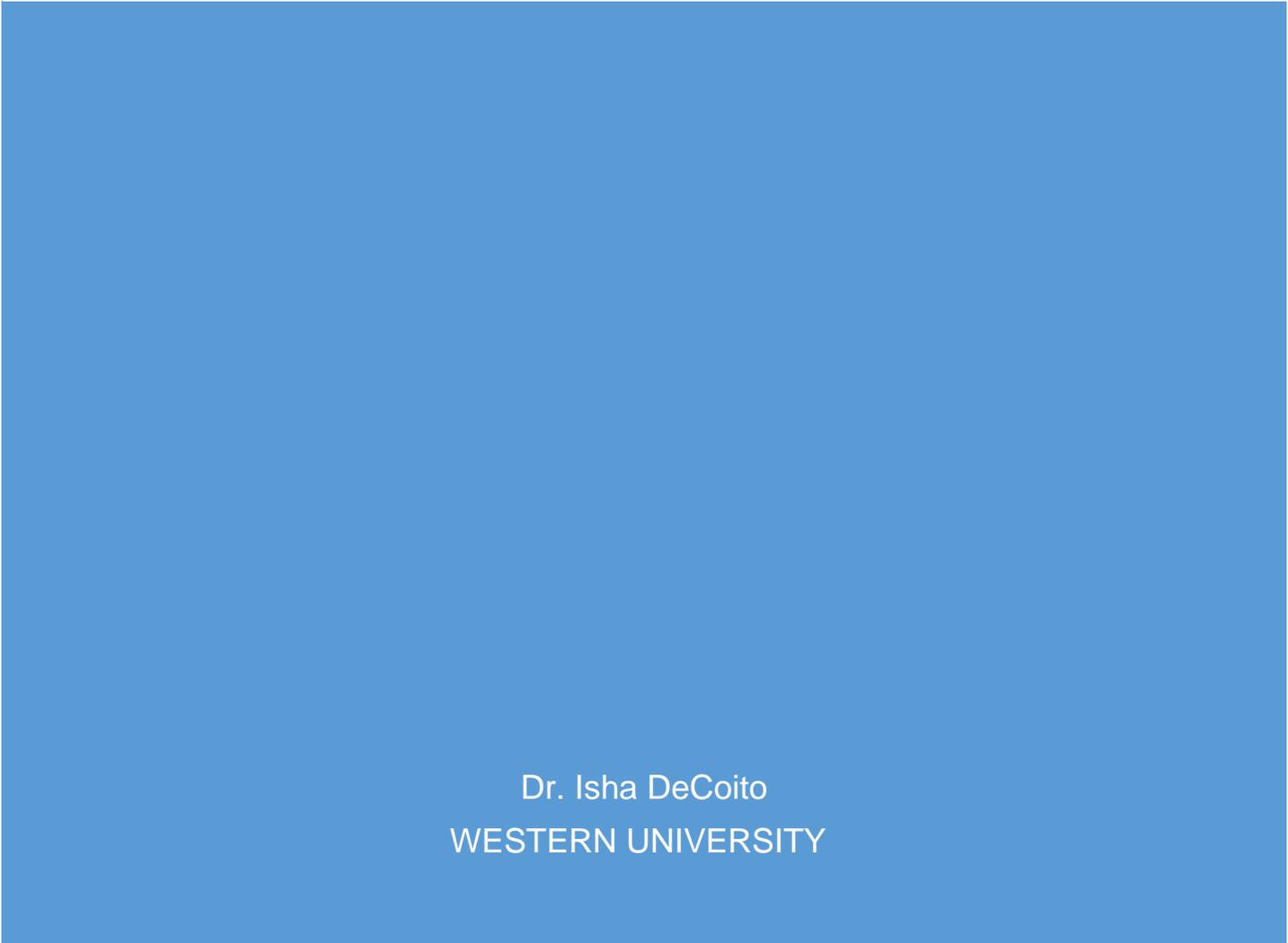




**Focusing on Science, Technology, Engineering,
Mathematics (STEM) Initiatives in K-12
Education**
A Knowledge Synthesis



Dr. Isha DeCoito
WESTERN UNIVERSITY

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Key Messages

This knowledge synthesis of STEM initiatives and their impact on teaching and learning in K-12 education in the last 10 years amalgamated a variety of knowledge sources. What is evident is that there is a dearth of various types of knowledge sources available on STEM education in Canada.

Peer Reviewed Articles and Policy Journals

- Published articles reveal various aspects of STEM related initiatives in Canada, with a cross-section of specific areas including engineering science, robotics, and environmental science focusing on gender, culture, socio-economic status, and Aboriginal perspectives at K-12 and post-secondary levels.
- There is a dire need for conducting further research on the impact of STEM initiatives on teaching and learning in K-12.

Private/Public Research and Policy Reports

- There is a lack of commentary by various provincial and territorial Ministries of Education on STEM education in the school system.
- A complex network of various private, public, and government agencies are needed in Canada to provide the necessary STEM based education to K-12 students and beyond.
- Major technology companies like Google, Samsung, Cisco, and Microsoft are starting to support STEM based initiatives in Canada.

Periodicals, Websites, Professional Development Trade Books

- Universities and various non-profit organizations across Canada have developed various STEM related initiatives for K-12 and university students.
- Major private sector technology companies are partnering with non-profit organizations to provide STEM based initiatives to Canadian youth.
- STEM related activities are slowly becoming part of K-12 education, with software being developed by Canadian companies to track and coordinate STEM based activities in school systems.

Stakeholders' Viewpoints

- STEM education is an important aspect in K-12 teaching and learning.
- There is a lack of awareness of university based and outreach STEM initiatives across Canada.
- Identifying successful STEM initiatives across Canada is challenging.
- Canada lacks a vibrant STEM community.
- A STEM network that facilitates cohesion across STEM Initiatives and STEM communities in Canada is a necessary, including an online community for researchers, practitioners, teachers, parents, and students alike.

Executive Summary

Introduction and Background

According to the Programme for International Student Assessment (PISA), in many countries including Canada, students have not demonstrated significant gains in math and science from 2003–2013. Elementary science education has come under scrutiny as educators, researchers, and policy makers unite around the notion of the important foundational role elementary science plays, as inadequate science, technology, engineering and mathematics (STEM) preparation in the early grades ultimately plays a role in high school course choices, as well as post-secondary and eventually career choices. Across Canada, many movements have been initiated to generate more interest in STEM. STEM initiatives, including outreach programs, provide STEM enrichment and valuable experiences designed to ignite interest; demonstrate how math, technology, engineering and science connect to everyday lives and careers; and allow students and teachers to expand their skills.

Despite the STEM initiatives implemented across Canada, until now no single or comprehensive overview has been conducted that takes into account the impact of these STEM initiatives on teaching/learning outcomes in K-12 education. This synthesis provides a national overview of STEM initiatives and programs, including successes, criteria for effective programs, and how these successes can be applied to other STEM programs and initiatives. This synthesis acts as a catalyst for knowledge mobilization, specifically, the development of a web-based STEM education network that will showcase STEM initiatives, research, and resources, and will model best practices that will inform and support planning for future STEM initiatives. Finally, this knowledge synthesis provide insights into the efficacy of STEM initiatives and their potential to develop science literacy and confidence in youth and to foster a dynamic, competitive and diverse workforce to assist Canada in becoming a global leader in science literacy and innovation.

The synthesis aimed to amalgamate STEM initiatives, including outreach from the following three vantage points related to STEM education: 1) broader impacts on students and teachers, 2) program structure and educational outcomes, and 3) program assessment. Three overarching questions guided the knowledge synthesis: i) What do we know about STEM initiatives and outreach programs? ii) How robust is the research base about the impact of STEM initiatives and outreach programs on teaching and learning in K-12 education? iii) What further research and development are needed for successful implementation of STEM initiatives and outreach programs?

Research Design, Participants, and Methods

The knowledge synthesis focused on STEM initiatives in K-12 education across Canada. The goal was to review the range of STEM initiatives, including outreach programs, what is known about implementation around STEM initiatives, and their impact on teaching and learning in K-12 education. In order to address these questions, the knowledge synthesis included: i) developing an inventory of provincial STEM initiatives and outreach programs; ii) planning for a general assessment of STEM

initiatives, including strategies, programmes, and existing networks; iii) identifying key stakeholders and ambassadors that are part of the STEM initiatives; and iv) a scoping review of relevant studies on STEM initiatives over the past 10 years, and their impact on teaching/learning in K-12 education. The synthesis includes a range of knowledge sources, as restricting the knowledge synthesis only to empirical and descriptive studies in peer reviewed journals was too incomplete to aid end users in fully understanding the issues, both because the amount of research in STEM education is currently limited, and because there is a great deal of “working knowledge” on STEM initiatives and outreach found through other sources.

Therefore, in order to capture a wide variety of information, four kinds of knowledge sources for analysis and synthesis were identified: Type 1 includes empirical and descriptive studies published in peer reviewed education and policy journals; Type 2 knowledge sources includes empirical and descriptive studies published (including online) in venues other than peer reviewed journals; Type 3 sources includes published expert knowledge, opinion and/or advice (not research) located in periodicals or on websites and professional development trade books. Type 4 sources was collected through visits to various locations to meet with stakeholders (community partners, university programs, outreach, school board, etc.) affiliated with the specific STEM initiatives. This source reflects current practice based knowledge gathered through 8 interviews and discussion, including participants’ backgrounds and basic beliefs about STEM initiatives and effects on teaching and learning. The participants also reflected on general ideas about STEM initiatives, based on the research synthesis. Finally, the participants reacted to specific questions about the most effective ways to develop and sustain STEM initiatives. The above identified four types of knowledge sources was used to assist in identifying potential knowledge gaps and barriers to successful implementation of STEM initiatives in K-12 education.

Key Findings

Nationwide, there are a number of STEM initiatives in place, however, until now no single or comprehensive overview has been conducted that takes into account the impact of these STEM initiatives on teaching/learning outcomes in K-12. The knowledge synthesis research findings indicate that in Canada there is a growing number of academic and policy literature written on STEM based initiatives over the past 10 years; more so within the last 5-6 years. However, for the most part, the research is done in isolation from the other, with little or no contact between the different researchers or cross-fertilization between and amongst researchers and policy writers/makers. Further, there is a substantial increase in the number of STEM based initiatives by various stakeholder groups over the past decade in Canada, but again, in most cases, this work is done in isolation from other STEM based stakeholder groups. Despite the STEM initiatives implemented across Canada, currently there isn’t an existing network that links the initiatives and takes into account the impact of these STEM initiatives. As such, there is a very real need, and a growing imperative for a place where these constituent interest groups can come together to discuss and share their experiences, initiatives, and research – and learn from one another, and create a vibrant STEM based network community in Canada and internationally. Below are highlights of the findings:

- Over the past 10 years, the literature on STEM initiatives, including research is quite sparse;
- On a national level there is a vital need for STEM initiatives that includes and honor the perspectives of Aboriginal culture;
- There is an urgent need for research in areas such as gender disparity, diversity, socio-economic status, and how these factors affect participation in STEM initiatives;
- Governments at all levels must engage in a national strategy for STEM education;
- STEM education is necessary in order to improve innovation in Canada;
- Canada lacks a vibrant STEM community;
- STEM initiatives are not aware of the existence of each other;
- A STEM-Network is needed to foster cohesion and increase impact of STEM initiatives and outreach programs across Canada.

Summary

This knowledge synthesis of STEM initiatives and their impact on teaching and learning in K-12 education is aimed at both the research community and the practice community, but also has value for the policy community. The research community will benefit from a deeper understanding of where knowledge gaps exist in the research base around STEM initiatives, as well as hypotheses for new or further investigation, and a suggested agenda for future research in the areas related to STEM initiatives and outreach programs. The practitioner community will benefit from the discussion of what is known about different models, their impacts, implementation issues and generalizability – along with what gaps are present with respect to these topics. The policy community can use this information as they consider professional development plans and expenditures, staffing models, and school organizational design and use of resources, including outreach programs that promote STEM education. Finally, this knowledge synthesis provide insights into the efficacy of STEM initiatives in terms of engagement, interest, skills, and ultimately career aspirations.