Chapter 5
Science Education in Manitoba: Collaborative Professional Communities

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Abstract Manitoba is the province at the longitudinal centre of Canada, bordered by Ontario to the east and Saskatchewan to the west. It is one of the three prairie provinces (along with Alberta and Saskatchewan) and Canada's fifth most populous province. Its population is diverse and includes the largest percentage of First Nations, one of the largest Francophone communities outside of Québec, as well as significant German, Ukrainian, Icelandic, and Filipino populations. Manitoba was one of the lead provinces for the implementation of the *Common Framework* and develops curricula using government consultants, lead writers, and teacher teams. In Manitoba, there are five postsecondary institutions that offer science education teacher programs. A great strength is that science educators are strongly connected through the Manitoba Education Research Network and often collaborate in research projects that involve government, universities, and school divisions. As well, in the past sustainability education has been strongly emphasized and supported by the provincial government and has led to many integrated programs with science content included.

5.1 Introduction

Two recent publications of the Council of Canadian Academies—*Science Culture: Where Canada Stands* (2014) and *Some Assembly Required: STEM Skills and Canada's Economic Productivity* (2015)—describe the state of science and mathematics knowledge, both nationally and internationally, as fairly strong. One point on which the two expert panels agree is that, in order to strengthen Canada's innovation and productivity in the future, more investment needs to be made in the elementary and secondary educational system. However, what would this investment look like?

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This chapter explores the potential for promoting science and innovation in the province of Manitoba by first examining demographic features of the public school population and then looking at provincial and university-based initiatives to develop science and science, technology, engineering, and mathematics (STEM) skills.

5.2 Manitoba Context

Manitoba is the province at the longitudinal centre of Canada, bordered by Ontario to the east and Saskatchewan to the west. It is one of the three prairie provinces (along with Alberta and Saskatchewan) and Canada's fifth most populous province. The name *Manitoba* originates from the languages of the Cree and Assiniboine First Nations; Manitou, or Great Spirit (in Ojiibway, *Manito-bau*), is the unique sound made by the waves washing against the limestone rocks at Lake Manitoba Narrows (Government of Manitoba, n.d.). Manitoba's economy is based largely on natural resources, particularly mining, forestry, hydroelectric, and agriculture. Much of its natural ecosystem is protected in more than 80 provincial parks, where hiking, biking, canoeing, camping, and fishing are all popular activities.

In 2016, Manitoba had a population of nearly 1.3 million, which was an increase of 5.8% from 2011 (Statistics Canada, 2017). Winnipeg (Fig. 5.1), the largest city in the province, has a population of just over 800,000 and is incredibly diverse. It has one of the largest urban Francophone populations outside of Québec totalling just over 110,000 as well as significant German (121,000), Ukrainian (115,000), and Filipino (59,000) populations (Manitoba Immigration & Multiculturalism, 2007). In recent years, Manitoba has been growing as a result of increased immigration; as a result, the school population has also been growing. Predictions put forward in *Impacts of Demographic Change in Manitoba* (Manitoba Bureau of Statistics, 2016) are that the Grades 5–8 population will increase significantly in the next 5 years.

Manitoba's population includes the highest percentage of Indigenous peoples in Canada, at 17% of the province's population, an increase of 13% between 2006 and 2011 (Statistics Canada, 2016). Additionally, Winnipeg has the largest urban Indigenous population of all cities in Canada at just over 78,000 people. As a comparison, the city of Edmonton in the province of Alberta, with a population of 1.3 million, has the second largest urban Indigenous population at just under 62,000 people (Indigenous & Northern Affairs Canada, 2016).

5.3 Manitoba's Education System

The provincial student population from Kindergarten through Grade 12—which was just over 202,000 in 2014, up 0.8% from 2013—is distributed throughout 37 school divisions (districts) with 691 schools (Manitoba Education & Advanced Learning, 2016). These data do not include the 16,000 students attending 56

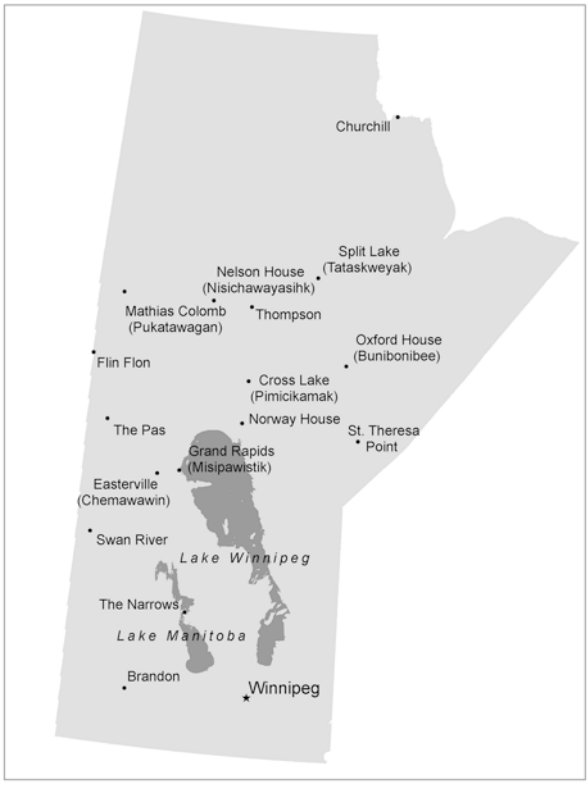

Fig. 5.1 Map of Manitoba. Names in brackets are the Anishinaabe First Nations names

Manitoba First Nations schools that are under federal jurisdiction. In 2016, the Manitoba First Nations School System was established, with 10 participating First Nations and 2,160 students (Manitoba First Nations Education Resource Centre [MFNERC], 2016a). In 2016, the high school graduation rate was 78.3% (Manitoba Education and Training [MET], n.d.).

At the beginning of the millennium, there were several reports published criticizing MET for its inability to provide a satisfactory education to inner-city Indigenous students (Silver, Mallett, Greene, & Simard, 2002). Since these reports, the provincial government has responded with initiatives to improve the educational experiences of Indigenous students, such as requiring teacher candidates to complete Indigenous education courses and increasing the number of Indigenous teachers in the elementary system. The Manitoba government funds programs that support Indigenous elementary preservice teachers such as Brandon University's Program for the Education of Native Teachers and the University of Winnipeg's ACCESS Education Programs that include the Education Centre and the Community-Based Aboriginal Teacher Education Program. Indigenous secondary preservice teachers are also supported by the provincial government but to a lesser degree.

5.3.1 Science Curriculum

Manitoba was one of the lead provinces for the implementation of the *Common Framework of Science Learning Outcomes, K to 12* (Council of Ministers of Education, Canada [CMEC], 1997). The science curricula based upon the *Common Framework* were rolled out over a 5-year period: *Kindergarten to Grade 4 Science* (MET, 1999), *Grades 5 to 8 Science* (MET, 2000a), *Senior 1 Science* (Grade 9; MET, 2000b), *Senior 2 Science* (Science 10; MET, 2001), and Grades 11 and 12 science courses (MET, 2003, 2005, 2006, 2010, 2011, 2013a, 2013b). All science curricula were created by committees that consisted of teacher experts as well as a designated writer and a government consultant. For each science curricula, the province produced two documents: a framework document and a foundation document. The framework document contains the outcomes for each grade level, and the foundation document is a collection of learning experiences that are meant as suggestions for implementing the science curriculum.

All students are required to take science from Kindergarten through Grade 10. In K–10, outcomes for science skills are presented separately from outcomes for content knowledge (Fig. 5.2). There are approximately 15 science skills outcomes that increase in complexity every 2 years, with new outcomes introduced in Kindergarten/Grade 1, Grade 3, Grade 5, Grade 7, and Grade 9. All curricula include science

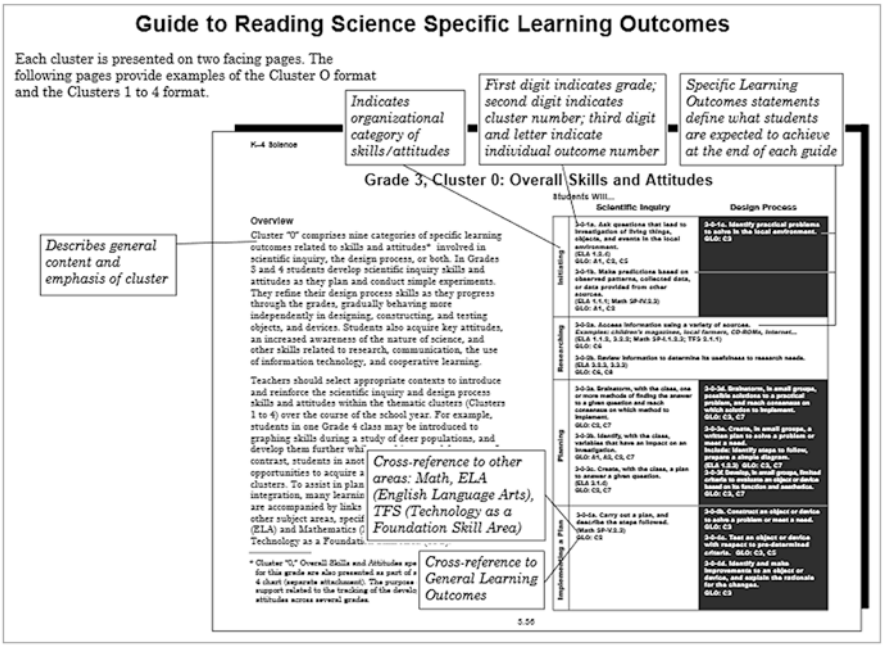

Fig. 5.2 Organization of specific learning outcomes related to skill development in science (MET, 1999, p. 3.4)

inquiry skills; early and middle years' curricula include design process skills, while Grades 9 and 10 curricula include science, technology, society, and environment (STSE) issues skills. Students' mastery of skill and content outcomes are reported separately on the provincial report card for Grades 1–10. However, the science skills outcomes are to be integrated into the content topics in each grade.

The content topics from K–10 are very similar to the ones identified in the *Common Framework* (CMEC, 1997). A notable exception is the topic heat capacity, which was in the curriculum before the implementation of the framework and was retained in Grade 8 (Table 5.1). Topics are organized in four clusters that are related to life sciences, physical sciences, and earth and space sciences. Particular science resources or textbooks are not mandated. In K–6, teachers use a variety of resources to build their own units for each of the prescribed science topics. For Grades 7–10, two textbook series that were created based on the *Common Framework* (CMEC, 1997)—*Science and Technology* (Nelson) and *Science Power* (McGraw-Hill Canada)—are frequently used in the classroom.

Students in Manitoba are not required to take science courses after Grade 10 in order to graduate; however, most postsecondary institutions require upper-level science courses as prerequisites into some programs. Science is an elective in Grades 11 and 12 when Biology, Chemistry, and Physics are offered as separate courses;

Table 5.1 Manitoba science topics for Kindergarten through Grade 10 by cluster

Grade	Cluster 1 Life sciences	Cluster 2 Physical sciences I	Cluster 3 Physical sciences II	Cluster 4 Earth/Space sciences
K	Trees	Colours	Paper	–
1	Characteristics and needs of living things	The senses	Characteristics of objects and materials	Daily and seasonal changes
2	Growth and changes in animals	Properties of solids, liquids, and gases	Position and motion	Air and water in the environment
3	Growth and changes in plants	Materials and structures	Forces that attract and repel	Soils and the environment
4	Habitats and communities	Light	Sound	Rocks, minerals, and erosion
5	Maintaining a healthy body	Properties of and changes in substances	Forces and simple machines	Weather
6	Diversity of living things	Flight	Electricity	The solar system
7	Interactions within ecosystems	Particle theory of matter	Forces and structures	Earth's crust
8	Cells and systems	Optics	Fluids	Water systems
9	Reproduction	Atoms and elements	Nature of electricity	Exploring the universe
10	Dynamics of ecosystems	Chemistry in action	In motion	Weather dynamics

Note. Adapted from MET (1999, 2000a)

skills and content outcomes are no longer separated and teachers are not required to report on skill mastery. The curricula for these courses are shown in Table 5.2. In addition to the core science courses, Interdisciplinary Topics in Science courses may be offered in Grades 11 and 12. MET contracted a writer to create a sample Grade 12 interdisciplinary course about Lake Winnipeg that included lesson plans, black-line masters, and assessment tools (MET, 2013a, 2013b).

Many Grades 11 and 12 science teachers do not use a single textbook but develop their courses using a variety of resources. The reasons are partly historical. MET had approached textbook companies about the feasibility of textbooks to address Grades 11 and 12 biology curricula, but the companies declined because of the relatively small student population and predicted lack of profit. Textbooks that are used in Manitoba typically are developed for other provinces.

5.3.2 Assessment

MET does not conduct any province-wide standardized testing in science. However, Manitoba does participate in national and international assessments such as the Pan-Canadian Assessment Program (PCAP) and the Programme for International Student Assessment (PISA) as one approach to monitoring progress in science education. Manitoba's mean 2013 PCAP science score was 465 ± 3.1, below the national average of 500 ± 1.9 (O'Grady & Houme, 2014, p. 107). Manitoba's mean 2015 PISA science score was 523 ± 6.4, below the national average of 534 ± 4.0 but above the international average of 501 ± 0.5 (O'Grady & Houme, 2014, p. 17). Despite lower scores on both PCAP and PISA compared to the national average, the province has not recently devoted any additional resources to science education.

Table 5.2 Manitoba science topics for Grades 11 and 12 by course

Grade	Biology	Chemistry	Physics
11	Wellness and homeostasis Digestion and nutrition Transportation and respiration Excretion and waste management Protection and control Wellness and homeostatic changes	Physical properties of matter Gases and the atmosphere Chemical reactions Solutions Organic chemistry	Waves Nature of light Mechanics Fields
12	Genetics Biodiversity	Reactions in aqueous solutions Atomic structure Chemical kinetics Chemical equilibrium Acids and bases Electrochemistry	Mechanics Fields Electricity Medical physics

Note. Adapted from MET (2000b, 2001)

5.4 Teacher Education

There are five institutions in Manitoba that offer degrees in education: Brandon University (BU), Collège Universitaire de Saint-Boniface (CUSB), University College of the North (UCN), the University of Manitoba (UofM), and the University of Winnipeg (UWinnipeg). Depending upon the institution, preservice teachers can choose one of the following streams:

- Early years (EY): K–Grade 4, a generalist program
- Early/middle years (E/MY): K–Grade 8, a generalist program
- Middle years (MY): Grades 5–8, a generalist program
- Senior years (SY): Grades 9–12, a subject-specific program that requires greater content

Admission requirements include credits for teachable major and minor subjects which are identified in Table 5.3. EY, E/MY, and MY teacher candidates require 18 credit hours (the equivalent of six full-semester courses) in a teachable major, 12 credit hours in a teachable minor, and 6 credit hours in each of mathematics, physical or biological sciences, English or French, and geography or history. SY teacher candidates require 30 credit hours in a teachable major and 18 credit hours in a teachable minor.

Pathways for earning a Bachelor of Education (BEd) degree differ by institution and are described in the following sections. The required science courses vary according to institution and stream (Table 5.4).

Table 5.3 Acceptable major and minor teachable areas according to stream

Early, early/middle, and middle years		Senior years	
Major areas (18 credit hours)	Minor areas (12 credit hours)	Major areas (30 credit hours)	Minor areas (18 credit hours)
Art, biology, chemistry, computer science, English, French, general science, geography, other approved language, history, human ecology, industrial arts, mathematics, music, native studies, physical education (health), physics, theatre	All major teachable areas are accepted as a minor teachable area except general science	Art, biology, business education, chemistry, computer science, English, French, general science, geography, other approved language, history, human ecology, industrial arts, mathematics, music, native studies, physical education (health), physics, theatre, vocational industrial	All major teachable areas are accepted as a minor teachable area
Early/middle and senior years' subjects acceptable as a minor area only: Anthropology, classics, dance, developmental studies, earth science, economics, environmental studies, law, philosophy, sociology, political science, psychology, religious studies			

Note. According to the *Education Administration Act* (Government of Manitoba 2017)

Table 5.4 Science methods courses offered in Manitoba education faculties

Institution	Stream			
	Early years	Early/middle years	Middle years	Senior years
Brandon University	Science methods (EY)	–	Science methods (MY)	Science methods (MY) Science methods (SY)
Collège Universitaire de Saint-Boniface	–	Didactique élémentaire	–	–
University College of the North	–	Science methods	–	–
University of Manitoba	Pedagogy for sustainable well-being: science, mathematics, and social studies (6 credit hours)	–	Teaching science in MY	SY teaching general science *Prerequisite*: SY curriculum and instruction: sciences *Electives*: SY teaching biology SY teaching chemistry SY teaching physics
University of Winnipeg	EY curriculum, instruction, and assessment: science SY curriculum, instruction, and assessment: science	EY curriculum, instruction, and assessment: science MY curriculum, instruction, and assessment: science	EY curriculum, instruction, and assessment: science MY curriculum, instruction, and assessment: science	*Prerequisite*: SY curriculum, instruction, and assessment: theory of science teaching *One or two of:* SY curriculum, instruction, and assessment: biology SY curriculum, instruction, and assessment: chemistry SY curriculum, instruction, and assessment: geography SY curriculum, instruction, and assessment: physics

Note. EY = early years, *MY* = middle years, *SY* = senior years. Unless otherwise indicated, courses are 3 credit hours or approximately 36 class hours

5.4.1 Brandon University

BU offers both consecutive (post-degree) and direct-entry degrees in education. The consecutive program requires 2 years of study in education after completing an undergraduate degree in a teachable major. Candidates in the direct-entry program enter after high school and complete 5 years of study that includes their teachable major and course requirements as well as education courses.

A variety of specialized programs have been offered at BU to meet the needs of specific communities. For example, the Brandon University Northern Teachers Education Program was a northern community-based program. The Brandon University Hutterian Education Program was established because many of the province's Hutterite colonies found it more suitable to have teachers from their own colonies; this program has been discontinued. Currently, the Project for the Education of Native Teachers provides Indigenous individuals working as educational assistants in northern communities the opportunity to obtain a BEd by completing summer courses at the BU campus. None of these programs were structured to lead to undergraduate teacher candidates becoming secondary science specialists.

5.4.2 Collège Universitaire de Saint-Boniface

CUSB offers the only French language preservice teacher program in the province and is the only program that offers an extended 7-month practicum experience. Admission to this after-degree program is based upon grade point average, suitable courses in teachable areas outlined by the province, professional suitability, and language competency. There are two streams: E/MY and SY. Each year approximately 40 candidates are admitted to this certification program. Candidates complete most of their course work in the first year, spending 21 weeks in classes and 4 weeks in practicum blocks. In the second year, candidates are in practicum blocks for 7 months (September–March) and meet once per week at CUSB for seminars on professional issues and methods courses. Science methods courses are taught during second year.

5.4.3 University College of the North

UCN has two main campuses located in The Pas and Thompson. As well, there are 12 regional centres. Previous locations for the community-based programs have been Easterville (Chemawawin), Churchill, Cross Lake (Pimicikamak), Flin Flon, Grand Rapids (Misipawistik), Norway House, Nelson House (Nisichawayasihk), Oxford House (Bunibonibee), Split Lake (Tataskweyak), Mathias Colomb (Pukatawagan), St. Theresa Point, and Swan River. UCN's BEd program is unique because of the college's mandate to include Indigenous and northern perspectives in both theory and practice.

UCN's Council of Elders selected the Kenanow Learning Model (UCN, n.d.) as the organizing framework for the BEd program. This model incorporates identity, sense of place, community history, and responsibility in the context of teaching. The model bridges the link between Western education perspectives and the Aboriginal perspectives in the transmission of knowledge. *Kenanow* is a word drawn from the Cree language. Translated literally, it usually reads 'all of us, all of us who are here' which includes all our relations as described in the model. In this model, the kinship system is envisioned as an organically functioning system into which education is naturally and harmoniously integrated and transmitted. The BEd incorporates Indigenous cultural knowledge with best practices in pedagogical approaches into all courses, including science, while emphasizing collaboration among Elders, faculty, local educators, community members, and students. Another unique aspect of the program is that education students attend a culture camp prior to graduation to incorporate land-based teachings to their educational practice. Science requirements for the program are shown in Table 5.4.

5.4.4 University of Manitoba

UofM offers an after-degree undergraduate program that is similar in structure to those of BU and UWinnipeg. In this program, prospective teachers select a specific stream (i.e., EY K–4, MY Grades 5–8, or SY Grades 9–12). Each stream has specific characteristics. The EY program uses an immersion delivery model where many of the university classes are conducted in the same school. The MY stream has a focus on the physical, social, emotional, and intellectual development and needs of adolescents. The SY stream places teacher candidates into classrooms related to their major and minor teachable subjects to develop their instructional capabilities at the upper high school level. The UofM Faculty of Education has an Office of Indigenous Initiatives with a director who provides leadership and support and who connects the faculty with the Indigenous communities in the province.

5.4.5 University of Winnipeg

UWinnipeg offers both a 2-year post-degree and a 5-year direct-entry integrated program. Because of an inner-city focus in these programs, teacher candidates are required to do one placement in an urban setting. The different program streams are distinguished by the grade levels of each of the four placements (Table 5.5). In EY, E/MY, and MY streams, teacher candidates take the same two 3 credit hour science methods courses in the certification years; in SY, teacher candidates take methods courses in their science major and minor teachable areas (Table 5.4).

UWinnipeg has three off-campus ACCESS programs, which are funded by the provincial government and designed for marginalized or nontraditional students such as northern residents, inner-city residents, single parents, and immigrants.

Table 5.5 Practicum grade level placements by stream at the University of Winnipeg

	Stream			
	Early years	Early/middle years	Middle years	Senior years
Practicum 1	K–4	K–4	K–4	5–9
Practicum 2	K–4	K–4	5–8	9–12
Practicum 3	5–8	5–8	5–8	9–12
Practicum 4	K–4	5–8	5–8	9–12

- At the Winnipeg Education Centre, cohorts of about 20 teacher candidates from the inner city take classes together for a 5-year period. Upgrading and tutoring supports are provided, and all practicum placements are in the inner city.
- The Community-based Aboriginal Teacher Education Program is a partnership between the university and two school divisions: Seven Oaks and Winnipeg. This BEd program allows Indigenous educational assistants to work in their respective school division from September to April while attending classes part-time and then be released from their position to attend classes full time from May to July.
- The Immigrant Teacher Education Program is a partnership between several school divisions and the university that supports teachers educated internationally as they gain experience in the Manitoba school system. These teachers work in partner schools during the day and complete coursework during evenings and weekends.

None of the ACCESS programs are specifically designed to lead to a specialization in science.

5.5 Professional Development for Science Teachers

The provincial government takes a leading role in professional development (Pro-D) and has implemented programs to support the introduction of new curricula, created an educational research network, and established an online learning community. Pro-D for Manitoba teachers is also provided by teacher associations and specialized organizations. Pro-D for teachers of science exists within these more general opportunities. For example, when the current science curricula were introduced (i.e., 1999–2004), MET provided funding for teams of expert teachers—individuals who had piloted the new curricula—to create a resource with suggested activities for the specific learning outcomes in each topic. For two summers, the expert teacher teams facilitated grade-specific workshops intended to help teachers implement the new curriculum.

Another professional learning opportunity funded by MET is the Manitoba Education Research Network (MERN; http://www.mern.ca/), which has a full-time director who initiates collaborative research projects by connecting teachers and researchers with similar interests. Teachers work together while following an inquiry approach and identify questions they are most interested in exploring in

their own pedagogy, and researchers assist in the design of research projects. A science collaborative group that included 10 teachers was established in 2015; it is anticipated that an additional 10 teachers will be involved in subsequent years. MERN also hosts four or five forums a year in various regions of the province, with an average of 16 presentations in each forum. The forums are an opportunity for university and teacher researchers to present to colleagues and develop a professional network. Between 2007 and 2015, three forums focused on science education.

In 2013, MET created the Manitoba Professional Learning Environment (MAPLE; http://mapleforem.ca/en/), an online educational community that provides a virtual space where educators across the province can access resources and services (MET, 2017b). There is a specific science educators' MAPLE group where teachers share lesson ideas and discuss classroom issues. MET uses MAPLE as an official means of communicating initiatives, curricula, and programs.

Professional learning opportunities supported by teacher associations include an annual province-wide Pro-D day. Special Area Groups, such as the Science Teachers' Association of Manitoba (STAM; http://stam.mb.ca/), host conferences on this day. STAM presentations and topics usually highlight senior-level science content. Teachers may also present innovative science units and projects.

Specialized organizations such as MFNERC also provide Pro-D for teachers of science. In 1998, the Assembly of Manitoba Chiefs created MFNERC to provide support in administration, technology, language, and cultural education for First Nations schools in Manitoba. MFNERC's science team has developed an astronomy curriculum that incorporates local Indigenous knowledge; it has invested in a portable astronomy laboratory that travels to First Nations throughout the province to teach about the night sky from an Indigenous perspective. Since 2003, MFNERC has hosted an annual science fair for Indigenous students. In 2016, more than 490 students took part in the event, presenting over 200 projects, with winners going on to compete in the Canada-Wide Science Fair (MFNERC, 2016b). As well, MFNRC has hosted a national science camp for Indigenous and Inuit students. The camp is a chance for students to participate in science programs and learn about possible science careers in science, while networking with like-minded youth from across the country.

5.6 Strengths in Science Education in Manitoba

A current strength in Manitoba science education is that the science education community is relatively small and members are typically very supportive of one another. MERN is unique to Manitoba and has resulted in some very strong collaboration between the government, universities, and school divisions and have led to several initiatives that are described next.

5.6.1 Manitoba Centre for Research in Youth, Science Training and Learning (CRYSTAL)

In 2005, the UofM became host to one of five Canadian university-based Centres for Research in Youth, Science Training and Learning. CRYSTAL Manitoba (http://umanitoba.ca/outreach/crystal/) was supported by a 1 million dollar grant from the Natural Sciences and Engineering Research Council of Canada. For 5 years, a CRYSTAL team composed of researchers from UofM, UWinnipeg, CUSB, and BU, as well as University of Regina, University of Saskatchewan, and Lakehead University—in the neighbouring provinces of Saskatchewan and Ontario—worked with government and community partners to investigate science education from four perspectives: the learner, the learner as part of a classroom and school community, the learner as part of a local community, and the learner as part of a global community.

Sixteen separate research projects led to the development of more than 100 teacher resources, many of which are still in use. Topics of these resources include contextualizing science through story and historical narrative (http://sci-ed.org), integrating Inuit knowledge to provide two-way learning experiences (http://umanitoba.ca/outreach/crystal/nunavut.html), and sustainability in secondary science (http://umanitoba.ca/outreach/crystal/sustainability.html). Another lasting impact of CRYSTAL Manitoba was the collaborative groups that were created—many of which continue to work together on new and exciting projects.

5.6.2 Education for Sustainable Development (ESD)

Manitoba is a global leader in the promotion of ESD (Manitoba Education & Advanced Learning, n.d.). ESD initiatives fall under MET's priority area of citizenship, sustainability, and well-being; every school in Manitoba is encouraged to have an ESD plan by 2019 (MET, 2017a). To support ESD, MET has established the ESD Leadership Council that is comprised of senior-level representatives from various educational sector groups, faculties of education, and government departments. The council has six goals: ensure quality education for all, infuse ESD pedagogy into teacher education, integrate ESD into curricula and learning (preK through Grade 12 and teacher education), establish ESD school plans, strengthen ESD capacity building at all levels through training and professional learning opportunities, and reorient technical and vocational education and training in support of a green economy. MET has taken a whole-school approach to ESD—meaning that not only is the curriculum reflective of ESD principles, but schools themselves become a model learning environment demonstrating how sustainability can be embedded into school policies, operations, and management.

From 2004 to 2006, a considerable amount of effort to integrate ESD into the curriculum was invested by MET. Huppé, Creech, and Buckler (2013) reviewed all

Manitoba curricula so as to identify sustainability themes already present and gaps that existed to create a baseline on where to move forward in sustainability education. The review was completed in 2006, and subject area correlation charts with ESD themes were posted on the EDS government website (http://www.edu.gov.mb.ca/k12/esd/correlations/index.html). ESD is important to mention here because, although it is integrated into every subject and grade in Manitoba, it receives particular emphasis in science education, social studies, and physical education/health education. As a result, there are many locally-created resources for teachers to use that help them teach science using a more integrated approach.

5.6.3 Design It

Engineering design is part of Manitoba's K–8 science curriculum. To complement this aspect of the curriculum, Design It, an engineering outreach initiative based at UWinnipeg, was started in 2009 with a team of three preservice teachers (Sutherland, Thomson, Claudio, & Lumbera, 2014; http://dsutherlan4.wixsite.com /designit). The Design It team provides design-based workshops that include a problem context; instruction on science concepts and technical drawing; time for planning, building, and testing designs; and discussions on design thinking. The team has created more than 15 different workshops that are available for Winnipeg classroom teachers and afterschool programs. Recently, the Design It team has offered a weeklong summer camp. In 1 year, the Design It team can reach more than 1,500 students and currently has 13 staff members during the school year and four in the summer.

Design It has become a vehicle for strengthening the science teaching skills of team members who are not science specialists, helping them to become leaders in science education. In the process of developing workshops, the Design It team forms a collaborative group whose members brainstorm possible design challenges, create and teach the lessons to the rest of the team, and critique and refine lessons. This iterative workshop development process has led to a group of preservice teachers who participate in conferences and other dissemination opportunities to explain how their confidence in science teaching has been enhanced as a result of working with Design It.

5.7 Challenges in Science Education in Manitoba

Some of the challenges in teaching science in Manitoba are challenges that can be found nationally. Many generalist teachers do not have the science background to feel comfortable teaching science content and may not have much confidence in teaching science even at the lower grades. In addition, there are many Francophone communities in Manitoba where science is taught in French. National assessments

in science achievement and interests show that Francophone students, outside of Québec, score lower than their English counterparts (O'Grady & Houme, 2014). The national assessments seem to suggest that teaching science in French in small Francophone communities in Manitoba has additional challenges. Although science content can be contextualized using a cultural or sustainability lens or taught in a way that assists students in becoming active citizens regarding science issues, it often is not.

Teacher self-efficacy in science instruction at the elementary level is a common challenge to science education programs. Research associated with professional adequacy, professional interest and motivation, and professional science knowledge has found these factors to be impediments to science program delivery (Lewthwaite, 2007). These issues are prevalent in Manitoba elementary schools as well. In Manitoba science is not a required course after Grade 10, and entry into the Faculty of Education at UWinnipeg from high school, for example, requires only 5 credits at the Grade 12 level which include 1 credit of English and 1 credit of mathematics. Once in a program, teacher candidates are required to take only one 6 credit hours science course; most students take biology, astronomy, or physical geography to fulfil this requirement. In addition, EY, E/MY, and MY education programs attract a disproportionate number of humanities and language specialists. For example, more than 80% of the teacher candidates in EY and MY science methods courses at UWinnipeg have a language major. To address the challenges of inadequate science knowledge and low confidence in teaching science, teacher inquiry projects and collaborative learning communities in science have been established and funded by MERN. These collaborations have resulted in some promising findings in mathematics (Betts, Rosenberg, Kammerlock, & Birse, 2015) and perhaps will help in science teaching.

Teachers in small Francophone communities who teach science face similar challenges, as well as some challenges more specific to their teaching context (Lewthwaite, Stoeber, & Renaud, 2008). Science teachers in these communities have the additional challenge of teaching science in French to students who may not have strong French language skills. Within these contexts, the "priority placed on French language development often compromise[s] the attention given to science as a curriculum area" (Lewthwaite et al., 2008, p. 39).

Another challenge is that, in general, science education in Manitoba does not demonstrate to students how they can use scientific knowledge to enhance their ability to participate in Canadian society. Many of Manitoba's current socioscientific issues require technical information as well as scientific and traditional perspectives about energy, air, land, and water. These issues have the potential to create a political and economic nexus between Indigenous communities and provincial or federal governments. For example, the slogan *Idle No More* has been taken up by a group opposed to the removal of Indigenous people from decision-making processes concerning their land, water, and treaty rights. An implication of the Idle No More movement for science education is its new way of thinking about science knowledge, in that it is not passive or objective but rather contextual and experiential. Science educators can be a support network for those who question, explore, and

challenge their local, provincial, and federal governments in order to take an active role in determining their own future.

5.8 Concluding Thoughts

The Council of Canadian Academies (2014, 2015) described the state of science and mathematics knowledge, nationally and internationally, as fairly strong and pointed out that, in order for Canada to remain strong in innovation and productivity, more investment needs to be made in science education in elementary and secondary schools. In Manitoba, the government has invested in supporting collaborations between government consultants, university professors, and professional educators to research best practices in science education. This investment has resulted in strong relationships among stakeholders in science education across the province and a greater understanding of the science education needs of the province. Next steps involve enacting best practices findings into Manitoba classrooms through collaborative inquiry and other forms of professional development, supporting science teachers within Francophone communities, and providing opportunities for science teachers to create contextualized and integrated science lessons.

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