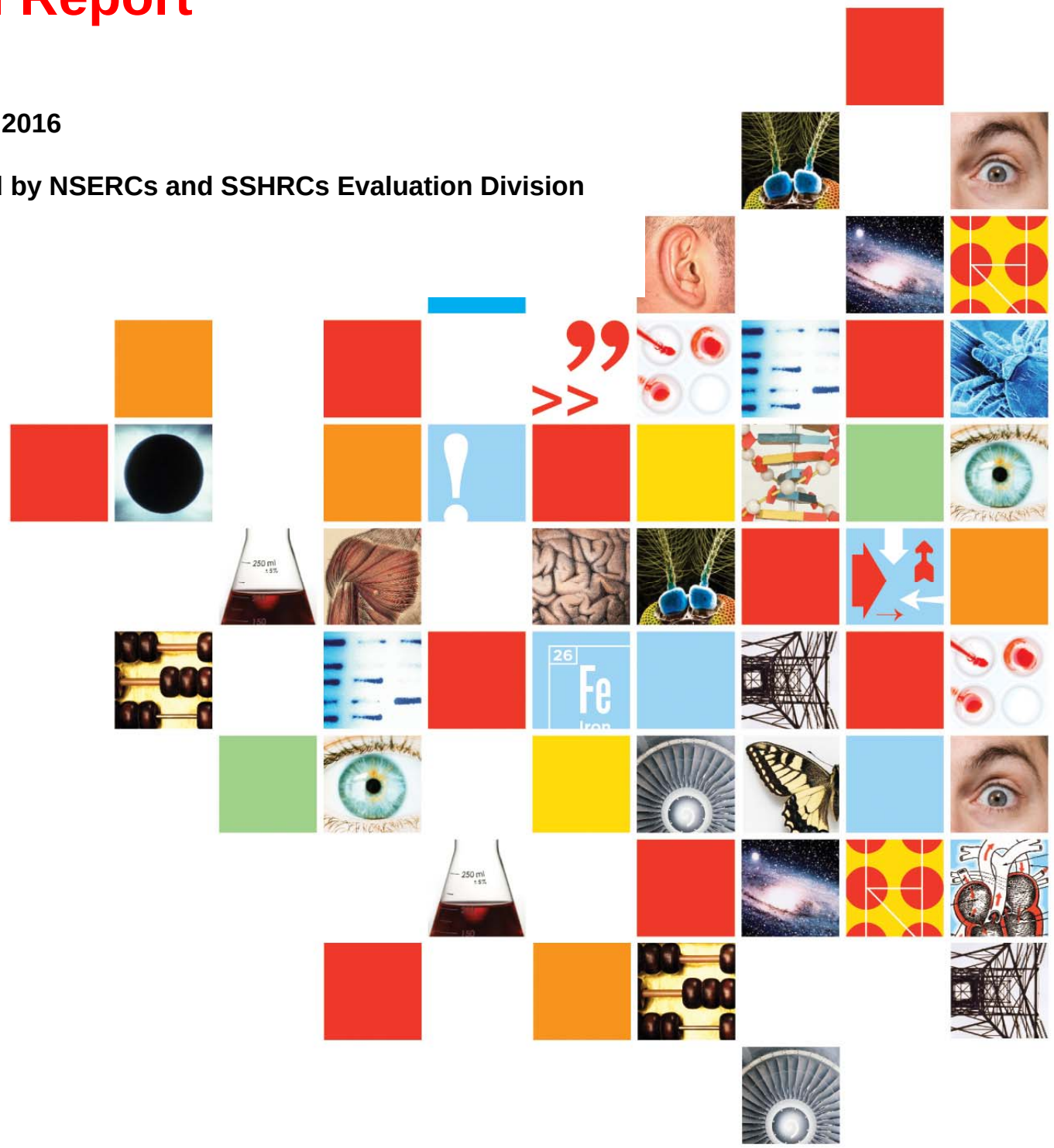
Evaluation of PromoScience – Final Report

February 2016

Produced by NSERCs and SSHRCs Evaluation Division



NSERC CRSNG

Canada

Table of Contents

Executive Summary

Why is it important to fund informal science, technology, engineering and mathematics (STEM) learning?

The evaluation confirms the continued need for PromoScience. Over the last 20 to 30 years, there has been a notable trend within science education research of youth exhibiting low levels of interest when it comes to pursuing STEM-related activities, education and/or careers. Informal science learning can help make STEM fun by creating more authentic links between STEM theory and practice and by cultivating deeper interest in science through active learning or prolonged engagement.

PromoScience plays a key role in STEM promotion by funding informal science learning in Canada that offer opportunities for youth to participate in activities that are known to build engagement, interest, skills and knowledge. PromoScience target groups are appropriate and must continue to target youth and groups under-represented in STEM to achieve its objectives. There are also indications that teachers play a significant role in developing youths' interest in STEM, and are one of the main factors influencing youth to pursue further STEM education. This influence is noted as being particularly important for youth in secondary school.

Is it an appropriate and necessary role for the federal government?

Funding informal science learning through PromoScience is an appropriate role for the federal government and NSERC. Overall, PromoScience is considered an essential funding opportunity because it helps to address gaps in formal STEM education at a national level, and it is the only national and consistent, public funding available for informal STEM learning. By funding PromoScience, NSERC provides strong national leadership that fosters a science culture and encourages a shift towards a more positive image of STEM. It supports a robust and reliable pipeline of STEM professionals in order to remain competitive within the global economy and it also provides grantees with the opportunity to leverage their relationship with NSERC to secure more funding.

How PromoScience supports informal STEM learning in Canada

The provision of hands-on and/or interactive activities and making activities authentic to the participant are well documented in the literature as contributing to increased engagement and interest in STEM. Additionally, such activities are key for increasing engagement and challenging misconceptions of STEM by helping youth establish connections between STEM and their daily lives. This is particularly important with Aboriginal youth where such misconceptions and lack of connections are particularly present.

PromoScience funds projects that are well designed for engaging youth in informal STEM learning activities because they include hands-on and/or interactive activities. PromoScience grantees also tailor activities to make them more accessible to the diverse identities, interests and beliefs representative of young Canadians. In addition to increasing engagement and interest in STEM, tailoring the content and delivery of informal STEM learning activities results in increased understanding of STEM, as well as feelings of inclusiveness and self-efficacy. The link between tailoring and engagement is important as higher engagement is also correlated with more perceived

positive outcomes for project participants including increased STEM interest, skills and knowledge, as well as increased motivation to pursue post-secondary education and/or a career in STEM.

PromoScience funding improved grantees' organizational capacity to deliver informal STEM learning activities, such as the ability to reach target groups, as well as developing new and/or strengthening existing partnerships. Grantees generally attribute their improved capacity to the permitted uses of PromoScience funding, such as the development and/or improvement of project content and delivery, as well as operational costs, such as travel, materials and supplies. They further credit other aspects of the PromoScience funding model to the success of funded projects, including the up to three years of funding per application and the opportunity to reapply for a grant once a funding period has expired.

PromoScience funds may be used by grantees to provide training and/or resources to elementary and/or secondary school teachers in Canada. This is important as there are indications that teachers play a significant role in developing youth's interest in STEM, and are one of the main factors influencing youth to pursue further STEM education.

How youth are responding to PromoScience-funded projects

There is a strong indication that PromoScience-funded projects increase youth exposure to, and interest in, STEM. There is also a strong indication that youth were highly engaged in projects, illustrated by: expressions of enthusiasm; curiosity; eagerness of using scientific tools; exploring ideas physically; persistence in tasks; and, the sharing and exploring of ideas/knowledge. Youth engagement was perceived by grantees as positively correlated with observed increases in interest, skills and knowledge, particularly for Aboriginal youth, youth living in rural and/or remote areas, youth with disabilities and visible minority youth. This correlation was credited to the use of hands-on and/or interactive activities. Almost all of the teachers surveyed (96%) share the same perception as grantees, namely that PromoScience-funded projects have a positive impact on youth interest in STEM, with many teachers (63%) perceiving the impact as significant. The measure of increased motivation to pursue post-secondary education or a career in STEM was somewhat more limited. However, among the teachers who taught secondary school-aged youth (28% of all survey respondents), more than half (53%) perceive PromoScience-funded projects as influencing their students' pursuit of further STEM education to a great extent.

PromoScience's Operational Efficiency

Overall, it appears that the PromoScience funding opportunity is delivered in an efficient manner. The ratio of administrative expenditures for every $1 of grants expenditures between fiscal years 2010-11 to 2013-14 was 6.59 cents. When compared to other administrative ratios for NSERC, the PromoScience ratio was noted as being slightly higher due to the smaller size of grants distributed through PromoScience, in comparison with the other NSERC funding opportunities.

Areas for Improvement

Grantees appear to be satisfied with their experience with PromoScience, including the eligibility criteria, the duration of the grants, as well as the ease of understanding and completing the application forms. There are, however, opportunities for improvement with regards to the monitoring of the performance of PromoScience-funded activities and how performance data is used by PromoScience staff and grantees. There are also opportunities for improvement with regards to bringing the informal STEM learning community together to share best practices, resources and for grantees to support the

capacity development of other grantees. Although there were no specific barriers experienced by grantees when applying for PromoScience funding, some organizations could be at a disadvantage during the application process.

Recommendations

1. **It is recommended that the federal government continue to offer PromoScience through NSERC, as the findings from the evaluation clearly demonstrate a continued need for funding to support informal STEM learning opportunities for all young Canadians.** PromoScience is aligned with federal government priorities and NSERC strategic outcomes, and continues to be an appropriate role for the federal government as it helps to support the development of a positive STEM culture in Canada. Evidence collected from the case studies, key informant interviews, file review and various surveys also indicate that PromoScience is achieving its immediate outcomes as funded projects increase the exposure, engagement and interest of young Canadians in STEM and/or increase the training and resources available to improve the capacity of Canadian teachers responsible for STEM education. Additionally, evidence indicates that PromoScience funds enable grantees to improve their organizational capacity to deliver informal STEM learning activities, including reaching out to and/or tailoring project activities for groups traditionally under-represented in STEM. PromoScience's successes in achieving many of its objectives are primarily attributed to the program's funding model and the fact that all funded projects include hands-on and/or interactive activities.

2. **It is recommended that PromoScience conduct a strategic discussion to further refine its objectives, expected outcomes and target groups.** In particular, the program should consider which outcomes and target groups it can affect to a greater extent and perhaps concentrate efforts in these areas. For instance, evidence collected throughout the evaluation suggests that PromoScience makes a greater contribution exposing various groups of youth to STEM and generating an interest in these disciplines, than it does to increasing their STEM skills and knowledge and/or their motivation to pursue further STEM education. There are also indications that teachers play a significant role in developing youth's interest in STEM, and are one of the main factors influencing youth to pursue further STEM education. This influence is noted as being particularly important for youth in secondary school. Another notable theme throughout the evaluation is the importance of providing informal STEM learning activities for youth living in rural and/or remote areas, as this group of youth have fewer opportunities to engage in such activities and may also be further disadvantaged in terms of the STEM learning opportunities they receive through the formal education system.

3. **It is recommended that PromoScience develop a new final activity report that includes more close-ended questions regarding the impact of its funding on the implementation, reach and quality of projects to provide more useful, accessible and comparable performance information.** The report should also continue to include a few open-ended questions to provide grantees with the opportunity to highlight some of the unique attributes of their program. It is further recommended that PromoScience consult with current and former grantees about what performance data is requested in the new final activity report to ensure that the data is useful for grantees and feasible to collect. Additionally, data collected during the evaluation suggests that some grantees do not have the capacity to provide all of the data requested and that the validity of the data is questionable at times. Several key informants and grantees attribute this lack of capacity to the fact that grantees are unable to use PromoScience funds for project evaluation. Grantees would therefore, likely benefit from more comprehensive and structured information on how to

complete the new final activity report and the type of data requested, as well as opportunities to use part of their PromoScience grant to collect the data requested by the program.

4. **Bringing the informal STEM learning community together is important and it is recommended that PromoScience provide opportunities for current and former grantees to connect with one another, and with the larger informal STEM learning community to share best practices and resources.** Such opportunities may include, but are not limited to: an online network/community of practice; PromoScience conferences; and/or, PromoScience staff directly connecting grantees to one another. For instance, PromoScience staff may place two or more grantees in contact with one another if they believe there are opportunities for partnerships and/or that one grantee may help support the capacity development of another grantee. It is believed that providing grantees with the opportunity to connect with one another, and/or with other organizations delivering informal STEM learning activities, will increase the reach, quality and impact of PromoScience-funded projects. It is also recommended that the platform used to bring grantees and the informal STEM learning community together is national in scope in order to support the development of a positive and inclusive STEM culture across Canada. Currently, some national platforms exist that PromoScience may want to consider partnering with in an effort to avoid repetition and to utilize existing knowledge and/or networks. Such systems included, but are not limited to Actua's annual network member conferences and the Science and Technology Awareness Network (STAN).

1. Introduction

This report presents the key findings, conclusions and recommendations from the evaluation of the Natural Sciences and Engineering Research Council's (NSERC) PromoScience funding opportunity. This is the first evaluation of PromoScience, and covers the period from fiscal year 2000-2001 until 2014-2015. NSERC's and SSHRC's (Social Sciences and Humanities Research Council) Evaluation Division (hereafter referred to as the Evaluation Division) conducted the evaluation in collaboration with Goss Gilroy Inc. (GGI) and Alderson-Gill & Associates Inc. The purpose of the evaluation is to provide NSERC senior management with an assessment of PromoScience's relevance, delivery, performance and efficiency. The evaluation was also designed to ensure that NSERC adheres to the requirements of section 42.1(1) of the *Financial Administration Act* and the Treasury Board *Policy on Evaluation* (2009)[1].

1.1. The PromoScience Funding Opportunity

Objectives and Target Groups[2]

PromoScience is the main funding opportunity within NSERC's Science and Engineering Promotion sub-program, helping to ensure that the next generation of Canadian youth select the natural sciences and engineering as a field of study and/or career. Created in 2000, PromoScience specifically focuses on promoting an understanding of science, technology, engineering and mathematics (hereafter referred to as STEM) as well as an interest in these fields among Canadian youth aged 4 to 18 years. This is achieved by providing financial support to organizations involved in developing and/or delivering informal STEM learning activities[3] for/to Canadian youth. PromoScience also provides funding for the development and provision of training and/or resources for Canadian elementary and secondary school teachers in order to improve their capacity to deliver STEM education.

Another main objective of PromoScience is to provide STEM experiences to groups of Canadian youth that are traditionally under-represented in STEM post-secondary education programs and/or careers. Such groups include, but are not limited to: girls; Aboriginal[4] youth; youth living in rural and/or remote communities; visible minority youth; and, youth from a low income background. Reaching out to under-represented youth, and in particular girls and Aboriginal youth, has been part of the funding opportunity's selection criteria almost since its inception in an effort to encourage applicants to target one or more of these groups.

Selecting and Monitoring PromoScience Grantees

The types of activities funded by PromoScience and the intensity and frequency of these activities vary significantly from project to project. Activities funded included, but are not limited to: camps, clubs, workshops, research, outreach, conferences and competitions. A call for applications is generally made

[1] Treasury Board (2009). *Policy on Evaluation.* Retrieved from: http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=15024

[2] A target group is a set of individuals that are specifically pursued as it is perceived that they will benefit from the program and support the achievement of objectives.

[3] Informal STEM learning is broadly defined as learning about STEM in an environment that is accessed outside of school, or other formal learning spaces (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003).

[4] For the purposes of this program, NSERC uses the Canadian *Constitution Act, 1982* definition of Aboriginal as including the First Nations, Inuit, and Métis peoples of Canada.

in the month of September and must be submitted through the designated platform, as outlined on the PromoScience website[5]. Only Canadian non-profit or charitable organizations, post-secondary institutions, or non-federal museum or science centres that demonstrate ongoing involvement in the promotion of STEM to young Canadians are eligible to receive a PromoScience grant. Please see Appendix A for a map outlining the types of organizations funded and the amount of funding received, as well as the amount of funding distributed by province between 2004 and 2010.

Eligible applications are peer reviewed by the PromoScience/NSERC Awards for Science Promotion Selection Committee. Members of this committee are chosen from the science and engineering promotion community, and the education community, based on their stature and expertise. Successful applications are then screened by PromoScience staff to ensure adherence to NSERC's policies and guidelines. When the list of successful applicants is finalized, staff inform all applicants of the results in writing and the list of grantees is posted on the PromoScience website, usually by mid-January. Approximately 50 grants are awarded each year and grantees receive their first or only installment of funding by early February.

PromoScience staff is responsible for administering grants, as well as monitoring the use of funds through the statements of accounts submitted by grantees on an annual basis. They are also responsible for monitoring the outcomes of PromoScience-funded projects by means of the final activity reports submitted by grantees at the end of their granting period. These reports include a description of implemented activities, participation statistics, and, in some cases, performance results regarding the extent to which participants' interest in STEM increased, as well as their motivation to pursue further education and/or a career in STEM. PromoScience staff may also interact with grantees by phone or through occasional site visits[6].

Expected Outcomes

PromoScience's expected outcomes are anticipated to occur at a variety of levels and points in time. The achievement of these outcomes relies heavily on the activities of and decisions made by grantees, which are not under direct control of NSERC. Expected outcomes are graphically depicted in the PromoScience logic model, found in Appendix B, along with the funding opportunity's activities and outputs.

1.2. Evaluation Questions

The evaluation questions, located in Table 1 below, were developed in consultation with PromoScience staff and management, and address the core evaluation issues outlined in the *Directive on the Evaluation Function*. The questions pertaining to performance are explicitly linked to the expected outcomes noted in the funding opportunity's logic model, found in Appendix B. The evaluation matrix located in Appendix C illustrates which sections of the report correspond to each evaluation question.

[5] Applications must include a description of how the proposed project addresses the PromoScience selection criteria including quality, as well as expected reach and impact.

[6] Site visits are used primarily to represent NSERC rather than evaluate the performance of PromoScience grantees.

Table 1: Evaluation questions

Relevance: The extent to which PromoScience addresses a demonstrable need, is aligned with federal government priorities and reflects an appropriate role for the government.
1. Is there a continued need for PromoScience? Are the target groups appropriate? 2. Is PromoScience aligned with federal government priorities and NSERC strategic outcomes? 3. Is it appropriate and necessary for the federal government to fund science promotion and education programs?
Design & Delivery: The extent to which PromoScience is administered and delivered in its intended manner and reflects best practices.
4. To what extent is the PromoScience programming appropriately designed for youth? 5. To what extent is the PromoScience programming tailored to the social and cultural contexts of groups traditionally under-represented in STEM? 6. Are there any barriers encountered by organizations to access PromoScience funding?
Performance: The extent to which PromoScience is achieving or demonstrating progress towards expected outcomes.
7. To what extent has PromoScience improved the capacity of funded organizations to serve the target groups? 8. To what extent has PromoScience supported the development or the improvement of tools available to STEM teachers? 9. To what extent PromoScience increased/improved youth interest in STEM? 10. To what extent have youth skills and knowledge in STEM increased as a result of PromoScience? 11. Is the funding opportunity likely to increase the number of young Canadians pursuing education and careers in STEM?
Efficiency and Economy: PromoScience's resource utilization in relation to the production of outputs and progress towards expected outcomes.
12. Is PromoScience delivered in an efficient manner? Is economy achieved?

1.3. Methodology

Evaluating the extent to which PromoScience achieved its objectives and expected outcomes required multiple lines of inquiry including: a literature review, file review, case studies, key informant interviews, surveys of grantees, teachers, post-secondary students[7] and recipients of one or more NSERC prizes for research excellence[8], as well as a cost-efficiency analysis. The nine lines of inquiry

[7] A survey of post-secondary students that received funding from at least one of a variety of NSERC funding opportunities was conducted to inform several NSERC evaluations. During the survey, students were asked to indicate when they first became interested in/motivated to pursue further education in the natural sciences and engineering and what three factors most influenced this decision. They results of these questions helped inform the evaluation findings regarding the relevance of the PromoScience funding opportunity.

[8] During the time of this evaluation, the Evaluation Division was also conducting an evaluation of NSERC's Prizes including the: Gerhard Herzberg Canada Gold Medal for Science and Engineering; Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering; E.W.R. Steacie Memorial Fellowships; NSERC John C. Polanyi Award; Synergy Awards for Innovation; and, NSERC Awards for Science Promotion. In an effort to understand what drives individuals to pursue a career in STEM, recipients of NSERC's Prizes were asked when they first became interested in/motivated to pursue further education in the natural sciences and engineering and what three factors most influenced this decision. The results of these questions helped inform the evaluation questions pertaining to relevance for the evaluation of PromoScience.

used to conduct the evaluation and the team members involved in each one are described further in Appendix D. A methodological mapping of the case studies, as well as the surveys of grantees and teachers by geographic region is also illustrated in Appendix D. To guide the data collection, a detailed evaluation matrix, including the evaluation questions, indicators and the sources of data was developed with PromoScience staff and management.

1.4. Limitations[9]

While the evaluation benefitted from multiple lines of inquiry there are several limitations to the evaluation data. These limitations were identified throughout the evaluation, and when possible associated mitigation strategies were employed to facilitate data collection and/or analysis.

1) **Lack of counterfactual analysis** - The main limitation is that the evaluation did not include counterfactual analysis. Counterfactual analysis is necessary for comparing actual outputs and outcomes to what they would have been in the absence of the intervention, i.e. with versus without. For example, the evaluation did not include: a) comparison groups of unfunded versus funded projects as there were only a very small number of truly unfunded projects and it was expected that there would be difficulties reaching these organizations; or b) comparison groups of teachers or youths that never participated in a PromoScience-funded project and/or informal STEM learning activities, as contact information for such individuals was unavailable. To overcome these challenges, field work conducted by members of the evaluation team allowed for intensive on-site observation and interaction with participants and provided an invaluable source of qualitative data.

2) **Measuring long term outcomes** - The challenges associated with systematically measuring the long term outcomes of PromoScience, such as the extent to which skills and knowledge in STEM, or motivation to pursue an education and/or career in STEM increased among young Canadians as a result of their participation in a PromoScience-funded project, were also key limitations for the evaluation. In an effort to acquire more information regarding this longer term outcome, grantees and teachers were asked to provide their perceptions regarding the extent to which participants'/students' STEM skills and knowledge increased following their participation in a PromoScience-funded project. In particular, survey questions examined the nature of the activities, tools, and/or training provided by the PromoScience-funded organization to students and/or teachers, the impacts of these activities, tools, and/or training, and the characteristics of the youth impacted by these activities, tools, and/or training. The inclusion of the teacher survey in the evaluation was designed to address some of the limitations associated with the grantee survey. For example, it was expected that teachers would be in a better position to assess changes in students following the activities (having taught students before and after), and teachers may be less biased in their assessments of the impacts of the activities than grantees offering the activities.

3) **Quality of Performance Data** - There were some issues with the consistency of performance information produced by the funded organizations. Most, if not all of the grantees submitted their final activity report following the final funding period, but the quality of the information as well as the consistency among grantees varied. For instance, large amounts of data were missing from some categories of information, such as targets reached and evidence of the activities performed, while in

[9] Limitations pertaining to the individual lines of inquiry are noted in the respective technical reports.

other categories the existing information was unreliable. Consequently, these data were not used when drawing conclusions regarding PromoScience.

4) **Intensity and/or frequency of PromoScience-funded projects**. Another limitation of the evaluation is the inability to provide concrete information regarding the extent to which the intensity and/or frequency of the activities delivered by PromoScience-funded projects impacted project outcomes. The intensity and frequency of activities varies significantly across projects and while there is evidence that youth interest, skills and knowledge in STEM increased more following multi-event projects (as opposed to single-event projects), these relationships are very small . Additionally, the data used to determine the extent of these relationships are based on the perceptions of teacher survey respondents and may therefore not provide an accurate reflection of project outcomes. These relationships do suggest however, that the intensity and/or frequency of project activities are subjects for examination during future evaluations of PromoScience.

5) **Influence of family and/or social environment**. Finally, the evaluation did not specifically examine the influence of family members on increasing youth interest, skills and knowledge in STEM, or their motivation to pursue further education and/or a career in STEM. Instead the focus was on the influence of teachers as they are a target group of PromoScience. There is, however, some evidence collected throughout the evaluation suggesting that family members play a role in the achievement of these outcomes. Moreover, it is difficult to control social/environmental factors, other than the PromoScience-funded project, that may influence an increase in youth's skills and knowledge in STEM and/or their motivation to pursue further education and/or a career in STEM. As such, this is another subject area for further examination during future evaluations of PromoScience.

2. Informal STEM Learning in Canada

The findings in this section of the report present evidence for the evaluation questions regarding the relevance of the PromoScience funding opportunity. In particular, the findings highlight: the importance of informal STEM learning to encourage further education and/or pursuit of careers in STEM; that PromoScience targets the right groups, including teachers and youth traditionally under-represented in STEM; that the objectives of PromoScience align with the priorities of the federal government and NSERC's strategic outcomes; and, that there is a niche for federal government involvement in funding informal STEM learning in Canada.

2.1. Why is it Important to Fund Informal STEM Learning?

Fewer Youth are Pursuing further Education and/or a Career in STEM[10]

Over the last 20 to 30 years, there has been a notable trend within science education research of youth exhibiting low levels of interest when it comes to pursuing STEM-related activities, education and/or careers (The Institution of Engineering and Technology, 2008; Osborne, Simon, & Collins, 2003). In particular, fewer youth are choosing to enrol in optional STEM-related courses during secondary school, regardless of records of high achievement in mandatory science and math courses (Bordt, de Broucker, Read, Harris, & Zhang, 2001). Fewer youth choosing to pursue optional/further STEM education in secondary school is problematic as it also means that fewer youth (are able to) pursue and/or graduate from a post-secondary STEM education programs (Conference Board of Canada, 2013). While research indicates that Canada is not currently experiencing a shortage of STEM employees (Council of Canadian Academies, 2015), the possibility of fewer STEM graduates is of concern, as the Government of Canada 10-year labour market forecast indicates that some of the biggest areas of labour shortages until 2022 will occur in STEM-related fields (Employment and Social Development Canada, 2012).

Why are Fewer Youth Interested in STEM?

Based on the literature, one of the contributing factors for the low number of youth pursuing a STEM education and/or career is that teachers working in the formal education system lack the capacity to teach STEM in an interesting manner. They attribute this lack of capacity to the fact that elementary school teachers are generalists, focusing on a number of different subjects, while secondary school STEM teachers may not have experience employing hands-on and/or interactive activities in the classroom, despite having an educational background in STEM (Adams, 2014; Barlow, 2012). Consequently, teachers often present abstract theory straight from the textbook in a manner that is disconnected from everyday life. Such an approach tends to reduce student engagement as it may hinder the extent to which they understand and recall the theory (Mark, 2000; Kesidou & Roseman, 2002). Several grantees and teachers that participated in the case studies also attribute a lack of capacity of Canadian STEM teachers to the limited tools and materials available that allow them to make STEM education more engaging and thus interesting for their students.

[10] Most of the studies included in the report use the term "science" in reference to the subject of their research. The term "science" however, has been replaced with STEM to ensure consistency with the language used throughout the evaluation.

The notion that youth are not engaging with STEM through the formal education system is a concern, as school classes and teachers are some of the main factors influencing the pursuit of post-secondary education in STEM. Results from recent NSERC surveys of 3,572 post-secondary students and 91 recipients of one or more NSERC Prize indicate that it is during secondary school when youth generally decided to pursue post-secondary education and/or careers in STEM[11]. Additionally, 58% of post-secondary students and 36% of Prize recipients credited school classes as one of the most important factors that influenced their decision to pursue further education in STEM. Another important influence on their decision was secondary school teachers. A third (31%) of post-secondary students that received funding through NSERC's Research Partnerships Division (n = 652) and 47% of Prize recipients indicated that their decision to pursue post-secondary education in STEM was influenced by their secondary school teacher(s).

> *"We need to start a culture within the education system where there is a focus on teaching the teachers how to teach [STEM] using hands-on activities and making it interesting. We need good [STEM] teaching in the schools to encourage the kids to go into [STEM]."* – Grantee

Findings from the case studies and key informant interviews also emphasize the influence of teachers on the decision of certain youth to pursue post-secondary STEM education. This influence combined with their ability to reach large groups of youth prompted several grantees and key informant to advocate for more support for STEM teachers responsible for STEM education in Canadian schools. The need for support was further noted as being particularly significant for First Nations, Inuit, and rural and/or remote communities, as they generally experience high teacher mobility and/or have less access to teachers with a STEM background. It was suggested that providing teachers with new and creative ideas and materials for making STEM education fun and interactive would help to address some of the current challenges with formal STEM education.

STEM and the Impact on Under-Represented Groups

Groups traditionally under-represented in STEM may feel that these disciplines, as taught in schools, as do not fit with their identity, interests, beliefs and aspirations (DeCoito & Gitari, 2014; NSERC, 2010). In other words, STEM is not accessible and, as a result, it is perceived as something negative that is "not for them". When paired with images of the stereotypical scientist as a lonely, eccentric, white, male, and a lack of visible matched-demographic role models, the role of "scientist" is all but eliminated from the stream of possible careers (Alston & Hampton, 2000; Dorsen, Carlson & Goodyear, 2006; Nisbet, 2002). Consequently, there is little incentive for under-represented groups to pursue further STEM education at the secondary or post-secondary level.

The inaccessibility of STEM as experienced by under-represented groups may result in stereotypes of lower achievement and/or ability (Center for Advancement of Informal Science Education, 2010). During the evaluation, three case study grantees described how stereotypes have influenced some of their Aboriginal participants to have the faulty perception that they do not possess the same aptitude for STEM as other groups of youth. These grantees further highlighted that this is simply not true and that negative stereotypes need to be eliminated by providing Aboriginal youth with opportunities to demonstrate their aptitude for STEM by engaging in activities that are accessible, meaning relevant to their culture and physical environment.

[11] Secondary school was the most common answer among 12 of the 13 sub-groups of respondents.

Consequently, in addition to providing teachers with more education and support to teach STEM in a fun and interactive manner, attention must also be paid to the content and/or delivery of STEM educational materials. Efforts must to be made to ensure materials are authentic to, and inclusive of the diverse groups of youth across Canada. The question "authentic to who" must also be asked, because what is authentic to one group may have alienating effects for another group (Center for Advancement of Informal Science Education, 2010 Mason & McCarthy, 2006). For instance, one case study grantee that provides STEM activities for girls noted that overly technical content that is delivered in a highly competitive manner will usually discourage participation. A more social approach to learning however, was found to be successful at increasing participation, especially when coupled with subject matter representative of girls' general interests. Additionally, it is imperative to recognize that diversity exists within groups of youth (Royal Academy of Engineering, 2009) and avoid adopting a "blanket" approach when developing and/or delivering informal STEM learning activities.

Informal STEM Learning: Making STEM Fun and Inclusive

Informal STEM learning is sometimes perceived as a resource to fill the gaps found in formal education systems (National Science Foundation, 2003). The general objectives of informal STEM learning are to promote STEM, make STEM fun, to create more authentic links between STEM theory and practice, and to cultivate deeper interest in STEM through active learning or prolonged engagement (European Science Education Initiative, 2004a). In some cases, activities may also focus on increasing interest in higher education and STEM careers (National Science Youth Forum, 2013), as well as making STEM more accessible and inclusive for all groups of youth (Bell, Lewenstein, Shouse, & Feder, 2009).

To achieve these objectives, informal STEM learning activities tend to be:

- kinesthetic, also referred to as hands-on and/or interactive with a focus on "doing" science;
- authentic, in that they link back to the youth's identity including culture, gender and socio-economic background;
- discovery-based, unstructured or open-ended;
- co-operative in nature with a focus on team work and group learning; and,
- assessment-free with emphasis on trial and error learning (Hidi & Renniger, 2006).

"It is important to provide the students with highly interactive and hands-on activities, things like robotics or going to a science facility with a touch-tank. This not only increases their interest, but helps them learn - they learn by seeing and doing." – Attendee at a Grantee event

In Canada, informal STEM learning activities are generally offered through the following mediums: science centres; informal STEM learning programs; science media; and, take-home STEM kits and toys. Youth traditionally under-represented in STEM however, tend to have less access to these mediums. This is often a result of one or more of the following barriers: travel distances, cost of attendance, inability to accommodate certain disabilities, and/or that the content and/or facilitators are not reflective of the youth's gender, socio-economic demographic and/or cultural background (Bleeker & Jacobs, 2004; Cano & Bankston, 1992; National Science Foundation, 2003). Consequently, just as the formal education system must consider making STEM more accessible to under-represented groups; informal STEM learning mediums must consider making their activities more available.

2.2. An Appropriate and Necessary Role for the Federal Government

PromoScience is the only national and consistent, public funding available for informal STEM learning in Canada. Overall, PromoScience is considered as an essential funding opportunity because it helps to address gaps in formal STEM education at a national level. Other main sources of funding for informal STEM learning noted throughout the evaluation include non-profit/charitable organizations, industry and post-secondary institutions. While, some provincial governments funded STEM-related activities, recent cutbacks have resulted in more one-time funding opportunities or cancelled opportunities. Such funding cuts are of concern as key informants and case study grantees feel that there is already a troubling lack of funding available for informal STEM learning activities in Canada. This lack of funding poses a particular challenge for grantees specifically targeting Aboriginal youth, youth living in rural and/or remote areas and youth from low-income backgrounds because reaching these populations often involves high travel costs and less revenue-generating activities.[12]

Given the lack of funding available for informal STEM learning in Canada, key informants and case study grantees perceive PromoScience as an appropriate and necessary role for the federal government. In addition to supporting the federal government's recent commitment to "encourage more young people to pursue education and choose careers in science, technology, engineering and math disciplines and raise awareness of the inherent value of science, technology and innovation"[13], reasons offered for this perception include, but are not limited to:

- The importance of developing a more STEM literate society by providing youth across Canada with equal opportunity to develop their interest, skills and knowledge in STEM.
- The need to ensure a supply of post-secondary STEM graduates and/or STEM professionals in order to remain competitive within the global economy.

Another key reason why it is considered necessary for the federal government to continue funding informal STEM learning is the importance of having strong national leadership and a national scope for STEM education in order to build a more positive STEM culture within Canada. In particular, it was noted by key informants, as well as case study grantees and/or teachers that support from the federal government is critical for shifting negative perspectives of STEM to more positive ones[14]. It is believed that this shift will generate a long-term interest in STEM among young Canadians, subsequently resulting in more youth pursuing post-secondary education and/or careers in STEM. Despite being a key player in this shift, PromoScience's impact was noted as being somewhat limited due to its small budget and the small amount of funding provided to individual grantees.

When asked how PromoScience could further support grantees in their capacity to deliver informal STEM learning activities and reach target groups, several case study grantees and key informants suggested the creation of a "formal" system, such as a network or community of practice. Such a national network would allow organizations from across Canada to share best practices and new

[12] There are often fewer participants and/or activities are offered at a subsidized rate.
[13] Government of Canada (2014). Seizing Canada's Moment: Moving Forward in Science Technology and Innovations, 2014. Ottawa: Industry Canada., https://www.ic.gc.ca/eic/site/icgc.nsf/eng/h_07472.html
[14] PromoScience aligns with NSERC's strategic goal of "fostering a science culture in Canada", as outlined in the *NSERC 2020 Strategic Plan*.

information regarding STEM promotion and education and would provide a platform for grantees to partner with one another; thereby, increasing their resources, reach and impact. It may also help avoid redundancy in programming and within communities, as well as reduce competition for funds (Commonwealth of Australia, 2010). There are however, similar networks in existence and NSERC may want to consider partnering with these networks to avoid repetition and to utilize existing knowledge and/or contacts. Such networks included, but are not limited to: Actua's annual network member conferences; and the Science and Technology Awareness Network (STAN).

"There is a strong role for NSERC and the federal government to fund this program as the whole society benefits from it. When you get the students involved, they are so excited that it spreads out all around them as they talk to the parents, the family and it becomes more societal. Science is hard to sell and having tangible things that the public can see is essential. Promoting science among young Canadians and promoting a culture of science among Canadians are fully connected" – Grantee

3. PromoScience: Supporting Informal STEM Learning in Canada

The provision of hands-on and/or interactive activities and making activities authentic to the participant are well documented in the literature as contributing to increased engagement and interest in STEM. The evaluation findings below illustrate how projects funded by PromoScience are therefore, well designed to achieve such objectives as grantees are required to include hands-on and/or interactive activities in their funded projects. Moreover, they are encouraged to tailor activities to make them more accessible to the diverse identities, interests and beliefs representative of young Canadians. Additionally, the findings in this section highlight how PromoScience funding support informal STEM learning in Canada by positively impacting the capacity of grantees to serve their target population(s) and further engage youth in STEM education. In some cases, this is accomplished by increasing the capacity of teachers responsible for STEM education in Canada by providing them with tools/materials and/or professional development opportunities emphasizing teaching STEM in ways that are known to engage youth.

3.1. Hands-on/Interactive Activities

All of the case study projects include hands-on and/or interactive STEM learning activities. The nature of these activities however, varies significantly across projects and often relates to the needs of the community, the capacity of the organization (including financial resources), as well as the skills and knowledge of project staff. Examples of some of the hands-on and/or interactive activities offered by case study grantees include:

- interactive presentations, workshops and labs delivered in the classroom or onsite;
- field trips;
- creating an experiment for a science fair;
- role playing STEM education games; and,
- online games.

"Science is complicated. I do not see myself in science. Our experience was really easy. It was fun. We did not realize it was science" - Participant

Findings from the case studies indicate that hands-on and/or interactive activities are used to help youth establish connections between STEM and their daily lives. Offering youth opportunities to participate in hands-on, STEM-related activities and understand how they interact with STEM in their everyday lives is important as such opportunities contradict negative perceptions about STEM. Through the case studies, such perceptions were particularly noted among Aboriginal youth. For instance, informal interviews were conducted with 54 Aboriginal youth, 41 of whom (76%) indicated that they do not like science. Youth justified their answers by explaining that science is difficult and “not for them”. Additionally, none of them perceived the activities they participated in as scientific, but rather more of a leisure activity they enjoyed because the subject was interesting to them. A few youth did indicate however, that their perception of what it meant to “do” a STEM activity was more positive following their participation in the PromoScience-funded project. By funding organizations offering young Canadians hands-on and/or interactive informal STEM learning activities PromoScience is regarded as a key player in the effort to replace youth’s negative perceptions of STEM for more positive ones.

"All of the hands on learning where the kids actually participated in the experiments and investigations - they provide much more than I could ever do in my class." – Teacher Survey Respondent

"Students had the opportunity to touch/use materials that I do not have access to, such as animal pelts, hermit crabs, and microscopes." – Teacher

Teachers were provided with an opportunity to answer an open-ended question related to the impact of the PromoScience-funded project on their students increased STEM interest, skills and knowledge, as well as increased motivation to pursue post-secondary education and/or a career in STEM. Unprompted, approximately one in five of the 664 teachers (73%) that answered this question noted the value of the hands-on and/or interactive activities offered by PromoScience-funded projects that would otherwise be unavailable to students.

3.2. Tailoring Content and Delivery: Making STEM Accessible

Survey results indicate that a number of grantees tailored their PromoScience-funded projects to make them more accessible for project participants. In addition to increasing engagement and interest in STEM, tailoring the content and delivery of informal STEM learning activities further results in increased understanding of STEM, as well as feelings of inclusiveness and self-efficacy (Austin & Hickory, 2011; Hidi & Renniger, 2006). As outlined in Table 2 below, the most common tailoring strategy was the use of cooperative activities and group work (77%). This is somewhat expected as interactive activities, which likely include group work, are noted in the literature as a key strategy for engaging youth, and especially girls (Fancsali, 2002), in informal STEM learning activities. Using content relevant to the local environment, such as creating links between STEM and crop sustainability in a rural, farming community was also quite common among PromoScience-funded projects (65%). Other tailoring strategies were a little less common with approximately half of grantees using: materials that included examples of the same demographic group as participants (57%); physical activities (55%); matched demographic mentors/facilitators (54%); and/or catered the content to the language of the target population(s). Only a third of grantees (34%) used storytelling to deliver their activities.

Table 2: Strategies for tailoring, PromoScience-funded projects.

Strategy	% (n=92)
Using cooperative activities and group work	77%
Using content relevant to the local environment	65%
Program materials include examples of the same demographic group as participants	57%
Using physical activities	55%
Using mentors/facilitators from the same demographic group	54%
Catering the content to the language of the target population	50%
Catering the content through storytelling	34%

NB: Strategies for tailoring were not mutually exclusive and grantees could choose multiple strategies
Source: PromoScience Grantee Survey

Statistical analysis of the grantee survey results illustrate that the tailoring strategies listed above are generally associated with perceived higher engagement from project participants. Such associations are particularly high for projects that used: materials with examples of the same demographic groups as

participants, physical activities and/or cooperative activities and group work[15]. The link between tailoring and engagement is important as higher engagement is also correlated with more perceived positive outcomes for project participants including increased STEM interest, skills and knowledge, as well as increased motivation to pursue post-secondary education and/or a career in STEM.

The positive outcomes of tailoring informal STEM learning activities are especially prevalent among groups traditionally under-represented in STEM post-secondary education programs and/or careers. Case study findings indicate that PromoScience grantees tailored their PromoScience-funded project for at least one group of youth traditionally under-represented in STEM. For Aboriginal youth, projects were tailored by: involving Elders and/or other members of the community to help deliver activities; including culturally relevant language, knowledge and/or activities; and/or, employing match-demographic mentors who are not members of the community. Often, tailoring activities fused together the more traditional knowledge and approaches for STEM education with culturally relevant content that helped Aboriginal youth understand how STEM pervaded their everyday life. Making these connections helped youth understand the more theoretical concepts of STEM and develop an interest in what they were learning. Similar tailoring approaches were adopted to engage girls in informal STEM learning activities, including: topics that are more likely to align with girls' interests; making activities more cooperative and team oriented; and/or, "girls only" activities.[16] By using matched-demographic mentors in the delivery of activities for Aboriginal youth and girls, youth were given the opportunity to see STEM as a viable option for future education and/or a career.

> "*By engaging community members and Elders, we are able to deliver activities that bridge traditional culture with modern science and technology*". – Grantee

> "*When girls see a real female scientist, they become more interested and confident that they can also do hard science.*" – Grantee

3.3. Improving the Capacity of Grantees

Almost all of the survey (96%) and case study grantees that participated in this evaluation indicated that PromoScience funding improved their organizational capacity to deliver informal STEM learning activities. In particular, it was noted that PromoScience funding supported the successful implementation of funded projects, the ability to reach target groups and the quality of project staff and/or materials. In more than half of these cases, improved capacity was considered significant. Similar results were found through the file review with the majority of grantees funded between 2004 and 2010 (n=356)[17] noting that PromoScience funding significantly impacted the scope (85%), reach (83%) and quality (81%) of their project. Grantees generally attribute their improved capacity to the permitted uses of PromoScience funding, such as the development and/or improvement of project content and delivery, as well as operational costs, such as

> "*The funding made it possible to reach several thousand youth in over 20 communities over the past 10 years. The science camps are full to capacity and are usually fully registered well before they commence.*" – Grantee

[15] The correlations between these three tailoring strategies and perceived participant engagement were statistically significant with a small to medium effect size of larger than 0.35.

[16] While the importance of encouraging more girls to pursue STEM is widely recognized, it is equally important that this focus does not come at the expense of engaging boys. This concern was noted as being especially relevant in Aboriginal, as well as rural and/or remote communities where it is sometimes harder to engage boys in activities and where boys have a higher incidence of dropping out of school.

[17] The file review did not include all of the grantees between 2004 and 2010, but only the grantees that submitted a final activity report and/or progress report from which this data could be extracted.

travel[18], materials and supplies.[19] They further credit other aspects of the PromoScience funding model to the success of funded projects, including the up to three years of funding per application and the opportunity to reapply for a grant once a funding period is expired. Without PromoScience funds, grantees believe that they would have had to reduce the scale of their project (38%), postpone (23%) or cancel (20%) their project.

Outreach: Making STEM available

One of the benefits of PromoScience funding noted by case study grantees and key informants is that it permits grantees to use the funds for travel. Being able to use funds in this manner ensures that informal STEM learning activities are available to all young Canadians, as grantees are able to bring their project to the youth and/or bring the youth to the project. For example, one case study grantee used their PromoScience funds to reach out to Aboriginal girls living in a remote area and to pay for their travel to one of the locations of project delivery. Without being able to use funds for travel, the extent to which grantees engage under-represented groups in their funded project would be limited and in some cases non-existent. While PromoScience funds are integral to the outreach activities of grantees, increasing travel costs will likely impact the extent to which grantees are able to continue such activities in the future.

Findings from the case studies also highlight the need to provide youth from low-income backgrounds with more opportunities to attend informal STEM learning activities. Five case study grantees provide bursaries and/or subsidize the cost of their activities to increase the participation levels of youth from low-income backgrounds. In two cases, the grantees used their PromoScience funding to offer bursaries for students in several inner city schools so they could attend hands-on STEM activities at the grantee's facility. Both grantees discussed the importance of reaching out to schools located in low-income neighbourhoods as they often have fewer resources for hands-on activities in the classroom. Additionally, students who attend these schools tend to have fewer opportunities to participate in extra-curricular activities, especially STEM activities, which can be expensive.

Partnerships

Evidence from the evaluation suggests that PromoScience funding helped grantees develop new and/or strengthen existing partnerships, which likely contributed to the success of their projects. More than half of the grantees (60%) indicated that they delivered their PromoScience-funded project in partnership with at least one other organization. The majority of grantees with existing partnerships (n=45; 86%) indicated that PromoScience funding helped to strengthen that partnership, while the majority of grantees that developed new partnerships (n=26, 86%) as a result of PromoScience funding still maintain those partnerships today. Grantees that participated in the case studies echoed these findings as they all deliver their projects in partnership with one or more organizations and several grantees grew and/or strengthened their network of partners through the increased reach of their PromoScience-funded project. Such partners included, but were not limited to: First Nations and/or Inuit communities and/or organizations; private sector organizations; other organizations offering informal STEM learning activities; schools/school boards; research centres; universities; non-profit foundations; and/or other levels of government.

[18] Permitting the use of funds for travel, including inter-provincial travel, was noted as being unique to federal government funding and not generally allowed by other levels of government.
[19] Provided those costs are associated with STEM promotion and/or informal STEM learning.

For both sets of PromoScience grantees, it is likely that many of their partnerships were financial as the majority of survey grantees (79%) and all case study grantees receive funding from other sources. In some cases, grantees credited the funding received from PromoScience as a catalyst for securing other funding. According to key informants and case study grantees, recipients of a PromoScience grant are sometimes able to leverage their association with NSERC to acquire funding from other partners.

3.4. Improving the Capacity of STEM Teachers in Canada

In an effort to increase the number of young Canadians pursuing a post-secondary STEM education and/or career, PromoScience grants may be used by organizations to provide training[20] and/or resources to elementary and/or secondary school teachers in Canada. PromoScience grantees appear to be aware of the need to support STEM teachers in Canada because 57 grantees (62%) noted that one of the main objectives of their project was improving the tools available to STEM teachers and believe that they achieved this objective to some or to a great extent. Additionally, 55 grantees (60%) aimed to enhance STEM education in elementary and secondary schools and all but one grantee indicated achieving this objective to some or a great extent.

When asked to describe the types of project activities they offer to improve STEM education, the majority of grantees (80%) indicated that their PromoScience-funded project included in-class presentations and workshops. A smaller proportion of grantees developed new (59%) and/or adapted existing (61%) STEM education materials, while 38% of grantees included these materials on their organization's website. Additionally, almost half of grantees noted working with teachers (45%) and/or providing teachers with professional development opportunities (47%) to improve the delivery of the STEM curriculum in Canadian elementary and/or secondary schools. In just over one third of cases (36%), grantees focused on the next generation of STEM teachers by providing training to post-secondary education students who want to become STEM teachers.

Table 3: Types of activities related to improving STEM education included in PromoScience-funded projects.

Project activity	% (n=92)
In-class presentations and workshops	80%
Adapting existing STEM materials to your activities	61%
Developing new STEM materials	59%
Providing professional development to STEM teachers	47%
Working with teachers to develop or improve the curriculum in STEM	45%
Including new or adapted STEM education materials on your organization's website	38%
Training to students who want to become STEM teachers	36%
Source: PromoScience Grantee Survey	

[20] Training or professional development programs outside of accredited courses or degree requirements.

Though it was indicated in only eight of the PromoScience-funded case study projects that teachers were specifically targeted, all 16 case studies offer at least one project activity associated with improving the quality of formal STEM education. Moreover, the majority of the activities offered by case study grantees coincided with those noted by grantees surveyed including: in-class presentations and workshops; developing/adapting STEM materials/tools; professional development opportunities for STEM teachers; and/or engaging post-secondary students to develop and/or deliver their PromoScience-funded project.[21] With regards to in-class presentations and workshops, case study grantees indicated that these activities (including hands-on and/or interactive activities) generally occur at the request of teachers looking for new learning opportunities for their students. However, by observing and participating in those activities themselves, teachers may also acquire new ideas and approaches for teaching STEM.

> *"The majority of the instructors delivering the program were planning to enter, or currently enrolled in, education degrees. They said that instructing the program taught them how to create hands-on activities, how to engage youth by using activities to explain abstract concepts and how to teach science in general. All of them felt that the program increased their skill sets as teachers, and provided them a repertoire of activities they can use in the classroom."* – Grantee

The development or adaptation of STEM materials/tools also often stemmed from requests by teachers for new resources and/or for activities that correspond with the province's education curriculum. Other times, they were created by grantees in an effort to provide teachers with new ideas/approaches for teaching STEM in ways that increase youth engagement, i.e. hands-on, interactive, connected to the "real world", etc. Examples of such materials/tools include, but are not limited to: online games that allow teachers to track their students' progress; presentations that teachers can use in their classrooms; and, educational "kits" for teachers (available in hard-copy and/or electronically) with activities, teaching resources and best practices to encourage hands-on and/or interactive STEM learning in the classroom. Such STEM education "kits" were noted as useful tools for engaging students in STEM learning by several teachers surveyed.

> *"Being able to borrow the [learning] kits has been invaluable as we can't give students real lab experience with this equipment any other way."* - Teacher

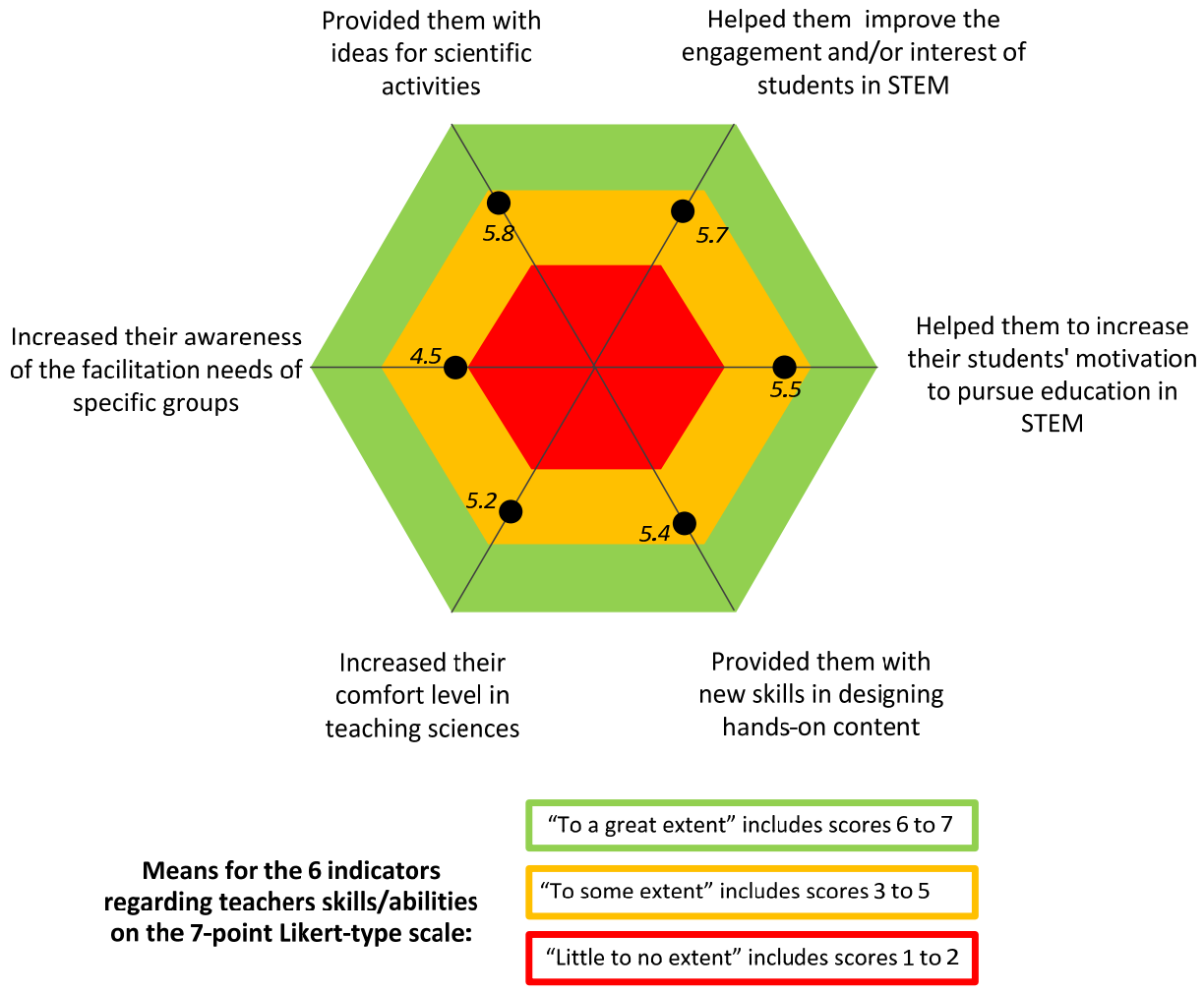
In an effort to gain a better understanding of the outcomes of some of the tools/materials and/or professional development opportunities offered by PromoScience-funded projects, teachers were asked to indicate the frequency with which they use the materials/tools provided through these projects, and/or the extent to which they continue to draw on what they learned. Of the 376 teachers who indicated that they and/or their students received educational materials/tools from a PromoScience-funded project, half (49%) responded somewhat frequently, while 17% use the materials/tools very frequently. Additionally, it appears that more recent tools were used with greater frequency. Of the 172 teachers (19%) that participated in a professional development opportunity provided by a PromoScience-funded project, more than half (58%) indicated that they continue to apply what they learned to a great extent, while 39% use their knowledge to some extent. The positive impact of professional development opportunity was also recognized by several teachers that described the outcomes of their involvement in a PromoScience-funded project.

In addition to frequency/extent of use, teachers were asked to identify the extent to which the materials/tools and/or knowledge they received increased their STEM teaching skills/abilities in six key

[21] Five of these grantees engage students enrolled in education programs, i.e. future teachers, while the remaining three grantees engage students enrolled in STEM programs.

areas. Overall, teachers reported a moderate increase for each key area, with the greatest increases being the provision of ideas for scientific activities and helping them improve the engagement and/or interest of their students in STEM. Materials/tools had the least impact on increasing teacher's awareness of the facilitation needs of specific groups of participants. Consequently, it appears that there is an opportunity for PromoScience-funded projects to contribute to improving the skills of Canadian teachers in this area. This may include educating teachers about the importance of catering the content and delivery of STEM learning activities and/or offering materials/tools that are designed for different audiences.

Figure 1: Teachers rate the extent to which the materials/tools and/or professional development opportunities offered by PromoScience-funded projects impacted their skills/abilities



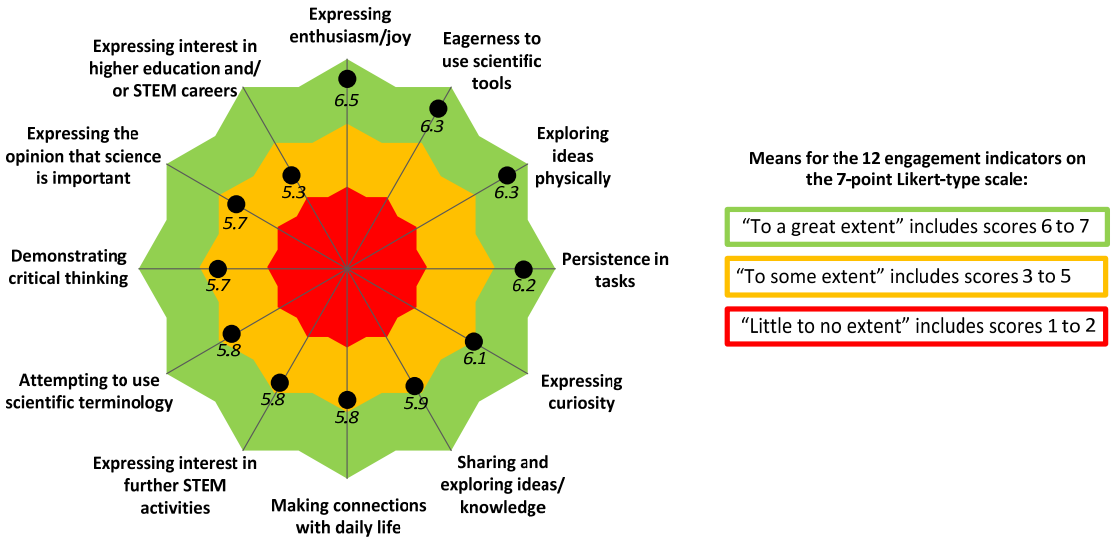
4. How Youth are Responding to PromoScience-Funded Projects

Overall, there is a strong indication that PromoScience-funded projects increase youth exposure to, as well as youth engagement in, STEM. Students were perceived as being highly engaged in projects when they expressed enthusiasm, curiosity and eagerness in using scientific tools, exploring ideas, persisting in tasks and sharing and exploring ideas and knowledge, as well as when they used critical thinking and used scientific terminology. Youth engagement was positively correlated with increases in interest, skills and knowledge but also confidence and ability to connect STEM to daily life. Although the measure of increased motivation to pursue post-secondary education or a career in STEM was somewhat more limited, there was anecdotal evidence suggesting that PromoScience-funded projects may have had an influence on motivating young Canadians to pursue further education in STEM; however, it is difficult to know to what extent it had an influence and what other factors were involved in the youths' decision to pursue further education.

4.1. High Levels of Engagement

In an effort to ascertain the extent to which youth are actively engaged in PromoScience-funded projects, teachers were asked to rate their students' level of engagement in project activities on a seven-point Likert scale. The notion of engagement was defined using 12 behavioural indicators examining the extent to which youth participated in and/or were interested by project activities. As illustrated in Figure 2, teachers, on average perceived their student's as highly engaged in projects when they demonstrated expressions of enthusiasm, curiosity and eagerness in using scientific tools, as well as the exploration of ideas physically, persistence in tasks and the sharing and exploring ideas/knowledge. Teachers were less apt to perceive behaviours more common among older youth, such as critical thinking and using scientific terminology as demonstrating high levels of engagement. This may be a reflection of the fact that the majority of teachers (76%) taught elementary school-aged children who may be less likely to demonstrate such behaviours.

Figure 2: Teachers rate their students' level of engagement in relation to 12 behavioural indicators



It should be noted however, that while PromoScience-funded projects are considered as generally successful at increasing youth engagement in STEM, findings from the case studies and key informant interviews indicate that it is not uncommon for some of the participants of these projects to already possess a strong interest in STEM. In other words, the projects are reaching "the converted", which may also account for high levels of engagement. Given the need however, to increase the number of youth pursuing a future in STEM, reaching the converted and nurturing their interest in STEM is not a negative result, it simply needs to be balanced with efforts to engage youth that may not already have this interest.

4.2. Increased Interest in STEM

Overall, there is a strong indication that PromoScience-funded projects increase youth exposure and interest in STEM. When asked about the extent to which STEM interest and exposure increased among youth that participated in their PromoScience-funded project(s), the vast majority of grantees perceived an increase to some or a great extent among all demographic and age groups identified in the survey, as illustrated in Table 4. The proportion of grantees reporting positive outcomes for youth with disabilities is however, smaller when compared to the other demographic groups. This divergence may however, be attributed to the fact that youth with disabilities are not a current target group of PromoScience, and therefore, there are fewer grantees targeting this demographic group. While not a target group of PromoScience, youth with disabilities is an emerging group within STEM education literature, and consequently, were included in the grantee survey to ensure a complete examination of all groups of youth under-represented in STEM.

Table 4: Grantees perceptions regarding the extent to which interest in, and exposure to STEM increased among participants of their PromoScience-funded project.

Demographic Group	Increased Exposure (to some or a great extent)*	Increased Interest (to some or a great extent)
Kindergarten-grade 8 (secondary 2) (n = 69)	97%	90%
Grade 9-12 (secondary 3-5 or CEGEP) (n = 66)	93%	87%
Girls (n = 68)	100%	97 %
Aboriginal Youth (n = 43)	91%	87%
Youth living in rural and/or remote areas (n = 53)	92%	88%
Youth from low-income background (n = 53)	95%	95%
Visible minorities (n = 48)	78%	75%
Youth with disabilities (n = 32)	66%	55%

NB: It is possible that grantees noted that certain participants represent multiple demographic groups, i.e. the groups listed above are not mutually exclusive (e.g. Aboriginal girls), and therefore, may have chosen one or more demographic group for certain participants.
Source: PromoScience Grantee Survey
NB: Using a 7 point Likert-type scale (to some extend includes scores from 3 to 5 and to a great extend includes scores from 6 to 7).

Almost all of the teachers surveyed (96%) share the same perception as grantees, namely that PromoScience-funded projects have a positive impact on youth interest in STEM, with many teachers (63%) perceiving the impact as significant. When asked to describe the positive impact, one third of teachers provided examples of the increased interest in STEM they observed in their students following their participation in project activities.

In several cases, teachers noted how their students pursued opportunities to participate in additional organized informal STEM activities while others engaged in such activities on their own by trying out what they learned at home. In one case, the teacher described how their student's engagement in the hands-on activities offered by a PromoScience-funded project led them to pursue higher education and careers in a STEM-related discipline.

"My students love the inquiry/project-based, hands-on, and real-world nature of science projects. (…) I have students from as far back as 25 years ago who still talk about the project they did in my class and how their science fair experience led to the STEM-related career they have today." – Teacher

The notion that engagement and increased interest in STEM are intertwined was noted by grantees surveyed, as well as grantees, teachers and/or participants for all 16 case studies. In particular, grantees perceive youth engagement in their PromoScience-funded project as positively correlated with the extent to which they perceived youth interest in STEM increasing. This correlation was noted for all participants and was particularly high for Aboriginal youth, youth living in rural and/or remote communities, youth with disabilities and visible minority youth. Additionally, the correlation between grantees' perceptions of engagement and increased interest was higher for older youth. This higher correlation may however, be attributed to a greater ability to observe engagement and/or increased interest among older youth, and/or because this group of youth is better able to communicate if and how they benefited from the project.

According to case study grantees and/or teachers, this correlation is credited to the use of hands-on and/or interactive activities that make learning about STEM fun by bringing it out of the traditional "textbook" setting and into the real-world. For 12 of the 16 case studies, the evaluation team had the opportunity to observe youth participating in PromoScience-funded projects and what they observed also supports the perceived connection between engagement, defined using the 12 behavioural indicators included in the grantee survey, and increased interest. Overall, participants appeared enthusiastic about what they were seeing and/or doing, asked the facilitator questions and participated in the hands-on and/or interactive activities. In some cases, evaluators overheard participants expressing their eagerness to try the activity at home and show their parents what they learned. When asked what they enjoyed about the PromoScience-funded project participants would often speak to the nature of the activities, that they thought the activities were fun and that it was better than learning in a classroom.

"Chemistry! I really enjoyed the show! It makes me want to learn more. It's so fascinating and shocking and really blew my mind. I never knew about all those substances and their effect on others. Hopefully, that we will use these substances in the future!" – Participant

"I don't like science class at school – it's terrible because it is boring and hard because you have to memorize and get the answers right…I like what we do here though. It's fun" - Participant

4.3. Increased STEM Skills and Knowledge

Increasing STEM skills and knowledge among young Canadians is a key outcome of PromoScience. There are however, challenges with systematically measuring the extent to which this outcome occurs and/or may be attributed to the PromoScience-funded project. Consequently, accounts of increased STEM skills and/or knowledge among PromoScience-funded project participants are primarily based on anecdotal evidence from grantees and teachers, and not objective assessments. In an effort to acquire information regarding this longer term outcome, grantees and teachers were asked to provide

their perceptions regarding the extent to which participants/student's STEM skills and knowledge increased following their participation in a PromoScience-funded project.

While only 79% of grantees explicitly stated that increasing the STEM skills and knowledge of young Canadians was one of their PromoScience-funded project's main objectives, almost all of the grantees believe their project achieved this objective. Among target groups, this increase appears to be particularly significant for girls; with 67% of grantees indicating that the skills and knowledge of girls increased to a great extent following their participation in a PromoScience-funded project. Grantees' perceptions that their projects successfully increased participants' STEM skills and knowledge were strongly and positively correlated with their perceptions that participants were highly engaged in their project[22]. This correlation can be interpreted in two ways: 1) grantees may be presuming that the more participants are engaged in project activities the more their skills and knowledge in STEM are increased (i.e., their perceptions of increases in skills/knowledge are assumptions based on their perceptions of engagement), or 2) there is a real relationship between engagement and skill/knowledge development such that participant engagement supports development."

Table 5: Grantee's perceptions of the extent to which STEM skills and knowledge increased among participants of their PromoScience-funded project.

Demographic group	Increased Skills/Knowledge	
	To some extent	To a great extent
Kindergarten-grade 8 (secondary 2) (n = 54)	22%	71%
Grade 9-12 (secondary 3-5 or CEGEP) (n = 53)	24%	68%
Girls (n = 59)	30%	67%
Aboriginal Youth (n = 41)	37%	49%
Youth living in rural and/or remote areas (n = 42)	35%	51%
Youth from low-income background (n = 45)	43%	51%
Visible minorities (n = 40)	32%	49%
Youth with disabilities (n = 29)	30%	39%

NB: It is possible that grantees noted that certain participants represent multiple demographic groups, i.e. the groups listed above are not mutually exclusive (e.g. Aboriginal girls), and therefore, may have chosen one or more demographic group for certain participants.
Source: PromoScience Grantee Survey

"…I had the chance to watch an engineering lab about torque. Then in September, the physics course that I was taking had torque as one of the main chapters. It was a nice feeling to be able to apply what I had learned…to my school work." – Participant

Almost all teachers (98%) espouse the same perception as grantees, that PromoScience-funded projects increase youth's STEM skills and knowledge. Moreover, many of these teachers (64%) perceive this increase to be considerable. Teachers were also asked to provide examples of the positive impact(s) they observed in their students following their participation in a PromoScience-funded project. One quarter provided examples of their students' increased STEM skills and knowledge. A common theme among these examples was students' improved understanding of specific STEM content. Teachers also noted how their student's confidence increased as a result of their

[22] Correlations were calculated between perceived engagement and perceived increases in skills/knowledge for each of 8 demographic groups represented by participants (e.g., girls, Aboriginal peoples, visible minorities). The average correlation across all these groups was 0.656, which is considered a large effect.

participation in a PromoScience-funded project, as did their ability to connect STEM to their daily lives.

"I think that when my students realized that they could carry out an experiment and be part of a team who produced results that would be used in the 'real world', it increased their confidence in themselves as learners, and helped them view themselves in a different light. That is, students took pride in their achievement and gained confidence in their own abilities. All in all, I think the experience helped my students to be more open and feel more positive about further education". – Teacher

Throughout the case studies, similar observations were noted by several grantees, teachers and project partners, while some of the youth also indicated how their knowledge of STEM improved following their participation in a PromoScience-funded project. During one case study, evaluators were able to observe a class that attended the PromoScience-funded project activity the week before and noted that some students remembered information acquired during their previous visit.

4.4. Increased Motivation to Pursue Post-Secondary Education in STEM

As previously stated, grantees were limited in the extent to which they were able to measure the impact of longer-term outcomes of their PromoScience-funded project, including participants' motivation to pursue further education and/or a career in STEM[23]. This was mostly attributed to the fact that they do not maintain long-term contact with the majority of participants. Grantees and teachers did provide anecdotal evidence and their perceptions regarding the extent to which participants' motivation to pursue STEM education and/or a career following a PromoScience-funded project. This anecdotal evidence suggests that PromoScience-funded may have motivated young Canadians to pursue further education in STEM; however, it is difficult to know to what extent it had an influence and what other factors were involved in the youth's decision to pursue further education.

Overall, grantees believe that their PromoScience-funded project is likely to have a positive impact on increasing the number of youth pursuing a STEM education. The majority of these grantees further indicated that they are achieving this objective to some or a great extent for all demographic and age groups, with the exception of youth with disabilities (54%)[24], as per Table 6. As mentioned under section 4.3, grantees' perceptions that their projects successfully increased participants' motivation to pursue STEM education were strongly and positively correlated with their perceptions that participants were highly engaged in their project[25]. This correlation can be interpreted in two ways: 1) grantees may be presuming that the more participants are engaged in project activities the more their motivation to pursue STEM education is increased (i.e., their perceptions of increases in motivation are assumptions based on their perceptions of engagement), or 2) there is a real relationship between engagement and motivation to pursue STEM education such that participant engagement supports motivation. Case study findings support this correlation as grantees tailored and delivered their projects with a focus of

[23] Successfully measuring the achievement of this outcome requires a longitudinal study that would follow two groups of youth, one exposed to informal STEM learning one that is not, over a certain period of time. Such a study would further require controlling for extraneous variables over time. Such a study would be appropriate for a SSHRC-funded researcher.

[24] This divergence may be attributed to the fact that youth with disabilities are not a current target group of PromoScience and therefore there are fewer grantees targeting this demographic group.

[25] Correlations were calculated between perceived engagement and perceived increases in motivation to pursue STEM education for each of 8 demographic groups represented by participants (e.g., girls, Aboriginal peoples, visible minorities). The average correlation across all these groups was 0.636, which is considered a large effect.

achieving high engagement, which in turn was expected to increase participant's motivation to pursue further education in STEM at the secondary and/or post-secondary level.

Table 6: Grantees perceptions of the extent to which motivation to pursue STEM education increased among participants of their PromoScience-funded project.

Demographic Group	Increased Motivation	
	To some extent	To a great extent
Kindergarten-grade 8 (secondary 2) (n = 63)	33%	48%
Grade 9-12 (secondary 3-5 or CEGEP) (n = 64)	23%	59%
Girls (n = 68)	28%	60%
Aboriginal Youth (n = 47)	46%	34%
Youth living in rural and/or remote areas (n = 49)	34%	54%
Youth from low-income background (n = 51)	41%	42%
Visible minorities (n = 45)	37%	39%
Youth with disabilities (n = 32)	25%	29%

NB: It is possible that grantees noted that certain participants represent multiple demographic groups, i.e. the groups listed above are not mutually exclusive (e.g. Aboriginal girls), and therefore, may have chosen one or more demographic group for certain participants.
Source: PromoScience Grantee Survey

Among teachers who taught secondary school-aged youth (28% of all respondents), more than half (53%) perceive PromoScience-funded projects as influencing their students' pursuit of further STEM education to a great extent. Teachers believe that PromoScience-funded projects encourage the pursuit of education in general; just under one-half (44%) of all teachers perceiving this impact to be significant.

A teacher allowed a student to participate in a PromoScience-funded project even though she was failing the course. Following the project, the student began to apply herself and managed to pass the course she was initially failing. The teacher reported that *"participating in the project was a life changing event for this student. She has not stopped talking about it and is convinced that she will enter sciences as a career. Before this event she said "I can't do science"*. – Teacher

Evidence from the case studies provides examples of increased motivation among project participants to pursue further education in STEM[26]. In certain instances, awareness of increased motivation was a result of hearing direct feedback from participants while in other cases, it was as a result of participant responses on post-project surveys or teacher's observations of students. For instance, one post-project survey revealed that 75% of participants were likely to take an optional science course in secondary school, while 74% were more likely to study science at the post-secondary level following their participation in a PromoScience-funded project. Such evidence is limited however, as it is anecdotal and collected at the end of, or immediately following a PromoScience-funded project and may not be representative of participants' long-term reality. Additionally, organizations may have asked participants about their increased motivation to pursue STEM education, but did not ask about the extent to which the PromoScience project influenced this motivation.

[26] Only two grantees were able to confirm that this further education was at the post-secondary level.

In some cases, former participants of the PromoScience-funded project returned when they were older to volunteer or work with the grantee while in university studying a STEM-related discipline. These former participants indicated that their participation in the PromoScience-funded project influenced their decision to pursue further education in STEM, among other factors. Thus, it appears that PromoScience-funded projects have some degree of influence in generating and/or supporting a long-term interest in STEM.

The PromoScience-funded project *"is a fantastic program! The program is why I chose to do engineering, a career which I love."* – Former Participant

The PromoScience-funded project *"has influenced my plans for the future. It's interested me in careers such as psychology, oil and gas engineering, and aircraft operator; things I hadn`t considered before."* – Former Participant

5. PromoScience's Operational Efficiency

Overall, it appears that the PromoScience funding opportunity is delivered in an efficient manner. A common measure of the operational efficiency of NSERC's grant programs is to assess the ratio of administrative expenditures[27] in relation to the total amount of grant expenditures, i.e. funds awarded. This ratio represents the cost to NSERC of administering $1 of grant funds. A programs' operational efficiency may also be presented as the percentage of administrative expenditures within the total program expenditures. Since 2000, PromoScience's total amount of grant expenditures almost tripled from $1,265,000 to $3,424,975. Human resources however, remained fairly stable with one full-time equivalency (FTE) program assistant and one part-time program officer (0.5 FTE). A team leader within the Innovative Collaborations, Science Promotion and Program Operations Division is also assigned to PromoScience at 0.15 FTE.

As per Table 7, the ratio of administrative expenditures for every $1 of grants expenditures between fiscal years 2010-11 to 2013-14 was 6.59 cents. When compared to other administrative ratios for NSERC, the PromoScience ratio was noted as being slightly higher. For example, the ratio of administrative expenditures for NSERC's Research Grants and Scholarships Directorate is 4.24 cents for every dollar spent, while the ratio of administrative expenditures for NSERC overall is 4.99 cents. The fact that the PromoScience administrative ratio is slightly higher than other programs is likely due to the smaller size of grants distributed through PromoScience, in comparison with the other NSERC funding opportunities. Although administrative expenditures and grant expenditures fluctuated over the years, the ratio of administrative expenditures to grant expenditures continued to decline. Consequently, there is evidence that PromoScience is delivered in an efficient manner and that economy is achieved as the program delivers more grant funds for a lower administrative cost.

Table 7. Operating expenditures for PromoScience grants between 2010-11 to 2013-14

Fiscal Year	Grant Expenditures	Administrative Expenditures	Total Administrative and Grant Expenditures	Administrative Expenditures per $1 of Grant Expenditures	Administrative Expenditures (% of Total Cost)
2010-11	$2,692,839	$186,487	$2,879,326	¢6.93	6.5%
2011-12	$2,764,875	$186,220	$2,951,095	¢6.74	6.3%
2012-13	$2,744,648	$176,745	$2,921,393	¢6.44	6.1%
2013-14	$3,030,908[28]	$190,349	$3,221,257	¢6.28	5.9%
Total	$11,233,270	$739,801	$11,973,071	¢6.59	6.2%

Source: Finance and Awards Administration Division, NSERC

[27] Administrative expenditures include the direct and indirect costs of administering the program. Direct costs include salary and non-salary expenditures, which relate to the adjudication of the award, post-award management, corporate representation and general administration of the Research Grants and Scholarships Directorate. Indirect costs include common administrative services for NSERC, such as Human Resources, Finance and Awards, IT, etc. Both direct and indirect costs are included in the total calculation of costs and estimated using the ratio of total Discovery Grant awards to total NSERC grant funds.

[28] Additional funding was made available for PromoScience from other RGS budgets.

5.1. Areas for Improvement

Overall, grantees appear to be satisfied with their experience with PromoScience, including the eligibility criteria, the duration of the grants, as well as the ease of understanding and completing the application forms. There are however, opportunities for improvement with regards to monitoring of the performance of PromoScience-funded activities and how performance data is used by PromoScience staff and grantees. While there are few issues with the funding opportunity, one-quarter of grantees indicated some dissatisfaction with the current reporting structure regarding project performance. Evidence collected during the file review suggests that some grantees do not have the capacity to provide all of the data requested. In particular, it appears grantees experience greater challenges providing data that is tracked over time, such as the number and types of participants for each year of their project[29], as well as qualitative data regarding the impact of PromoScience funding on the scope, reach and quality of the project. Furthermore, the open-ended questions requesting this qualitative data do not generate comparable data elements that can be summarized in an aggregated format and there are some concerns regarding the validity of the data, as what is collected is often based on the perceptions of grantees. Some key informants and case study grantees attribute the lack of capacity to collect performance data to the fact that grantees cannot use PromoScience funds for the purpose of performance measurement or evaluation. As many grantees struggle to find resources for simply developing and/or delivering informal STEM learning activities, they are limited as to available means for collecting and reporting performance data.

In addition to challenges collecting performance data for the final activity reports, just over a third of grantees (37%) did not indicate whether they use this data to help inform decisions regarding their PromoScience-funded project. This lack of use may be attributed to the fact that the data requested is not feasible to collect, or that grantees do not: have the capacity to engage in performance management; perceive the benefits of using the data for performance management; and/or, perceive the data as useful for performance management. Offering grantees the opportunity to collect data that not only informs NSERC about the project's performance, but also provides them with useful information for evidence-based decision making, would likely benefit both parties while increasing the number of grantees using data in this capacity.

There are also opportunities for improvement with regards to bringing the informal STEM learning community together to share best practices, resources and for grantees to support the capacity development of other grantees. Although there were no specific barriers experienced by grantees when applying for PromoScience funding, some organizations could be at a disadvantage during the application process. For instance, overall success rates for PromoScience funding are lower for non-governmental organizations, as compared to post-secondary institutions, which generally have greater knowledge and capacity for completing proposals. As such, non-governmental organizations may potentially require and benefit from guidance regarding how to successfully navigate the application process, guidance that may be provided by more successful applicants.

[29] Grantees are requested to provide the number of girls and Aboriginal youth that participated in their PromoScience-funded project activities. In some cases however, the number of participants for each group, as noted by grantees, appear to be a reflection of population statistics and not an actual number of program participants. For instance, some grantees will state that 50% of their participants are girls, because girls represent approximately 50% of Canada's youth population.

6. Conclusion

Why is it important to fund informal STEM Learning?

The evaluation confirms the continued need for PromoScience. Over the last 20 to 30 years, there has been a notable trend within science education research of youth exhibiting low levels of interest when it comes to pursuing STEM-related activities, education and/or careers. Informal science learning can make STEM fun by creating more authentic links between STEM theory and practice and by cultivating deeper interest in science through active learning or prolonged engagement.

PromoScience plays a key role in STEM promotion by funding informal science learning in Canada that offer opportunities for youth to participate in activities that are known to build engagement, interest, skills and knowledge. PromoScience target groups are appropriate and the program must continue to target youth and groups under-represented in STEM to achieve its objectives. In particular, informal STEM learning activities for youth living in rural and/or remote areas should be considered as an important priority as this group of youth have fewer opportunities to engage in such activities and may also be further disadvantaged in terms of the STEM learning opportunities they receive through the formal education system. There are also indications that teachers play a significant role in developing youths' interest in STEM, and are one of the main factors influencing youth to pursue further STEM education. This influence is noted as being particularly important for youth in secondary school.

Is it an appropriate and necessary role for the federal government?

Funding informal science learning through PromoScience is an appropriate role for the federal government and NSERC. Overall, PromoScience is considered an essential funding opportunity because it helps to address gaps in formal STEM education at a national level, and it is the only national and consistent, public funding available for informal STEM learning. By funding PromoScience, NSERC provides strong national leadership that fosters a science culture and encourages a shift towards a more positive image of STEM. It supports a robust and reliable pipeline of STEM professionals in order to remain competitive within the global economy and it also provides grantees with the opportunity to leverage their relationship with NSERC to secure more funding.

How PromoScience supports informal STEM learning in Canada

The provision of hands-on and/or interactive activities and making activities authentic to the participant are well documented in the literature as contributing to increased engagement and interest in STEM. Additionally, such activities are key for increasing engagement and challenging misconceptions of STEM by helping youth establish connections between STEM and their daily lives. This is particularly important with Aboriginal youth where such misconceptions and lack of connections are particularly present.

PromoScience funds projects that are well designed for engaging youth in informal STEM learning activities because they include hands-on and/or interactive activities. PromoScience grantees also tailor activities to make them more accessible to the diverse identities, interests and beliefs representative of young Canadians. The most common tailoring strategies are: cooperative activities

and group work (77%); content relevant to the local environment, such as creating links between STEM and crop sustainability in a rural, farming community (65%); materials including examples of the same demographic group as participants (57%); physical activities (55%); matched demographic mentors/facilitators (54%); and, catering the content (50%) to the language of the target population(s). In addition to increasing engagement and interest in STEM, tailoring the content results in increased understanding of STEM, as well as feelings of inclusiveness and self-efficacy. The link between tailoring and engagement is important as higher engagement is also correlated with more perceived positive outcomes for project participants including increased STEM interest, skills and knowledge, as well as increased motivation to pursue post-secondary education and/or a career in STEM. Moreover, the positive outcomes of tailoring informal STEM learning activities are especially prevalent among groups traditionally under-represented in STEM post-secondary education programs and/or careers.

PromoScience funding improved grantees' organizational capacity to deliver informal STEM learning activities. In particular, PromoScience supported the successful implementation of funded projects, the ability to reach target groups and the quality of project staff and/or materials. Grantees generally attribute their improved capacity to the permitted uses of PromoScience funding, such as the development and/or improvement of project content and delivery, as well as operational costs, such as travel, materials and supplies. They further credit other aspects of the PromoScience funding model to the success of funded projects, including the up to three years of funding per application and the opportunity to reapply for a grant once a funding period has expired. Without PromoScience funds, grantees believe that they would have had to reduce the scale of their project (38%), postpone (23%) or cancel (20%) their project. Evidence from the evaluation suggests that PromoScience funding helped grantees develop new and/or strengthen existing partnerships, which likely contributed to the success of their projects. More than half of the grantees (60%) indicated that they delivered their PromoScience-funded project in partnership with at least one other organization.

In an effort to increase the number of young Canadians pursuing a post-secondary STEM education and/or career, PromoScience funds may be used by grantees to provide training and/or resources to elementary and/or secondary school teachers in Canada. The majority of the training and/or resources offered to teachers by grantees were: in-class presentations and workshops; developing/adapting STEM materials/tools; professional development opportunities for STEM teachers; and/or engaging post-secondary students to develop and/or deliver their PromoScience-funded project. Overall, teachers reported that the training received was more helpful in terms of providing them with ideas for scientific activities and improving the engagement and/or interest of their students in STEM. Materials/tools had the least impact on increasing teacher's awareness of the facilitation needs of specific groups of participants. Consequently, it appears that there is an opportunity for PromoScience-funded projects to contribute to improving the skills of Canadian teachers in this area. This may include educating teachers about the importance of catering the content and delivery of STEM learning activities and/or offering materials/tools that are designed for different audiences.

How youth are responding to PromoScience-funded projects

There is a strong indication that PromoScience-funded projects increase youth exposure to, as well as youth engagement in, STEM. There is also a strong indication that youth were highly engaged in projects, illustrated by: expressions of enthusiasm; curiosity; eagerness of using scientific tools; exploring ideas physically; persistence in tasks; and, the sharing and exploring ideas/knowledge. Youth engagement was perceived by grantees as positively correlated with observed increases in interest, skills and knowledge, particularly for Aboriginal youth, youth living in rural and/or remote areas, youth

with disabilities and visible minority youth. This correlation was credited to the use of hands-on and/or interactive activities. Almost all of the teachers surveyed (96%) share the same perception as grantees, namely that PromoScience-funded projects have a positive impact on youth interest in STEM, with many teachers (63%) perceiving the impact as significant.

Almost all of the grantees believe their project contributed to increasing the STEM skills and knowledge of young Canadians. Among target groups, this increase appears to be particularly significant for girls with 67% of grantees indicating that the skills and knowledge of girls increased to a great extent following their participation in a PromoScience-funded project. The measure of increased motivation to pursue post-secondary education or a career in STEM was somewhat more limited. However, among teachers who taught secondary school-aged youth (28% of all respondents), more than half (53%) perceive PromoScience-funded projects as influencing their students' pursuit of further STEM education to a great extent. Teachers believe that PromoScience-funded projects encourage the pursuit of education in general; just under one-half (44%) of all teachers perceived this impact to be significant. Moreover, there was also anecdotal evidence suggesting that PromoScience-funded projects may have motivated young Canadians to pursue further education in STEM; however, it is difficult to know to what extent it had an influence and what other factors were involved in the youths' decision to pursue further education.

PromoScience's Operational Efficiency

Overall, it appears that the PromoScience funding opportunity is delivered in an efficient manner. Since 2000, PromoScience's total amount of grant expenditures almost tripled from $1,265,000 to $3,424,975. The ratio of administrative expenditures for every $1 of grants expenditures between fiscal years 2010-11 to 2013-14 was 6.59 cents. When compared to other administrative ratios for NSERC, the PromoScience ratio was noted as being slightly higher. For example, the ratio of administrative expenditures for NSERC's Research Grants and Scholarships Directorate is 4.24 cents for every dollar spent, while the ratio of administrative expenditures for NSERC overall is 4.99 cents. The fact that the PromoScience administrative ratio is slightly higher than other programs is likely due to the smaller size of grants distributed through PromoScience, in comparison with the other NSERC funding opportunities.

Areas for Improvement

Grantees appear to be satisfied with their experience with PromoScience, including the eligibility criteria, the duration of the grants, as well as the ease of understanding and completing the application forms. There are, however, opportunities for improvement with regards to the monitoring of the performance of PromoScience-funded activities and how performance data is used by PromoScience staff and grantees.

There are also opportunities for improvement with regards to bringing the informal STEM learning community together to share best practices, resources and for grantees to support the capacity development of other grantees. Although there were no specific barriers experienced by grantees when applying for PromoScience funding, some organizations could be at a disadvantage during the application process. For instance, overall success rates for PromoScience funding are lower for non-governmental organizations, as compared to post-secondary institutions, which generally have greater knowledge and capacity for completing proposals. As such, non-governmental organizations may potentially require and benefit from guidance regarding how to successfully navigate the application process, guidance that may be provided by more successful applicants.

7. Recommendations

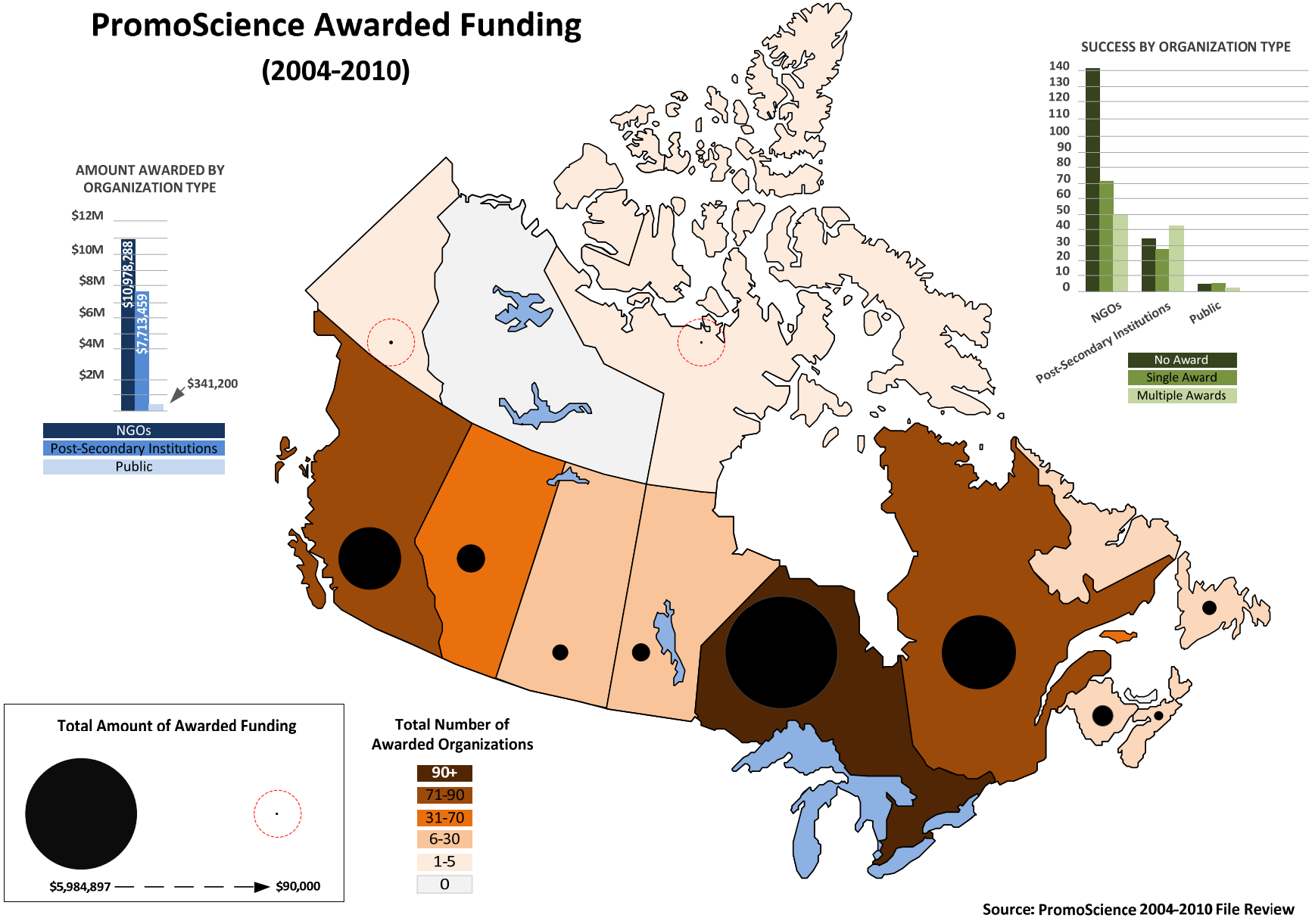
1. **It is recommended that the federal government continue to offer PromoScience through NSERC, as the findings from the evaluation clearly demonstrate a continued need for funding to support informal STEM learning opportunities for all young Canadians.** PromoScience is aligned with federal government priorities and NSERC strategic outcomes, and continues to be an appropriate role for the federal government as it helps to support the development of a positive STEM culture in Canada. Evidence collected from the case studies, key informant interviews, file review and various surveys also indicate that PromoScience is achieving its immediate outcomes as funded projects increase the exposure, engagement and interest of young Canadians in STEM and/or increase the training and resources available to improve the capacity of Canadian teachers responsible for STEM education. Additionally, evidence indicates that PromoScience funds enable grantees to improve their organizational capacity to deliver informal STEM learning activities, including reaching out to and/or tailoring project activities for groups traditionally under-represented in STEM. PromoScience's successes in achieving many of its objectives are primarily attributed to the program's funding model and the fact that all funded projects include hands-on and/or interactive activities.

2. **It is recommended that PromoScience conduct a strategic discussion to further refine its objectives, expected outcomes and target groups.** In particular, the program should consider which outcomes and target groups it can affect to a greater extent and perhaps concentrate efforts in these areas. For instance, evidence collected throughout the evaluation suggests that PromoScience makes a greater contribution exposing various groups of youth to STEM and generating an interest in these disciplines, than it does to increasing their STEM skills and knowledge and/or their motivation to pursue further STEM education. There are also indications that teachers play a significant role in developing youth's interest in STEM, and are one of the main factors influencing youth to pursue further STEM education. This influence is noted as being particularly important for youth in secondary school. Another notable theme throughout the evaluation is the importance of providing informal STEM learning activities for youth living in rural and/or remote areas, as this group of youth have fewer opportunities to engage in such activities and may also be further disadvantaged in terms of the STEM learning opportunities they receive through the formal education system.

3. **It is recommended that PromoScience develop a new final activity report that includes more close-ended questions regarding the impact of its funding on the implementation, reach and quality of projects to provide more useful, accessible and comparable performance information.** The report should also continue to include a few open-ended questions to provide grantees with the opportunity to highlight some of the unique attributes of their program. It is further recommended that PromoScience consult with current and former grantees about what performance data is requested in the new final activity report to ensure that the data is useful for grantees and feasible to collect. Additionally, data collected during the evaluation suggests that some grantees do not have the capacity to provide all of the data requested and that the validity of the data is questionable at times. Several key informants and grantees attribute this lack of capacity to the fact that grantees are unable to use PromoScience funds for project evaluation. Grantees would therefore, likely benefit from more comprehensive and structured information on how to complete the new final activity report and the type of data requested, as well as opportunities to use part of their PromoScience grant to collect the data requested by the program.

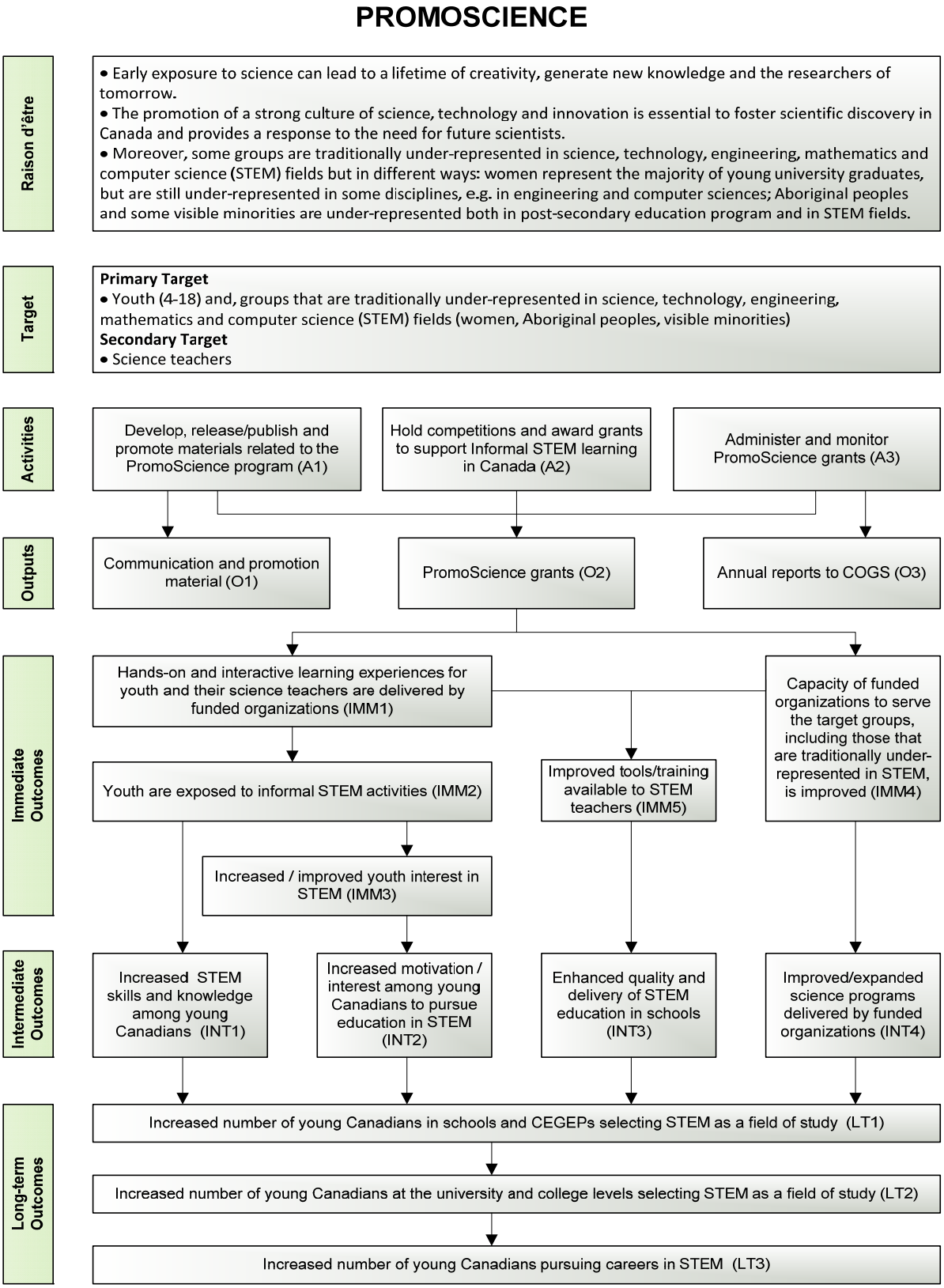
4. **Bringing the informal STEM learning community together is important and it is recommended that PromoScience provide opportunities for current and former grantees to connect with one another, and with the larger informal STEM learning community to share best practices and resources.** Such opportunities may include, but are not limited to: an online network/community of practice; PromoScience conferences; and/or, PromoScience staff directly connecting grantees to one another. For instance, PromoScience staff may place two or more grantees in contact with one another if they believe there are opportunities for partnerships and/or that one grantee may help support the capacity development of another grantee. It is believed that providing grantees with the opportunity to connect with one another, and/or with other organizations delivering informal STEM learning activities, will increase the reach, quality and impact of PromoScience-funded projects. It is also recommended that the platform used to bring grantees and the informal STEM learning community together is national in scope in order to support the development of a positive and inclusive STEM culture across Canada. Currently, some national platforms exist that PromoScience may want to consider partnering with in an effort to avoid repetition and to utilize existing knowledge and/or networks. Such systems included, but are not limited to Actua's annual network member conferences and the Science and Technology Awareness Network (STAN).

Appendix A: PromoScience Funding Across Canada



Source: PromoScience 2004-2010 File Review

Appendix B: Logic Model



Appendix C: PromoScience Evaluation Matrix

The evaluation matrix used to guide data collection and outlining the sections of the report that correspond to each evaluation question

Question	Indicators	Methods	Sections of the report that correspond with the evaluation questions
Relevance			
1. Is there a continued need for PromoScience? 1.1 Are the target groups appropriate?	• Evidence of importance of early exposure to science to encourage higher level STEM education and careers • Evidence of the importance of hands-on/interactive and extra curricula activities to support a science culture • Evidence of the need for science promotion and awareness activities for Canadian youth • Evidence that certain groups are under-represented in STEM education • Evidence that certain groups are under-represented in STEM occupations	Key informant interviews Literature review Document review Case Studies Post-Secondary Student Survey Prize Recipients Survey	2.1 2.2
2. Is PromoScience aligned with federal government priorities and NSERC strategic outcomes?	• Extent of alignment between PromoScience's objectives and federal government priorities • Extent of alignment with NSERC's PAA • Extent of alignment between PromoScience's objectives and NSERC's mandate	Document review Key informant interviews	2.2
3. Is it appropriate and necessary for the federal government to fund science awareness and education programs?	• Existence or absence of similar funding opportunities for target populations • Evidence of a niche for federal government involvement versus other levels of government	Key informant interviews Literature review Document review Case Studies	2.2
Design and Delivery			
4. To what extent was the PromoScience programming appropriately designed for youth?	• % of projects that include hands-on and/or interactive learning experiences • Nature of the programming delivered by grant recipients • Evidence that the funding opportunity design results in hands-on and interactive activities (existence of guidelines, criteria, selection process) • Evidence that programming reflects the latest/ promising practices • Evidence that high quality grant applications are selected	Key informant interviews Document review Literature review File review Case studies Grantee Survey Teacher Survey	3.1 3.2 4.1

Question	Indicators	Methods	Sections of the report that correspond with the evaluation questions
5. To what extent was the PromoScience programming tailored to the social and cultural contexts of groups traditionally under-represented in STEM?	• % of projects that include programming developed or adapted for targeted under-represented groups (girls, Aboriginal) and other under-represented groups (youth from low-income families, youth living in remote communities, youth with disabilities, visible minorities) • Nature of the strategies used to tailor programming to the targeted under-represented groups • Evidence that programming reflects the latest/promising practices for targeted under-represented groups	Key informant interviews Case studies Grantee Survey Teacher Survey	3.2
6 Are there any barriers encountered by organizations to access PromoScience funding?	• Types of barriers experienced by funded and unfunded organizations and degree of impact on their programming • Types of organizations encountering barriers when accessing the PromoScience funding	Key informant interviews Case studies Grantee Survey Teacher Survey	There were no barriers noted during the evaluation
Performance			
7. To what extent has PromoScience improved the capacity of funded organizations to serve the target groups?	• % of organizations reporting having developed capacity to deliver STEM programming to youth and under-represented groups as a result of PromoScience • % of organizations reporting having increased their reach (number of participants, groups (age, under-represented, location) as a result of their PromoScience project • % of organizations reporting having developed new and/or strengthened existing partnerships as a result of their PromoScience project	Key informant interviews File Review Case studies Grantee Survey Teacher Survey	3.3
8. To what extent has PromoScience supported the development or the improvement of tools available to STEM teachers?	• # of teacher participants reporting that the tools developed through PromoScience projects are being used • Nature of the tools developed/improved and distributed to STEM teachers (general public youth versus under-represented groups) • Number of STEM teachers/schools reached • % of organizations that perceive that PromoScience-funded projects improved the tools available to STEM teachers • % of organizations reporting that new STEM materials were developed or existing materials were improved as part of their PromoScience project	Key informant interviews Case studies Grantee Survey Teacher Survey	3.4

Question	Indicators	Methods	Sections of the report that correspond with the evaluation questions
9. To what extent PromoScience increased/improved youth interest in STEM?	• Evidence of the active engagement/participation of youth in PromoScience project activities (such as participation during the activities, asking questions, etc.) • % of participants reporting increased interest in STEM • % of participants reporting increased motivation to pursue informal STEM learning opportunities (after-school, extra-school) • % of organizations that perceive that PromoScience programming has increased participants' interest in STEM • Anecdotal evidence of increased interest and motivation	Key informant interviews Case studies Grantee Survey Teacher Survey	4.1 4.2
10. To what extent have youth skills and knowledge in STEM increased as a result of PromoScience?	• Evidence that activities funded by PromoScience are likely to increase skills and knowledge in STEM (*NOTE: The purpose of this indicator is to establish the link between what the theory says and what should happen or is likely to happen*) • Perception of teachers that participants' knowledge of STEM and their ability to apply this knowledge have increased • % of organizations that perceive that PromoScience programming has increased participants' STEM skills and knowledge	Key informant interviews Case studies Grantee Survey Teacher Survey	4.3
11. Is the program likely to increase the number of young Canadians pursuing education and careers in STEM?	• % of participants that report becoming interested in STEM because of science learning activities associated with PromoScience • % of participants reporting increased interest in pursuing formal education in STEM • % of participants reporting increased interest in pursuing a career in STEM • % of organizations that perceive that PromoScience programming has increased participant's interest in pursuing education in STEM	Key informant interviews Case studies Grantee Survey Teacher Survey	4.4
Efficiency and Economy			
12. Is PromoScience delivered in an efficient manner? Is economy achieved?	• Administrative Ratio (¢:$1) (Operating Expenditures to Grant Funds Awarded) • Administrative Expenditure as a Percentage of Total Program Expenditures	Key informant interviews Financial data review (Efficiency Analysis)	5

Appendix D: Methodology and Mapping

The nine lines of inquiry used to conduct the PromoScience evaluation, and the team members involved in each one are described in the table below. Following the table is a methodological map illustrating the case studies, and the teachers and grantees surveys. The map also illustrates the location, per province, of the main offices of grantees that provided activities for teacher survey respondents and/or their students.

Lines of inquiry used for the evaluation of PromoScience

Line of Inquiry[30]	**Team Members**
Literature Review (109 documents)	
The literature review provided context for the evaluation and informed the development of the evaluation design. The findings also contributed to answering evaluation questions pertaining to relevance, as well as design and delivery. The review included eight internal government documents and 101 external documents, such as literature regarding the outcomes and indicators of informal science learning programs.	Evaluation Division
File Review (n = 356)	
The file review provided evidence regarding the design and delivery of PromoScience-funded projects, the impact of PromoScience funding on the grantees and project outcomes when data was available. The review focused on grantee files for competition years 2004 until 2010[31]. This time frame was chosen as the granting period was ended for all grantees and most, if not all had submitted their final activity report.	Evaluation Division
Case Studies (n = 16)	
The case studies gathered in-depth evidence on the design and delivery, as well as the performance of certain PromoScience-funded project. It was also expected that case study participants would provide further context about the relevance of PromoScience. Each case study included a document review, as well as interviews with a minimum of five to seven stakeholders of the PromoScience-funded project. The evaluation team also conducted site visits with 14 of the 16 case studies and observations of and/or interviews with participants for 12 of the 16 case studies.	Evaluation Division/ Goss Gilroy /Alderson-Gill & Associates
Grantee Survey (n = 92; 38% response rate)	
The grantee survey provided a broader range of grantees with the opportunity to provide information about their experience with PromoScience and their funded project, including design, delivery and perceived impact. It was determined that the sample would include grantees from competition years 2004 until 2010, in order to remain consistent with the file review. Ultimately, 249 were invited to participate in the survey and 92 responded.	Evaluation Division

[30] For more information on the methodology for each line of inquiry please consult the respective technical reports.
[31] Some files during the time period in question were unavailable and/or did not include final activity reports and therefore, were not incorporated in the file review.

Teacher Survey (n = 913; the response rate for this survey is unavailable)	
The teacher survey provided information on PromoScience outcomes, specifically the impact of funded projects on teacher capacity and/or youth interest, skills, knowledge and/or motivation relating to STEM. Teachers were contacted indirectly through the grantees; therefore it is not possible to know the exact number of teachers contacted. A total of 913 teachers completed the survey.	Evaluation Division
Surveys with Post-Secondary Students (n = 3572; response rate is unavailable)	
Results from the surveys with post-secondary students provided information regarding the relevance of the PromoScience funding opportunity, including which groups should be targeted. The results from these surveys will be used in future evaluations regarding the following NSERC programs, grants and scholarships: (1) CREATE; (2) NSERC's Postgraduate Scholarships Program, Industrial Innovation Scholarships Program, and Industrial Postgraduate Scholarships Program; and, (3) NSERC's Collaborative Research and Development Grants, Engage Grants, Industrial Research Chairs Grants and Strategic Partnerships Grants.	Evaluation Division
NSERC Prize Recipients Survey (n = 91 ; response rate 58%)	
Results from the survey were used to inform arguments regarding the relevance of PromoScience within Canada. This survey was part of the evaluation of NSERC's suite of prizes, another component of the Science and Engineering Promotion sub-program. The sample included 156 prize recipients from 2003 to 2013, and 91 recipients completed the survey.	Goss Gilroy Inc.
Key Informant Interviews (n = 15; 75% response rate)	
The purpose of the key informant interviews was to acquire a strategic perspective regarding the relevance of PromoScience in Canada, the importance and challenges of reaching out to groups under-represented in STEM, as well as the design and delivery of PromoScience and the projects funded. Fifteen interviews were conducted with five stakeholder groups including: NSERC management and staff; selection committee members, experts in the fields of informal STEM learning, representatives of two national Aboriginal organizations and representatives from other federal government departments.	Evaluation Division
Cost-Efficiency Analysis	
This line of inquiry determined if PromoScience was delivered efficiently and whether economy was achieved. Given the timing of the evaluation, the most recent complete set of financial data covered the fiscal years 2010-2011 until 2013-2014. The data for this analysis were provided by the NSERC-SSHRC Finance and Awards Administration Division. The analysis examined total administrative expenditures relative to grant expenditures for the PromoScience funding opportunity and results were compared to the cost-efficiency analyses for the NSERC's Research Partnerships, and Research Grants and Scholarships Directorates.	Evaluation Division

PromoScience Evaluation Methodological Map

Case Study Focus

Aboriginal · Girls · All · Low income/rural/remote

1. Bamfield Marine Sciences Centre
Type: Non-Profit
Scope: BC & AL
Funding: Total $330,000/Project $120,000

2. Society for Canadian Women in Science and Technology
Type: Non-Profit
Scope: Provincial
Funding: Total $224,500/Project $81,700

3. Big Little Science Centre
Type: Non-Profit
Scope: Regional
Funding: Total $144,300/Project $39,000

4. UBC Physics Olympics
Type: Academic (UBC)
Scope: Provincial
Funding: Total $147,641/Project $41,200

5. Canadian Light Source Inc.
Type: Academic (U of SK)
Scope: National
Funding: Total $145,400/Project $78,200

6. Science Ambassador
Type: Academic (U of SK)
Scope: Regional (SK, MN, AL)
Funding: Total $76,400/Project $76,400

7. Educating Youth in Engineering and Science
Type: Academic (U of Regina)
Scope: Provincial
Funding: Total $186,100/Project $75,000

8. Youth BioLab
Type: Academic (U of M)
Scope: Regional
Funding: Total $60,000/Project $60,000

9. Women in Science and Engineering
Type: Non-Profit
Scope: Provincial
Funding: Total $105,000/Project $75,000

10. ACTUA
Type: Non-Profit
Scope: National
Funding: Total $974,666/Project $60,000

11. Adventures in Engineering and Science (AES)
Type: Academic (U of O)
Scope: Regional
Funding: Total $121,900/Project $41,900

12. Quebec Aboriginal Science & Engineering Association
Type: Non-Profit
Scope: Provincial
Funding: Total $114,600/Project $75,000

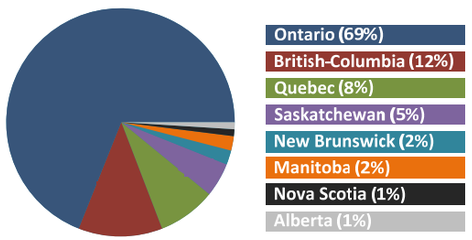
13. Conseil du loisir scientifique
Type: Non-Profit
Scope: Regional
Funding: Total $31,300/Project $31,300

14. Sciences et mathématiques en action (SMAC)
Type: Academic (Laval)
Scope: Provincial
Funding: Total $278,600/Project $42.600

15. Chemistry is Everywhere
Type: Academic (MUN)
Scope: Regional
Funding: Total $156,200/Project $34,631

16. Women in Science and Engineering Newfoundland and Labrador
Type: Non-Profit
Scope: Provincial
Funding: Total $312,699/Project $99,999

% of teacher surveyed associated with grantees' main offices (N=913)



Note: respondents can only be associated with 33 grantees

% of grantees per province that completed the grantee survey

More than 30%
19-30%
9-18%
Less than 9%

Appendix E: References

Adams, Cindy (2014). *Elementary Science Education for the 21st Century*. Retrieved from: http://www.stemeducationawareness.ca/young-minds/elementary-science-education

Alston, R. J., & Hampton, J.L. (2000). Science and engineering as viable career choices for students with disabilities: A survey of parents and teachers. *Rehabilitation Counseling Bulletin, 43*(3), 158-164.

Austin, J., & Hickey, A. (2011) Incorporating indigenous knowledge into the curriculum: Responses of science teacher educators. *The International Journal of Science in Society, 2*(4), 139-152.

Barlow, Reni (2012). Canada's declining youth STEM engagement – An urgent and important challenge. *Media Planet: STEM Education, 1*, 2.

Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M.A. (2009). *Learning Science in Informal Environments: People, Places & Pursuits*. Retrieved from: http://www.nap.edu/catalog.php?record_id=12190

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in Math and Science: Do Mothers' Beliefs Matter 12 Years Later? *Journal of Educational Psychology, 96*(1), 97-109.

Bordt, M., de Broucker, P., Read, C., Harris, S., & Zhang, Y. (2001). Science and technology skills: Participation and performance in elementary and secondary school. *Education Quarterly Review, Statistics Canada, 8*(1), 12-21.

Cano, J., & Bankston, J. (1992). Factors which influence participation and non-participation of ethnic minority youth in Ohio 4-H programs. *Journal of Agricultural Education, 33*(1) 23 - 29.

Center for Advancement of Informal Science Education [CAISE], Inquiry Group. (2010). *Making Science Matter: Collaborations Between Informal Science Education Organizations and Schools*. Retrieved from: http://informalscience.org/research/ic-000-000-001-939/Making-Science-Matter-Collaborations-Between-Informal-Science-Education-Organizations-and-Schools

Commonwealth of Australia, Department of Innovation, Industry, Science and Research, Science Communication and Strategic Partnerships. (2010). *Inspiring Australia: A National Strategy for Engagement with the Sciences*. Kingston, ACT: Commonwealth of Australia.

Conference Board of Canada (2013). Percentage of Graduates in Science, Math, Computer *Science, and Engineering*. Retrieved from: http://www.conferenceboard.ca/hcp/details/education/graduates-science-math-computer-science-engineerin.aspx

Council of Canadian Academies. Expert Panel on STEM Skills for the Future, & Canadian Electronic Library (Firm). (2015). *Some Assembly Required: STEM Skills and Canada's Economic Productivity*. Retrieved from: http://www.scienceadvice.ca/uploads/ENG/AssessmentsPublicationsNewsReleases/STEM/STEMFullReportEn.pdf

DeCoito, I. & Gitari, W. (2014). Contextualizing Science Outreach Programs: A Case for Indigenizing Science Education Curriculum in Aboriginal Schools. *First Nations Perspectives, 6*(1), 26-51.

Dorsen, J., Carlson, B., & Goodyear, L. (2006). *Connecting Informal STEM Experiences to Career Choices: Identifying the Pathway*. Retrieved from: http://stelar.edc.org/publications/connecting-informal-stem-experiences-career-choices-identifying-pathway

Employment and Social Development Canada (2012). *Imbalances Between Labour Demand and Supply (2013-2022).* Retrieved from: http://occupations.esdc.gc.ca/sppc-cops/l.3bd.2t.1ils@-eng.jsp

European Science Education Initiative. (2004). *Assessment of Pilot Projects: Resource Centre 1*. Naples, IT: PENCIL.

Fancsali, C. (2002). *What we know about girls, STEM and afterschool programs.* Prepared for Education Equity Concepts. New York: Academy for Educational Development.

Hidi, S., & Renninger, K.A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111-127.

Kesidou, S., & Roseman J. E. (2002). How well do middle school science programs measure up? Findings from project 2061's curriculum review. *Journal of Research in Science Teaching, 39*(6). 522-549.

Mark, H.M. (2000). Student's engagement in instructional activity: Patterns in the elementary, middle and high school years. *American Educational Research Journal, 37* (1), 153-184.

Mason, D. D. M., & McCarthy, C. (2006). 'The feeling of exclusion': Young peoples' perceptions of art galleries. *Museum Management and Curatorship, 21*(1), 20-31.

National Science Foundation, Division of Science Resources Statistics. (2003). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002*. Arlington, VA: NSF.

National Youth Science Forum. (2013). *2013 Annual Report*. Canberra, AU: Author.

Nisbet, M. C. (2002). Knowledge, reservations, or promise? A media effects model for public perceptions of science and technology. *Communication Research, 29*(5), 584-608.

NSERC, Corporate Planning & Policy Directorate. (2010). *Women in Science and Engineering in Canada*. Retrieved from: http://www.nserc-crsng.gc.ca/women-femmes/index_eng.asp

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049- 1079.

Royal Academy of Engineering. (2009). *National Engineering Programme: Strengthening Engineering Education*. London, UK: Author.

The Institution of Engineering and Technology (2008). *Studying Stem: What are the barriers?* Retrieved from: www.theiet.org/factfiles/education/stem-report-page.cfm?type=pdf