Focusing on Science, Technology, Engineering, and Mathematics (STEM) in the 21st Century

By Isha DeCoito, PhD

Defining STEM

STEM, coined at the National Science Foundation (Howard-Brown & Martinez, 2012), is the intersection of science, technology, engineering, and mathematics. It is an approach to solving problems in a holistic way; seeing how the components of STEM interact with and inform each other (Figure 1). STEM education is critical to and supportive of many education reforms being undertaken today, from adoption of common international standards to better teacher preparation to enhanced coordination across the entire K–12 education system. STEM emphasizes a multidisciplinary approach, including inquiry and problem-solving, for better preparing all students in STEM subjects, and increasing the number of post-secondary graduates who are prepared for STEM occupations (Mishagina, 2012; National Research Council, 2012, 2013). A major goal of the STEM agenda is to improve the proficiency of all students in STEM, regardless of whether or not they choose to pursue STEM careers or post-secondary studies, while fostering 21st century skills identified as being crucial for success, including critical thinking, problem solving, creativity, collaboration, self-directed learning, and scientific, environmental and technological literacy, to name a few (DeCoito, 2012). The ability to understand and use STEM facts, principles, and techniques are highly transferable skills that enhance an individual's ability to succeed in school and beyond, across a wide array of disciplines. Hence, STEM elements are viewed as fundamental in the preparation of our next generation.

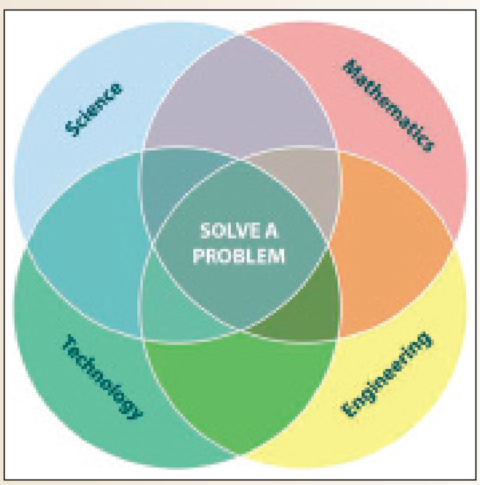

Figure 1. The intersection of STEM (Howard-Brown & Martinez, 2012)

Canada and STEM Education

Achieving greater STEM proficiency begins in the K–12 system, where in many countries including Canada, students have not demonstrated significant gains in math and science.

In 2007, based on PISA results and other factors, the Conference Board of Canada determined the following ratings for education and skills in Canada (Table 1).

Table 1
Report Card: Education and skills in Canada 2007

Overall	A
High-school completion	A
College completion	A
University completion	B
Ph.D. graduates	D
Science, math, computer science, and engineering graduates	C

As evidenced in Table 1, Canada's participation in STEM education at the post-secondary level is awarded a "C" grade, based on Canada's relatively low proportion of graduates in these fields (Mishagina, 2012; Orpwood, Schmidt, & Jun, 2012). In addition to receiving a D grade for the number of Ph.D. graduates, more disturbing is the ratio of male to females at the graduate level. Male and female participation in areas related to STEM continue to demonstrate a gender disparity, especially prevalent in science and engineering fields, as illustrated in Figure 2. In terms of educational attainment, the number of graduates in STEM fields has not increased. Statistics Canada (2013) indicates that at the post-secondary level, STEM fields represent 18.6% of all fields of study. Interestingly, women held a higher share of university degrees among younger STEM graduates than among older ones, but men still held the majority of university STEM degrees. In 2011, men represented the majority (67.4%) of adults aged 25 to 64 with STEM degrees at the university level. In comparison, among adults with a non-STEM university degree, 6 in 10 (60.6%) were women. The gender disparity continues in STEM graduates.

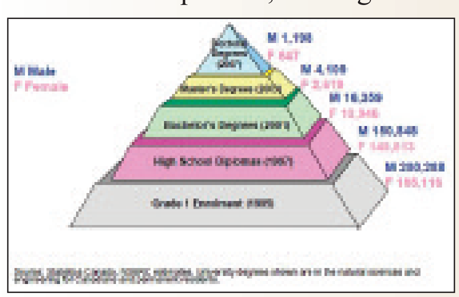

Figure 2. The Natural Science and Engineering Supply Chain

Globally, when it comes to STEM graduates Canada is awarded a "C" and ranks 12th out of 16 peer countries (Figure 3). In 2010, Canada's proportion of overall graduates emerging from science, math, computer science and engineering disciplines was 21.2 %, the third year of decline. These trends have ramifications in terms of satisfying labour demand and promoting business innovation. The Conference Board concluded that Canada needs more graduates with advanced qualifications and more graduates in STEM fields as these graduates are necessary to enhance innovation and productivity growth, and ultimately to ensure a high and sustainable quality of life for all Canadians (Conference Board of Canada, 2013). In response to Canada's overall ranking, Employment and Social Development Canada commissioned the Council of Canadian Academies to assess Canada's preparedness to meet future skills requirements in STEM. The main focus was the role of STEM skills in fostering productivity, innovation, and growth in a rapidly changing demographic, economic, and technological environment, as well as the demand for STEM skills in the global market. Additionally, the focus included the evolution of STEM skills, which skills are likely to be most important for Canada, and how well Canada is positioned to meet future STEM skills needs through education and international migration. The Council was also charged with exploring factors affecting Canada's supply of STEM skills, especially through the Canadian learning system and international migration.

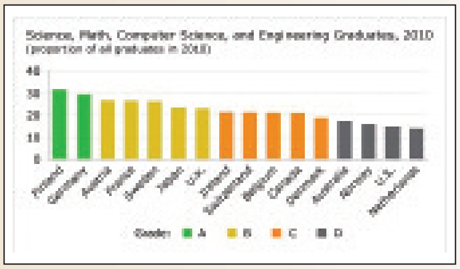

Figure 3. STEM Graduates (Conference Board of Canada, 2013)

The Importance of STEM

There is general consensus that one of the origins of the underrepresentation of STEM in our education system, combined with a 'negative image', resides in engaging curious young minds in the early grades, specifically at the elementary level. As a result, elementary science education has come under increased attention as educators, researchers, and policy makers have united around the notion of the important foundational role elementary science plays in later success in STEM education (Duschl, Schweingruber, & Shouse, 2007). Issues with inadequate STEM preparation in the early grades ultimately play a role in high school course choices, and ultimately post-secondary and career choices.

Integrating STEM subjects can be engaging for students, can promote problem-solving and critical thinking skills, and can help build real-world connections. However, STEM has long been an area of some confusion for some educators. While they can see many of the conceptual links between the various domains of knowledge, they often struggle to meaningfully integrate and simultaneously teach the content and methodologies of each these areas in a unified and effective way for their students (NRC, 2012; Thomasian, 2011).

Essentially the questions are: How can the content and processes of four disparate and yet integrated learning areas be taught at the same time? How can the integrity of each of the areas be maintained and yet be learned in a way that is complementary? These are ongoing challenges faced by educators, and are among the many factors affecting STEM preparation in the early grades. For example, failure to motivate student interest in math and science is prevalent in most K–12 systems, as math and science subjects are disconnected from other subject matter and the real world, and students often fail to see the connections between what they are studying and both their everyday world and STEM career options (AAAS, 2001). Yet these students rely on science and technology every day in smart phones, computers, televisions, medicines and everyday products, without understanding the underlying connections to math and science (NRC, 2012). This can potentially affect students' career choices as they typically form notions of their career path in secondary school. Without the pertinent information, fully capable students may circumvent STEM studies because they could not foresee the applications of STEM knowledge.

Similarly, the lack of STEM engagement and preparation in the early grades jeopardizes a student's ability to enter and complete a STEM post-secondary degree because the student did not enroll in the appropriate courses in high school or spend enough time practicing STEM skills in exciting, real-world hands-on activities. Clearly, determining factors that lead to better STEM preparation is important, including programs and initiatives that ignite the 'science spark' and encourage students to continue their studies in mathematics and science and to consider careers in engineering, science, and technology. Helping students see the connections between math and science and future career opportunities is a critical aim of the STEM pipeline. Motivating interest in math and science requires improved teaching strategies in the classroom and opportunities within and outside the classroom to demonstrate linkages between math and science, real-world applications, and future careers (Singh, Granville, & Dika, 2002; Tela, 2007). Five domains have been proposed for promoting STEM involvement including: interest and engagement; competence and reasoning; attitude and behavior; career knowledge and acquisition; and content knowledge. These domains will require integrating a STEM focus in teacher education programs, as well as sustained professional development of teachers in order to prepare students for success in STEM education. Furthermore, opportunities for students to interact with professionals in STEM fields are vital.

STEM Outreach

There has been widespread support for outreach programs and informal learning opportunities focusing on STEM enrichment. Outreach programs provide valuable experiences that ignite interest and demonstrate how math, technology, engineering and science connect to everyday

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life and careers, and allow students to expand their skills (Thomasian, 2011). *Go ENG Girl* is an example of the type of outreach program currently being advocated by the scientific community to promote STEM skills and interest for students. Through this initiative, grades 7-10 girls across Ontario interact with mentors in STEM professions, engage in STEM hands-on activities, and are exposed to STEM career choices at their local university. This year's event at Lassonde School of Engineering, York University introduced participants to the world of geomatics and real-world applications, such as land surveying. Currently, Ontario is experiencing a shortage of land surveyors. Once deemed a male-dominated profession, this is a career choice available to both boys and girls, and students should be exposed to and encouraged to pursue this STEM profession as an option. Research (Alvarez, Edwards, & Harris, 2010) indicates that exposure to outreach programs, such as *Go ENG Girl*, has the potential to positively affect STEM interest and achievement, and can support young people to develop increased interest in STEM and productively engage in STEM learning activities, value the goals of STEM and STEM learning activities, and develop an appreciation of the world of science and consider future STEM pathways.

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Early Observations - The Beginning of Surv.ca

By Blake van der Veen, O.L.S.

Having used many different systems from different provinces and states, including some familiar ones in Ontario, friends, colleagues and I observed that none solved the frustration we continuously ran into. What was needed was a good map-based system, not only to sell plans and field notes from, but to manage our project documents, for example, CAD's, site pictures, total station downloads, laser scan files, invoices, etc. So we created a system that does just that, and as it turns out, there are very good reasons why this type of system hasn't been created yet, but I'm getting ahead of myself, allow me to start from the beginning.

Curiosities in surveying for me began as a farm boy South of Ottawa. I wondered where my family's fields ended and how we knew where our limits were, basically, where we stopped planting. We moved to another farm, this one in Port Stanley where it got even more confusing because our fields now bordered several kilometers along lake Erie, our limits where changing constantly due to erosion at a rate of several feet per year, losing the same area as several city lots per year. For these reasons I decided to get into surveying, unfortunately my first property law course wasn't until the 3rd year, so it took a while in the program before I understood that our underwater property was no longer ours, I wish I'd had Izaak de Rijcke as a neighbour, he could have saved me some time.

After studying survey engineering (geodesy and geomatics engineering) in New Brunswick and articling in Ontario, I received my commission which was just a few years ago. Compared to most OLS's my 15 year survey history is short, it began as a bubble boy for Kim Husted Surveying Ltd, then I worked in the east coast, Boston, London, Ottawa, and Toronto. Early on my classmates, colleagues and I, who are now spread out in North America and exposed to different systems, observed the following:

1. In office research can be very time consuming. As more firms absorb older records, they also absorb their index systems, which are usually different from their regular routine of indexing. Doing research often necessitates a 'legal fabric' competent employee in order to search all records.
2. Communication between staff was often an issue. It can be frustrating not knowing where draftsmen (or women) saved their drawing, or where field staff saved their total

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