in math and science content knowledge when pre-reform cohorts were compared with cohorts instructed with the reform curriculum. Improvements were observed in problem solving skills, which has led to changes in pedagogy at the college level. Articulation between the two sectors could alleviate anxieties among faculty and students.

learning through participation in Professional Learning Communities.

MAGGIE MCDONNELL

Maggie McDonnell is a doctoral student and course lecturer in McGill University's Department of Integrated Studies in Education. She also teaches English Literature and Liberal Arts at Vanier College, and is a part-time yoga instructor. Her doctoral research focuses on personal and professional identity in higher education teachers, and the relationship between identity and approaches to assessment.

Introduction to the Research

In Quebec, the college system is somewhat different from the college system in other regions of North America. Colleges are referred to as CEGEP, which is an acronym for Collège d'enseignement général et professionnel. The CEGEP system is divided into two programs, one of which is perhaps best compared to two-year colleges in other regions of North America. Quebec students complete their secondary school in Grade 11. Following the two-year CEGEP program, students are admitted to university. In university, they receive advanced placement. Essentially, they would have one less year of university courses than a student entering a Quebec university from out of province (unless that student had completed an AP program in their home province) The province's CEGEPs also offer three-year programs which prepare students for direct entry into the workforce in a variety of technical fields. Study of the CEGEP system is an important endeavour, given the number of students involved in the system; in 2010, there were almost as many students enrolled in CEGEP (210,084) as university (277, 398) (Statistics Canada, 2010). In

2012/13, there were 198,672 full-time university students in Quebec, and 196,566 students enrolled in full-time college studies (Statistics Canada, 2014), in other words, almost a 1:1 ratio, which is significantly higher than the 2:1 national average.

Articulation, bridging of the gap, between educational sectors is an on-going preoccupation for secondary high school teachers and their college counterparts. In this study, a Quebec high school science teacher and a CEGEP teacher, had informal discussions with high school teachers and CEGEP teachers in science, technology, engineering and math (STEM) disciplines to gain insights into the gap between high school and CEGEP science and math curricula. Changes in science curricula at the high school level have direct implications for college level science courses. In Quebec, and across Canada, high school curricula changed both in content and in recommended content delivery when the *Common framework of science learning outcomes, K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum*, was published in 1997. In response to these changes in curricula, college teachers had numerous questions and concerns, including:

- Are students adequately prepared for college in light of these changes?
- Do students have the same skillsets they had prior to the implementation of new curricula?
- What are necessary adaptations in curricula and pedagogy that college teachers need to consider?
- In particular, how will these differences impact college students and professors of STEM disciplines?

In an attempt to understand the impact of curricula

changes, four CEGEP teachers initiated the *Integration of Students Entering the CEGEP Science Program after 2010 program*, which included a Math Science Diagnostic Test (MSDT) to measure the skills and knowledge of the first cohorts of post reform students. This initiative studied incoming college students, but did not include input from the high school sector with regard to required content knowledge and pedagogy. Feedback from the high school sector indicated that there is an expectation on the part of CEGEP teachers that certain content will be covered in high school. Some high school teachers are attempting to meet these expectations, at the expense of high school curricula. High school teachers questioned the reliability of the MSDT since it was developed without input from high school teachers, who have expert experience on knowledge expectations of their graduates.

What research has been done on the articulation of the high school and CEGEP sectors in Quebec? Answering the above questions is important. If the two sectors work in collaboration, the transition from high school to CEGEP has the potential to reduce student anxiety. High school teachers would gain insights into the expectations, both content and pedagogies, of higher level education. CEGEP teachers would gain an understanding of high school curricula, and would have a clear understanding of content covered and how the content was delivered. In so doing, the gap between the two sectors would narrow, easing the transition for students entering CEGEP. In this article, we (a high school science teacher and a CEGEP teacher) explore concerns of high school and CEGEP science teachers as the education reform was implemented, and eventually, its students entered the college network. Both sectors experienced numerous

stressors leading up to the transition. Currently, the first four reform cohorts have graduated from CEGEP.

The importance of STEM education has been discussed on a global level, not least because the demand for STEM graduates has increased while the number of incoming freshmen who declare a STEM major has remained stagnant (Brown, et al, 2015). In a report by the President's Council of Advisors on Science and Technology (2010), there is a stated need for a large and increasing supply of workers who can use STEM knowledge and skills in their jobs. Companies in STEM-related fields, such as aerospace, defense, life sciences, and energy sectors, are reporting shortages of skilled workers. Articulation and dialogue between high school and college teachers has the potential to increase student retention in STEM disciplines, and to improve access to college STEM courses, as well as projected STEM careers.

Background for the Research

The science curriculum in Quebec, part of the Quebec Education Plan (QEP), or Reform, is a competency-based curriculum that was introduced in 2000. The QEP involved a new approach to education requiring a paradigm shift for teachers. Prior to the Reform, teachers taught learning objectives that focused on the transmission of knowledge. In contrast, the QEP incorporates social constructivist theory with cognitive theory as a means of promoting competency development. Competency is defined as: “the mobilization of resources in a specific context, the availability of a diversified repertoire of resources and the capacity to reflect upon the process of mobilizing, reorganizing and integrating the resources” (Ministère de

l'éducation, du loisir et du sport (MELS), 2007). In secondary high school science courses, the QEP emphasizes student engagement with scientific inquiry and technological processes. Students develop scientific and technological literacy, enabling them to become active, critical, informed participants in social issues, using products of science and technology responsibly, and participating innovatively (MELS, 2007). Students must be taught and evaluated on their understanding of complex, authentic situations. Teachers choose strategies facilitating mastery of complex problems suited to students' learning needs while ensuring educational differentiation (MELS, 2007). The reform in science curricula involved significant changes in teaching practices and philosophy. Moreover, there were changes in science content. Some content was removed from the courses, while new topics were added. These content changes were perceived by high school teachers as minimal, whereas the changes in method of content delivery were seen as radically different to pre-reform pedagogies.

The first science reform cohort graduated from high school in 2011, precipitating some anxiety among CEGEP science teachers, who were concerned that the new curricula would not adequately prepare students for science programs in CEGEP. The question of high school student preparedness for college and university is well documented. In the United States, most states have adopted the Common Core State Standards (Achieve, 2015), with corresponding assessments to measure high school students' mastery of college content in English and mathematics. There is a "sense of urgency to close the gap between college eligibility and college success" (Annenberg Institute for School Reform, 2014). In the

US, government agencies have mobilized in an effort to increase graduation rates in colleges and universities. The first pan-Canadian research was released in 2007 by the Association of Canadian Community Colleges, Human Resources and Social Development Canada. The pan-Canadian research surveyed college students from colleges in all provinces and territories. Survey results indicated that a significant number of students believed their basic academic and learning skills were weak, in particular for studying, test taking and math skills (p. 59). A conclusion of the pan-Canadian research was the need for more secondary school and college collaboration and sharing of information to improve students' understanding of college programs (p.60). Currently, there is regular sharing of information between high school guidance personnel in Quebec high schools and CEGEP academic advisors. What is missing is the collaboration between teachers of the two sectors.

Articulation between Sectors

In an effort to bridge the gap between secondary science and CEGEP science sectors, the Quebec Educational Mathematics and Science Alignment Project (QEMSAP) was formed in 2007. QEMSAP was a project that was the result of a grant from Quebec's Ministry of Education, (MELS), initiated by S. Apollonia. The goal of QEMSAP was to cultivate an environment that provided opportunities for educators from high school, CEGEP, and university, to use their respective expertise to develop relevant problem-based situations for use in high school. (Apollonia, 2008). Apollonia recognized the fragmentation existing between the two sectors. As a CEGEP science teacher, Apollonia realized that if students arrived in CEGEP science courses and there was

no articulation between the two sectors, those students would be negatively impacted, and their college experience would potentially suffer. Teachers from the high school and CEGEP sectors as well as university 4th year education students met over the course of one year to analyze the alignment between the various institutions. Project members, including H. McPherson, worked in heterogeneous groups to develop complex problems consistent with the QEP. This provided an opportunity for all stakeholders to work collaboratively in a community of practice (CoP).

As a QEMSAP participant and high school science teacher, I (Heather) felt that the one-year initiative led to a shared understanding of the reform high school math and science curriculum. Participating in a CoP with high school and CEGEP teachers permitted both sectors to voice concerns, find solutions, and write lesson plans as a community with the common objective of ensuring that the transition from high school to college was a positive experience for students. Through the efforts of QEMSAP, stresses associated with reform were somewhat alleviated for those who participated. However, both sectors had unaddressed concerns. As a high school science teacher, I felt and still feel uninformed about changes in curricula at the CEGEP level. Were the changes in pedagogical approach going to leave students bewildered? Adhering to reform pedagogies required that high school teachers teach using inquiry-based learning, which involves probing students' preconceptions in an effort to elicit student thinking. Would this skill set be valued or recognized in CEGEP? Furthermore, were CEGEP teachers prepared to adapt CEGEP science courses to reflect the changes in science concepts outlined by the QEP? The importance of STEM

disciplines is well documented. But how can I, as a high school science teacher, ensure the success of my students if I am unaware of the expectations of CEGEP teachers? In conversations with CEGEP science teachers, they felt uninformed about high school science curricula.

Although efforts were made, through participation in QEMSAP, to bridge the divide between high school and CEGEP science, there were serious concerns amongst CEGEP teachers that incoming students would lack adequate content knowledge for CEGEP science in light of changes in high school curricula. If high school science courses were taught following the reform curricula, using problem-based learning, then the concern was that less time would be spent developing foundational science content knowledge. These concerns prompted a group of science and mathematics teachers from four English CEGEPs to collaborate, and ultimately release a report entitled “Integration of Students Entering the CEGEP Science Program after 2010.” (Forand, 2011). The report presented the findings of a Math and Science Diagnostic Test (MSDT), administered to incoming college students over three years, as well as a series of recommendations based on the results. The primary concern which the test was designed to address was the level to which students were prepared for CEGEP science courses in reference to the pedagogical reforms at the secondary level under the QEP.

Analysis

Teachers and administrators at the college level had concerns regarding post-reform students. Based on their analysis of curriculum documents proposed under the QEP, CEGEP teachers felt that “some college prerequisite topics/skills” were not covered by the new curriculum

(Forand, 2011, p. 3). As well, a perceived lack in “support material and pedagogical training” as the reform was implemented would likely result in “some level of divergence” in the skills and knowledge of incoming students (p. 3). To address these concerns, CEGEP teachers initiated the Integration of Students Entering the CEGEP Science Program after 2010 program, which included a Math Science Diagnostic Test (MSDT) to measure the skills and knowledge of incoming high school students. The group administered the test at four colleges in 2009, 2010, and 2011. The diagnostic test was designed to:

- assess the mastery of students with regards to certain topics in mathematics, chemistry and physics
- monitor changes in students’ skills/knowledge
- compare changes with students in the cohort preceding the implementation of the Reform (p.3).

Based on their findings, Forand (2011) and the group of CEGEP teachers felt they would be able to inform their colleagues about the skills and knowledge of the incoming students, enabling pedagogical adjustments and development of support material as required. The expectation among CEGEP teachers was that incoming post-reform students would be unprepared and would not possess the necessary knowledge to be successful in college-level science courses. There appears to have been little effective consultation between the government and its teachers. Most teachers at the different colleges shared the concern that students would be less well-prepared than their pre-reform counterparts. However, despite widespread concern regarding the potentially negative impact of the reform on students’ skills and

knowledge, within both science and mathematics programs, the diagnostic test revealed little of value. Differences in test results between pre- and post-reform cohorts were negligible. It was determined that the project revealed no significant effect of the new curriculum on students' performance (Forand 2011, p. 69).

By 2016, four post-reform cohorts have entered and graduated from CEGEP Science programs. We initiated conversations with two of the original coordinators of the integration program to reflect on their study, its results, and where they feel students and teachers are now situated. Below is a summary of the conversations:

1. *What were the reactions of the CEGEP community to the MSDT results? Were changes made in instructional goals, activities, or assessments?*

Given the “underwhelming” results, teachers felt their study was “met with thundering apathy.” One physics teacher suggested that his department was more concerned with the impact of the reform on incoming students' math skills, rather than their knowledge of physics. There was little effect on the physics curriculum, although more CEGEP teachers began using active learning strategies and tools such as Webworks. Similarly, one chemistry teacher indicated that he shifted the focus of his prior knowledge review, based on the results of the MSDT, and began using more active learning approaches. Most members of the CEGEP team observed a general trend toward more active learning and web-based learning tools; however, their analysis of this trend is that it reflects changes in pedagogical philosophy, rather than a direct

influence of the reform curriculum.

Two members of the team felt that limitations of the MSDT – it was relatively short, yet attempted to test student knowledge in three disciplines; there were limited numbers of students; and testing was done only over three years – coupled with the tepid results, undermined the project, and led to no significant or lasting changes, departmentally or systemically. However, most members of the team felt that the MSDT revealed small gaps, which allowed individual teachers to make adjustments to their introductory courses.

2. *Do classroom experiences with subsequent student cohorts meet expectations of the report? Are post-reform students better problem-solvers?*

Overall, the team felt that despite the handwringing panic prior to the first post-reform cohort, their students were prepared – or not – just as well as their pre-reform counterparts. One team member felt that post-reform students seem to have better problem-solving skills, but this was balanced against a general decrease in writing skills. Of course, as another team member pointed out, some teachers will always feel that their incoming students are ill-prepared, regardless of any curriculum reform.

The CEGEP team reported that post-reform students were about as prepared as the incoming students had been prior to the reform. In the classroom, this meant the same melange of students: the enthusiastic and motivated, the strugglers, and the wide range in between. Students scientific knowledge and skills remain the same.

However, teachers did feel that post-reform cohorts

are better able to work effectively in collaborative groups and with technology.

3. *Have reform pedagogies, such as multi-disciplinary projects, small group projects, or flipped classrooms been adopted in CEGEP science departments?* (Flipped classrooms are a pedagogical model in which class time is devoted to project-based activities, and students are responsible for accessing lecture material, through online videos, outside of class time).

One outcome of the reform “panic” was the institutional reflection on curriculum and teaching practices. CEGEPs have used teachers’ concerns about the incoming post-reform cohort as an opportunity to work collectively, on how and what to teach incoming post-reform students. The relief, generated by students who had, more or less, the same skills and knowledge as those who came before, meant that most teachers fell back into tried and true syllabi and instructional practices. Our respondents all reported that departmentally, very little has changed, although they also all felt individual teachers in different departments had embraced new instructional strategies and learning tools. On the other hand, shifts in pedagogy do not seem to be informed by the reform; teachers who are now using small collaborative group work, for instance, were likely using it before the reform, and those who are using on-line learning tools found these tools independently of the reform curriculum.

4. *Were high school teachers involved in developing or analyzing results of the MSDT?*

Some CEGEP teachers were involved with the QEMSAP project, prior to the creation of the MSDT

project, so had interactions with their secondary school colleagues. However, CEGEP teachers felt they were alone in the MSDT phase of reform-related projects, and that their high school colleagues were dealing with the implementation and impact of the reform at their own level. One respondent felt that what little interaction he had with the high school teachers suggested that many were uncomfortable and/or ill-equipped to implement the reform. The MSDT project team did not share their results widely, because the diagnostic test revealed very little impact of the reform, either positive or negative, on incoming students.

5. *While the CEGEP Science QEP specifically refers to preparing students for ongoing studies at the university level, there is no corresponding reference in the secondary QEP to prepare for CEGEP studies. What steps are taken to ensure preparation for the transition from CEGEP to university? Is there articulation between levels?* CEGEP teachers were divided in their responses here. Two were discouraged by the “lack [of] vision” in the Science programs at both levels. They reported that high school teachers are teaching to ministry exams, and as a result, students are taught to memorize formulae and “churn out” answers, without deep understanding of concepts. Similarly, CEGEP teachers are now learning that their university counterparts report a lack of coherence, despite QEP guidelines regarding preparation for subsequent levels. In short, there appears to be an insular view, at least systemically if not individually; high school teachers teach for exit exams, CEGEP

teachers teach for common exams, and all levels feel disappointed and ignored by the others. The good news is that there is an ongoing dialogue between CEGEP and university programs. CEGEP teachers seem optimistic about the renewed interest in articulation between CEGEP and university. One respondent reported that the CEGEP shift towards university preparatory material – as opposed to a focus on remedial support – seems to work well with students, and so his department is encouraged.

Conclusions

In summary, the anticipated gap in science and math content knowledge of the first three cohorts moving through high school to CEGEP graduation did not exist. Content changes in the QEP for high schools were minimal. The MSDT administered to incoming students prior and post reform revealed no significant difference in content knowledge. Looking back, it is unfortunate that the diagnostic was not administered to a greater number of cohorts, over an extended period of time. The results of the report coincided with the transition period of high school reform, which is on-going. High school pedagogies are in transition, as teachers are learning how to incorporate reform-based pedagogies into their lessons. To date, not all high school teachers are comfortable with inquiry-based and problem-based learning, and with competency evaluation. Reform pedagogies at the high school level are evolving. The opportunity to determine long term trends, both positive and negative, as reform delivery becomes consolidated would be of interest and value. To date, there has been no research completed on this topic.

The evolution of reform-based pedagogies is also of

interest. High school teachers are expected to incorporate problem-based and inquiry-based lessons into their teaching repertoire. In the CEGEP sector, individual teachers have embraced new instructional strategies and learning tools, however, these shifts in pedagogy do not seem to be informed by the reform; the CEGEP teachers who were previously inclined to incorporate reform-based pedagogies into their lessons do so. Here too, more research is required. It is expected that with time and better understanding of reform pedagogies, more CEGEP teachers would incorporate these pedagogies into their lesson. Articulation with their high school counterparts could facilitate discussions of alternative pedagogies.

Unfortunately, yet perhaps not surprisingly, the lack of communication and interaction between high school and CEGEP teachers remains problematic for all involved, including students. Common misconceptions, such as the comment made by one respondent, that high school teachers are simply teaching to ensure students pass end-of-year exams, and that high school science programs lack vision, could be addressed if articulation meetings happened on a regular basis. Science teachers, on average, review for one to two weeks prior to exams. As a high school science teacher (Heather), we are too busy delivering the QEP in all of its complexities and depths to complete the program earlier. Issues of time and location make meetings between these stakeholders difficult. The vision of QEMSAP was lofty and of value to participants. We hope for similar initiatives moving forward, as the need for articulation between high school and CEGEP would benefit teachers from both sectors, and, more importantly, it would benefit students.

An unexpected outcome of this study was the realization that the mission of MELS pre-university science programs in CEGEP is to provide “genuine continuity between pre-university programs and university programs ... using a «competency-based» approach” (MELS 2010, p. xvii). The mission of MELS high school programs are threefold: “to provide instruction, to socialize and to provide qualifications” (MELS, 2007, p. 5). Nowhere in the QEP is there an explicit goal for high school to prepare students for CEGEP. The authors found this gap interesting, as many high school teachers are preoccupied with adequately preparing students for CEGEP, and many CEGEP teachers expect high school teachers to prepare their students for CEGEP. The reality is that high school teachers are mandated to teach the QEP following guidelines prescribed by the Ministry of Education of Quebec. The authors feel that the intersection between high school and CEGEP needs to be better understood, and further research is required in this area. In Quebec, a renewed dialogue between the CEGEP and university sectors is a positive recent development. The need for similar articulation between high school and CEGEP is vital if these two sectors hope to align their course content, and to develop an understanding of expected student preparedness as they exit high school.

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