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Evaluation of the Science and Engineering Promotion Initiative:

PromoScience

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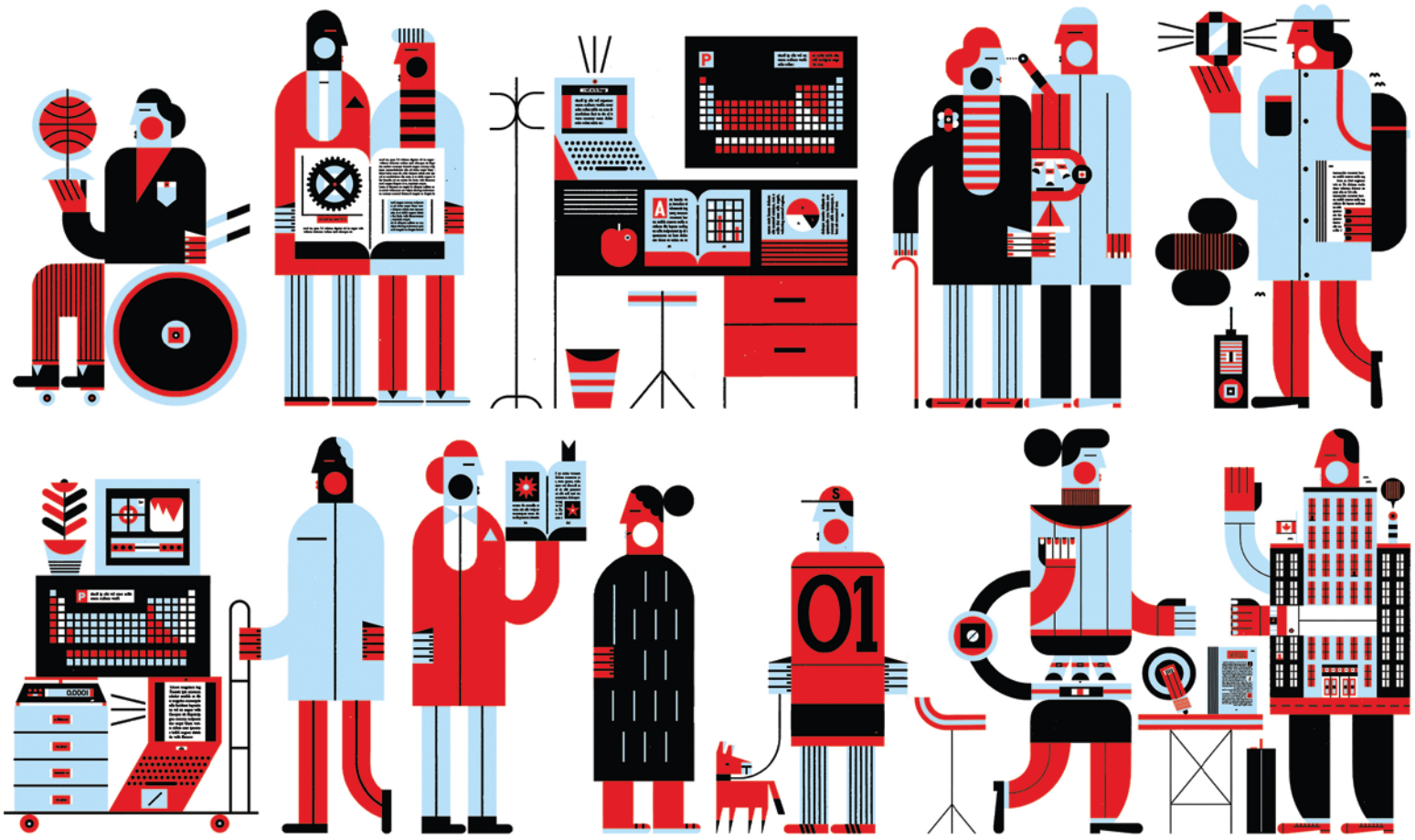

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Evaluation of the Science and Engineering Promotion Initiative: PromoScience
The Honourable François-Philippe Champagne, P.C, M.P. Minister of Innovation, Science and Industry

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Introduction

This report presents the key findings, conclusions, and recommendations of the evaluation of the Natural Sciences and Engineering Research Council of Canada (NSERC) PromoScience Program.[1] This is the second evaluation of the program and covers the period from fiscal year 2015-2016 to fiscal year 2019-2020. Conducted during the COVID-19 pandemic, it builds in part on the findings and conclusions of the 2015 evaluation, which not only covered the 15-year history of the program, but was also based on extensive data collection across Canada from funded organizations, youth, and teachers.

The purpose of this evaluation is to provide NSERC's senior management with an analysis of the relevance of the PromoScience program and the key findings from 2015, as well as an assessment of the program's delivery, performance and efficiency following the budget increases of the past five years. In addition, the evaluation was developed to ensure that NSERC meets the requirements of Section 42.1(1) of the Financial Administration Act and the 2016 Treasury Board Policy on Results.[2]

1. The Natural Sciences and Engineering Research Council of Canada's Promoscience Program is identified as PromoScience in this report.
2. Treasury Board (2016). Policy on Results. Retrieved from: https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=31300

Financial Support Offered by the PromoScience Program

Objectives and target groups[3]

PromoScience is the primary funding opportunity within NSERC's Science and Engineering Promotion subprogram, which is designed to encourage the next generation of young Canadians to study or pursue careers in the natural sciences and engineering.

Created in 2000, PromoScience aims to promote understanding of and interest in science, technology, engineering and mathematics (STEM) among Canadian youth aged 4 to 18, including those from underrepresented groups, primarily girls and Indigenous youth,[4] but also youth living in rural and remote areas, visible minorities youth and youth with disabilities.

In addition, PromoScience provides funding to develop and deliver training and resources for elementary and secondary school teachers to support their ability to teach STEM.

Selection of PromoScience proposals

To achieve its goals, the program provides financial support to organizations involved in the development and implementation of informal STEM learning activities. Informal learning refers to learning in an environment outside of a school or formal learning context (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003). The impact of these activities is well documented in the literature and they are known to help stimulate youth interest and engagement in science. Only Canadian not-for-profit or charitable organizations, post-secondary institutions, and non-federal museums or science centres that promote STEM to Canadian youth are eligible to receive PromoScience funding.

The types of activities funded, as well as their intensity and frequency, vary considerably from one project to another, as does the duration of the projects (one to three years).

Funded activities include, but are not limited to, camps, clubs, workshops, research activities, outreach activities, conferences, and participation in science competitions. A call for applications is usually held in September and applications must be submitted electronically via NSERC's secure submission site.

Eligible applications are reviewed by the PromoScience/NSERC Awards for Science Promotion Selection Committee. The peer reviewers are drawn from the science and engineering promotion and education communities because of their reputation and expertise. Successful applications are then reviewed by PromoScience staff to ensure that they meet NSERC's policies and guidelines.

3. A target group is a set of people who are specifically targeted when it is believed that they will benefit from the program and support the achievement of its objectives.
4. For the purposes of the PromoScience Program, NSERC refers to the definition in the Constitution Act, 1982, that "Aboriginal people" [aboriginal peoples of Canada in the Act] "includes the Indian, Inuit and Métis peoples of Canada."

Evaluation Questions

Lessons learned from the 2015 evaluation

In 2015, the evaluation confirmed that funding for informal STEM learning is important and that PromoScience should continue to target youth, especially those from underrepresented groups. PromoScience provides them with opportunities to participate in activities that increase their engagement, stimulate their interest, and deepen their skills and knowledge. The evaluation also recognized the importance of targeting teachers, given the important role they play in developing youth interest in STEM and influencing high school students' decisions to pursue STEM education.

An increase over three phases of the budget envelope demonstrates the importance placed on PromoScience and its objectives.

Between 2000 and 2015, annual PromoScience grant expenditures nearly tripled from $1,265,000 to $3,424,975. In 2017, annual spending increased to $11,512,511 and stabilized at just over $9 million in 2018 and 2019 with a goal of increasing support to organizations targeting underrepresented groups (including girls and Indigenous youth) and teachers, increasing the total number of projects funded and the average grant size, so as to reach more young Canadians. Over the past five years, just over $41 million has been allocated to the program.

Overarching evaluation questions

Given the findings of the last evaluation and the budget increases of recent years, this evaluation focuses on three main questions:

1. What is the impact of grants on the funded organizations' capacity, particularly in terms of their ability to reach more young Canadians?
2. What effects can we observe on youth who access informal science learning activities?
3. What are the effects on teachers' access to tools, resources, and training, particularly as it relates to their ability to teach science?

Methods and Limitations of the Evaluation

The evaluation is based on a literature review, a file review (n=275), a survey of both funded and unfunded grant applicants (n=248, 43% response rate), and a survey of teachers who participated in activities offered by grantees (n=277).

Limits

Although the evaluation is based on multiple lines of evidence, some limitations exist:

• During the evaluation period, a total of 469 projects were funded. However, only completed projects for which a final report was submitted were subject to a file review, reducing the number to 275. The final activity reports submitted by grantees at the end of their grant period include a description of activities completed, participation statistics and, in some cases, a presentation of results achieved. Although some work has been done in recent years, inconsistency or inaccuracy in the information produced by funded organizations continues to be an issue, particularly with respect to the diversity of participants or information on the strategies implemented to tailor activities to specific target groups.

• The COVID-19 pandemic had a direct and significant impact on the conduct of the evaluation. On the one hand, it severely limited qualitative data collection by making it impossible to conduct case studies, which would have allowed to observe the activities offered by grantees and meet with youth and teachers. It also had a direct effect on teacher participation in the survey. Indeed, fewer than 300 teachers, representing 33 of the 134 organizations that indicated they targeted teachers, responded. In 2015, more than 900 teachers had participated in the survey, in addition to those met during the case studies. While such a low response rate limits the nature and scope of the data collected, it did little to affect the findings and validity of the conclusions, which confirm those of the 2015 evaluation.

Why Is It Important to Fund Informal STEM Learning?

Fewer youth are pursuing STEM education or careers[5]

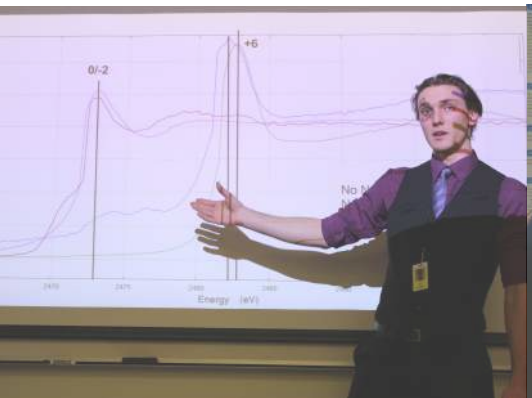
Over the past 30 years, research in the field of science education has noted a significant trend in the lack of interest that young people show in STEM activities, education or careers, a trend that is not limited to Canada (The Institution of Engineering and Technology, 2008; Osborne, Simon & Collins, 2003; Confederation of British Industry, 2012; Council of Canadian Academies, 2015; House of Lords, 2012; Landivar, 2013; U.S. Chamber of Commerce Foundation, 2015).

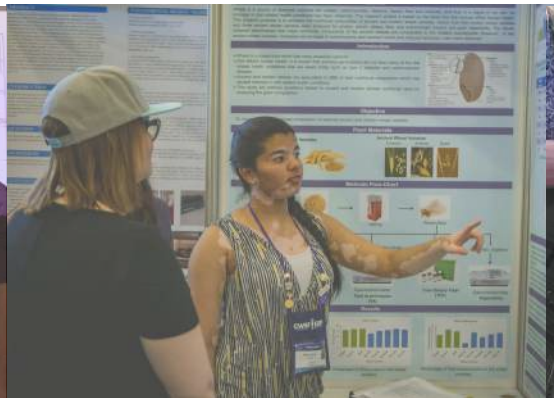
Specifically, fewer youth are choosing to enroll in STEM electives, despite their strong performance in required science and math courses (Bordt, de Broucker, Read, Harris, & Zhang, 2001), and this is more pronounced among youth from underrepresented groups (UNESCO, 2015).

While research tells us that Canada does not currently have a STEM labour shortage (Council of Canadian Academies, 2015), the possibility of a decline in the number of graduates in these fields is nonetheless a concern, especially since science and technology occupations, particularly engineering and computer science, are among the highest-paying and fastest-growing occupations (Statistics Canada, 2017).

Despite this demand, the data indicate that the percentage of STEM graduates in Canada who are also working in science-related occupations is declining. Only 24% of all university graduates in Canada focus on STEM (Picot and Hou, 2019), and less than half of these STEM graduates work in a STEM field (Frank, 2019).

5. Most of the studies in the report use the term "science" to refer to the subject of their research. The term "science", however, has been replaced with STEM to be consistent with the terms used throughout the evaluation.






Informal STEM learning: making STEM attractive and inclusive

Targeting youth is particularly important when considering that negative attitudes toward science and the perception of science as an unsustainable career choice are forged at a very young age (Baker, 1995; Prokop, 2007; Farenga, 1999; Osborne, 2003). By making science more appealing, creating more tangible connections between theory and practice, and offering active learning, informal STEM learning helps to fill the gaps observed in formal education systems (National Science Foundation, 2003).

To achieve these goals, informal learning activities in STEM are most often: hands-on, interactive, connected to everyday life, discovery and inquiry-based, cooperative in nature, and most importantly, not assessment-based, with an emphasis on learning by trial and error rather than producing "right answers" (Hidi & Renniger, 2006).

However, thinking outside the box is not enough and efforts must be made to ensure that materials are tailored to the reality of all in order to promote inclusion. In fact, what is tailored to the reality of one group may have alienating effects for another (Center for Advancement of Informal Science Education, 2010 Mason & McCarthy, 2006). For example, the literature review points out that a more social approach to learning better meets the needs of girls.

Youth traditionally underrepresented in STEM may not have as much access to the tools or activities offered. Travel distance, costs of participation, inability to provide accommodations for certain disabilities, or content or facilitators that are not representative of the youth's gender, demographic or socio-economic profile, or cultural background are all barriers to participation (Bleeker & Jacobs, 2004; Cano & Bankston, 1992; National Science Foundation, 2003).

The previous evaluation, which conducted numerous case studies across Canada, including some with underrepresented groups, concluded that preconceived notions among Indigenous youth that they did not like science did not survive in the context of informal learning, in part because the activity became a leisure activity they enjoyed because of their interest in the subject.

Therefore, just as the formal education system must consider making STEM more accessible to underrepresented groups, informal STEM learning tools must provide targeted activities accessible to all.

Relevant and necessary role for the federal government

Many initiatives focused on promoting informal STEM learning exist across Canada. However, PromoScience is the only public funding source available across the country that, regardless of the scientific discipline, supports informal STEM learning with a specific focus on traditionally underrepresented youth.

By supporting informal STEM learning for all Canadian youth, NSERC is demonstrating national leadership in helping to fill gaps in the formal STEM education system. The PromoScience program, by funding organizations that provide young Canadians with hands-on or interactive STEM learning activities tailored to their needs, can not only help to eliminate the stigma of STEM and build a positive view of STEM among young people, but also supports the development of a scientific culture accessible to all.

Supporting informal STEM learning in Canada

Capacity building for grantees

Almost all of the grantees surveyed (95%) indicate that PromoScience funding has improved their organization's ability to deliver informal STEM learning activities, including reaching more youth and teachers, targeting underrepresented groups, and increasing the geographic reach of their activities and the scope of their programming.

Over the past five years, PromoScience-funded organizations have reached nearly one million youths aged 5 to 18 across Canada, as well as thousands of teachers. Teachers have either participated directly in the activities with their students, or received toolkits or training to approach science education differently. In the absence of a PromoScience grant, the majority of unfunded organizations (61%) indicate that they were not able to implement their project.

In addition, the vast majority of grantees (88%) report that the funding has helped them strengthen existing partnerships, rather than create new ones, and that the program plays a catalytic role, which has likely contributed to the success of their projects. These partnerships continue beyond project implementation. This finding confirms those of the 2015 evaluation, which stated that the funding received from the PromoScience program had served as a catalyst, particularly for securing other funding.

Delivery of informal science learning activities

All grantees' projects and activities are aligned with the principles of informal science learning and include activities that are designed and recognized to support youth interest and engagement (Hidi et Renniger, 2006). Funded project activities are:

- kinesthetic, hands-on or interactive activities with the objective of "doing" science;
- relevant to everyday life and to the identity of young people, including their culture, gender and socio-economic background;
- discovery and inquiry-based, unstructured or open-ended;
- cooperative in nature with an emphasis on teamwork and group learning;
- without assessment, with an emphasis on learning by trial and error rather than producing "right answers" (Hidi & Renniger, 2006).

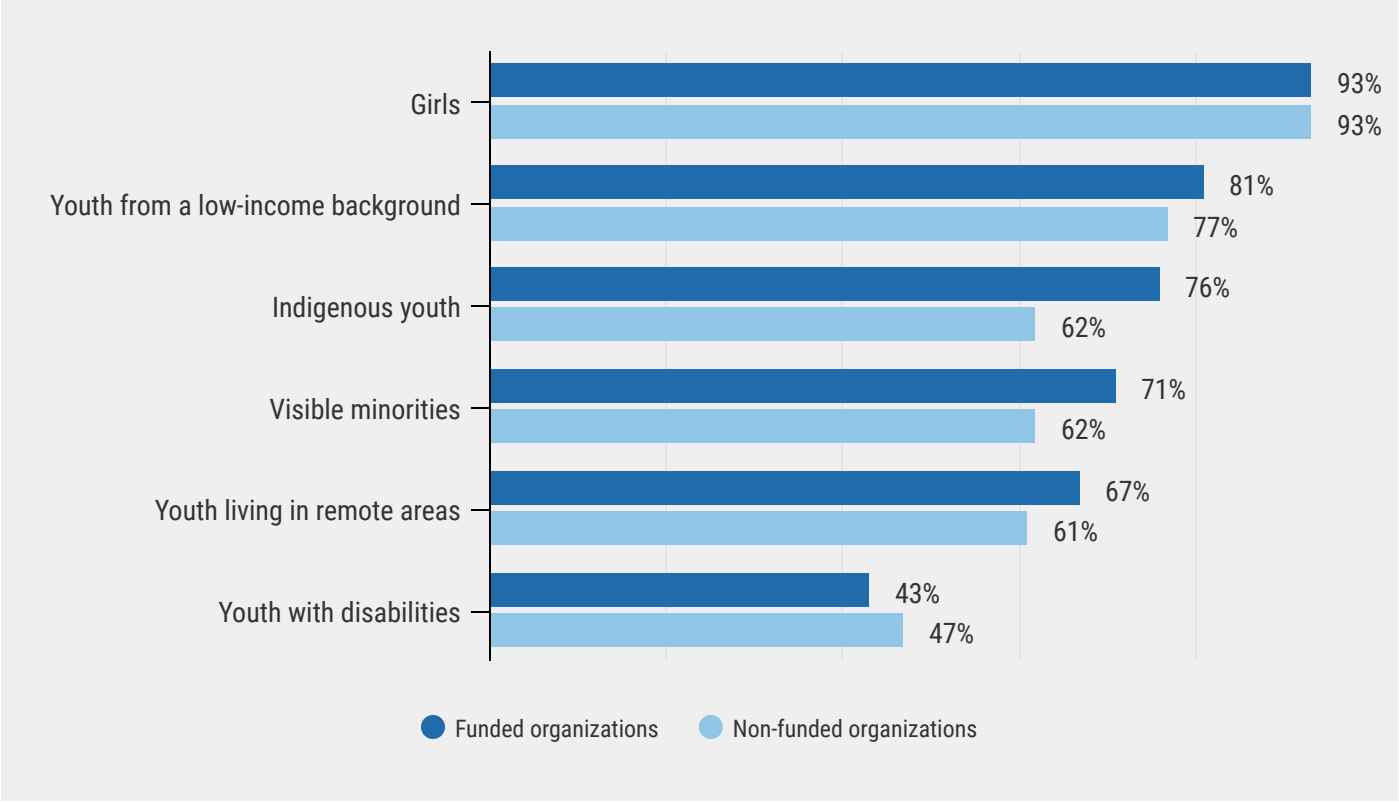
The activities funded are diverse and include, but are not limited to, camps, clubs, classroom workshops, outreach activities, coaching/mentoring initiatives, conferences, and participation in competitions or science projects. Delivery formats vary, but in almost half the cases (49%), activities span more than one event. Only 28% of funded organizations report offering a single event. This is important, as the literature on informal science learning highlights the impact associated with increased and/or repeated exposure.

Tailoring activities to underrepresented groups

While the vast majority of grantees (4 out of 5 or n=134) report targeting one or more underrepresented groups, girls are the most frequently named group as opposed to youth with disabilities, which is the least frequently named group. In addition, while the same percentage of grantees reports adopting measures to better reach these groups, there is a lack of information to accurately understand and describe these measures, to explain how they demonstrate a desire to adapt to a specific group or how they are implemented. For example, the evaluation does not have information on accommodation practices for youth living with a disability.

The following figure shows the frequency with which underrepresented groups are targeted by funded and non-funded organizations.

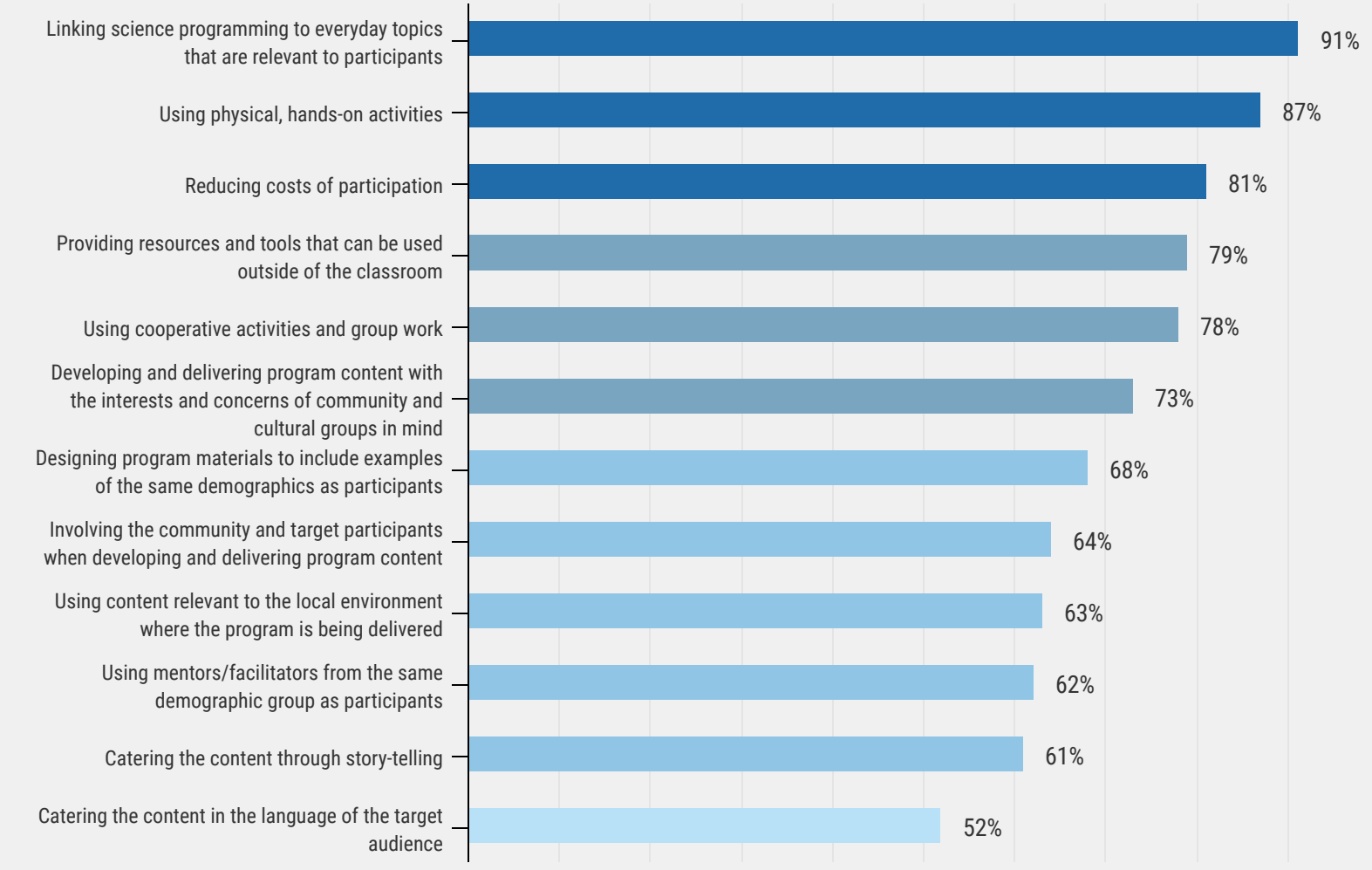
Figure 1 *: Frequency of underrepresented groups targeted by funded and non-funded organizations.*



The main strategies identified are not necessarily unique or original, and the majority of organizations report offering programming that is relevant to the lives of participants (91%), involves hands-on, interactive, tactile activities (87%), reduces the cost of participation (81%), and provides resources and tools that can be used outside the classroom (79%).

The following figure summarizes the strategies used to adapt activities and the percentage of grantees implementing them.

***Figure 2**: Percentage of grantees that report employing adaptation measures for target groups and the nature of these measures.*



How do young people respond?

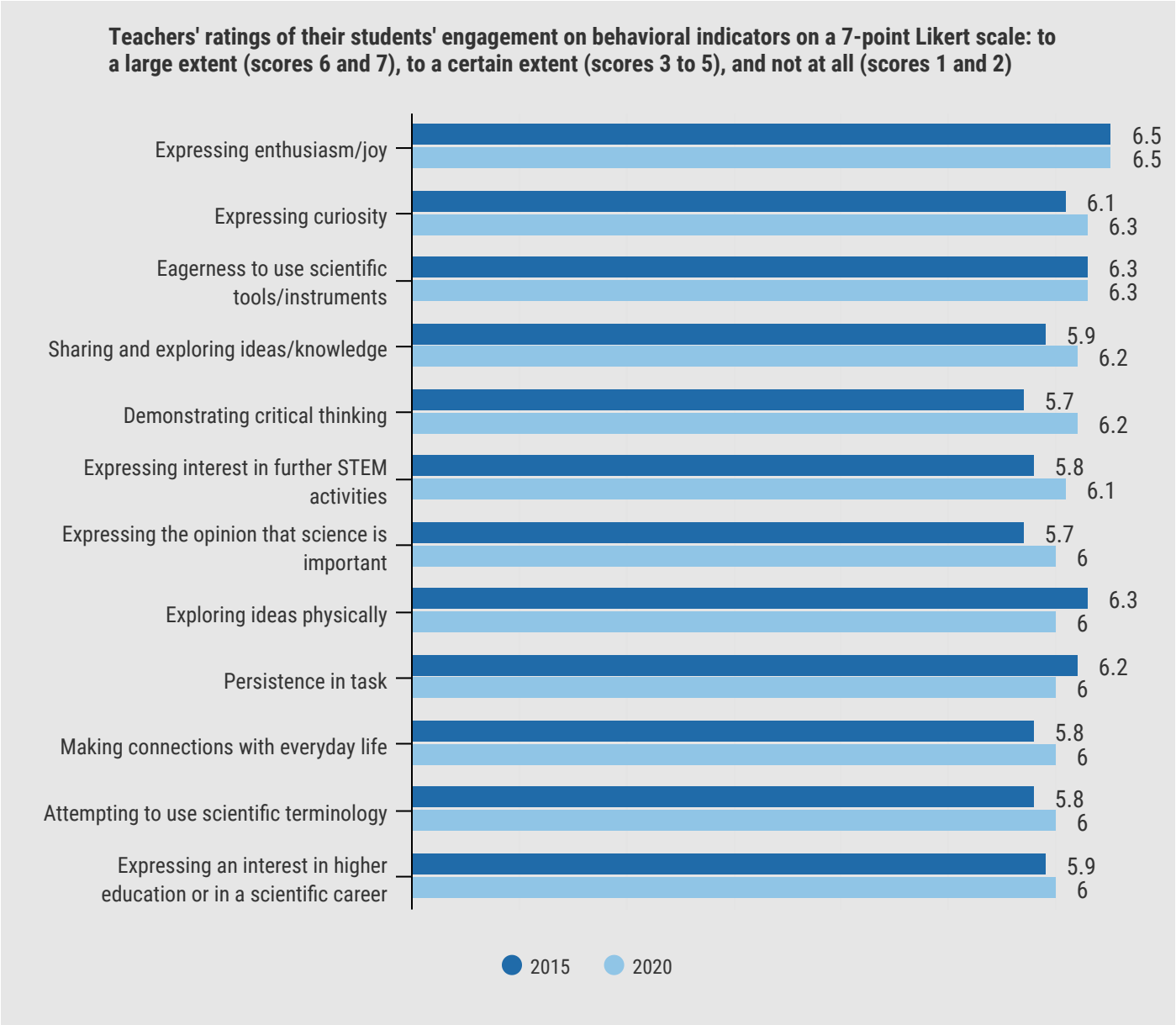
Since observing and meeting with youth during informal learning activities was not possible, both grantees and teachers were asked to provide feedback on the extent to which participants' STEM skills, knowledge and interest had increased as a result of their participation in a PromoScience-funded project. Teachers were asked for their feedback because they are thought to be in a better position to assess the changes observed in students after they have participated in STEM activities (since they have taught these students before and after the activities) and are more objective in their assessments of the impact of these activities on students than are the grantees who proposed the activities in question.

The evaluation confirms the 2015 findings and notes that PromoScience-funded projects raise awareness of and interest in science activities among youth. K-12 teachers testify that students are generally engaged in the projects, which was illustrated in various ways. These include enthusiasm, joy, curiosity, an ability to make connections between science and everyday life, and a willingness to explore kinesthetically through the use and handling of objects. In addition, students generally demonstrate persistence when performing tasks, an ability to articulate arguments and critical thinking, a willingness to use scientific tools and language and to share and explore ideas.

Teachers also found a positive correlation between youth engagement and increased interest, skills, and knowledge, as well as self-confidence and their ability to relate STEM to their everyday lives. The evaluation cannot conclude, however, that participation in PromoScience-funded projects systematically influences young people's motivation to pursue post-secondary education or a career in STEM, as other factors are known to enter into their decision to pursue science.

The following figure summarizes the assessment of youth engagement as perceived by teachers. It superimposes the findings from this evaluation with those from the 2015 evaluation which included an additional behavioural indicator.

Figure 3 *: Teachers' ratings of their students' engagement on behavioural indicators (2015 and 2020).*



When looking more closely at the impact of activities tailored to underrepresented groups, it remains difficult to draw strong conclusions because of the limitations noted above and the lack of reliable information on the diversity of participants. All organizations that reported tailoring their activities to target groups felt that their activities had a greater impact, including promoting creativity and cooperative learning (96%), making connections between science and everyday life (92%), and challenging stereotypes about science (92%). Teachers, while generally in agreement with these perceptions, are more measured in terms of the extent of this impact.

What is the impact on teachers' access to tools, resources, and training, particularly as it relates to their ability to teach science?

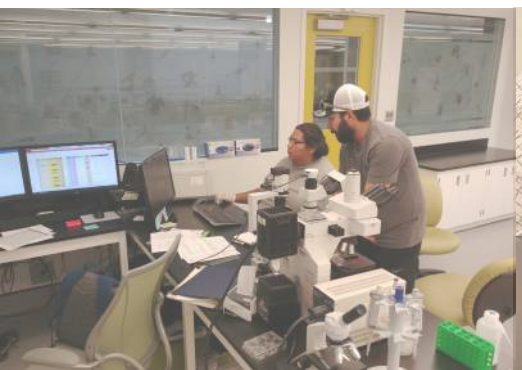
Approximately three quarters of funded organizations report providing support to Canadian teachers, and those surveyed report that these activities take place several times over the course of a year, in a variety of forms ranging from online learning to in-person training to conference attendance. Three main support strategies are implemented:

- Access to tools and resources (lesson plans or experiment kits)
- General training to improve understanding of scientific concepts or to learn techniques for conducting scientific experiments or to use youth-friendly communication strategies.
- Finally, and to a lesser extent, targeted[6] training such as strategies for adapting lessons to target groups. When asked about the nature of these trainings, the main strategies identified by respondents (organizations and teachers) were making connections between everyday life and science, promoting tactile learning, understanding the barriers that can limit interest in science, promoting collaborative learning, and fostering a sense of belonging.

The distinction respondents make between targeted and general learning has proven to be unclear at times, and there are strategies that are common to informal STEM learning in general. Although some of the above examples are used quite broadly, it is important to recognize that tailoring and structuring these activities is key to the inclusion of underrepresented groups. For example, a hands-on interactive activity, such as one on static electricity which could include rubbing a balloon on hair, is a fairly simple one. Yet it excludes youth who must cover their hair for cultural or religious reasons (Burns, 2019).

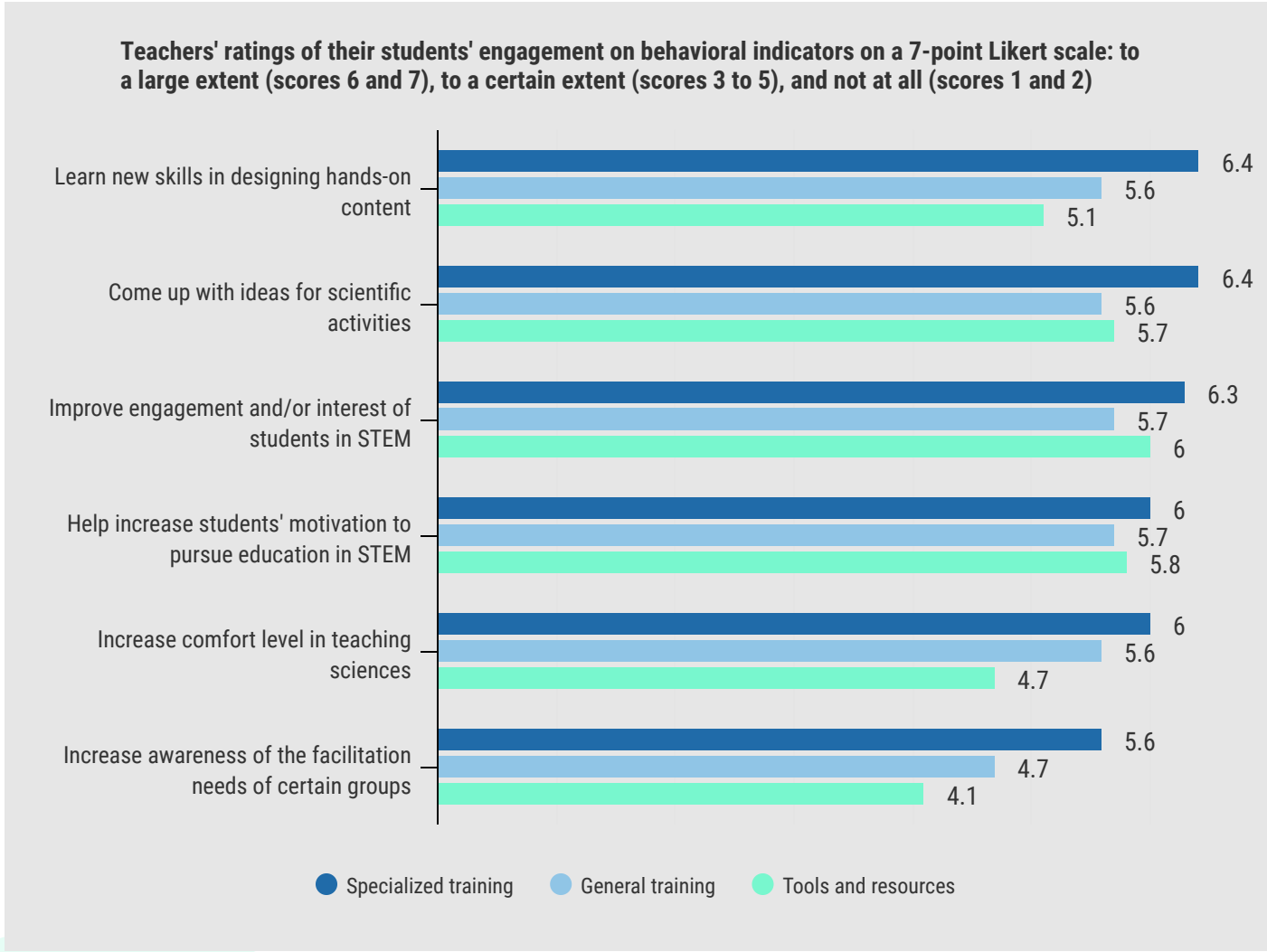
Overall, teachers who received tools and resources or participated in general trainings report that these activities have had a positive impact, particularly on their comfort level and skills, and also on their ability to implement creative strategies for their students. However, when it comes to their own awareness of the need for targeted-group facilitation training, the perception of the impact is not as strong. Still, the dedicated training that teachers have received concerning special group facilitation strategies appears to have had more impact on themselves and, they believe, on students. Yet, few organizations appear to offer this type of training and respondents' understanding of what such training entails varies from person to person. That said, due to the small number of teachers who responded to this question, it is important to remain cautious in our conclusions.

6. The term "specialized training" appeared in the evaluation surveys but has been replaced by dedicated, targeted or in-depth training in this report.



The following diagram summarizes the impact of the different activities offered to teachers as perceived by them. It overlays findings according to the three main strategies implemented by grantees: tools and resources, general training, and dedicated training.

***Figure 4** : Teachers' ratings of the degree of impact related to their participation in informal STEM learning activities on their comfort, skills, and creative initiative in teaching science.*



Conclusions

The PromoScience Program remains well positioned to support organizations promoting science

The evaluation confirms the continued need for the PromoScience Program. The literature confirms a significant trend showing that youth shows limited interest in pursuing STEM activities, education, or careers, a trend more prevalent among underrepresented groups.

Yet, the opportunity to participate in informal STEM learning activities is recognized as a factor that builds youth engagement, interest, skills and knowledge. Such activities allow them to develop further interest in these fields. Promoscience must continue to target youth, underrepresented STEM groups, and teachers to achieve its goals.

Many initiatives that promote informal learning in STEM exist across Canada. However, PromoScience is the only stable public funding source available across the country that, regardless of the scientific discipline, supports informal STEM learning with a specific focus on traditionally underrepresented youth.

The impact of funding on funded organizations' capacity, youth and teachers

The evaluation findings illustrate how PromoScience supports informal STEM learning in Canada: the program is having a positive impact on the grantees' capacity to serve their target population and to foster youth engagement and interest in science. In addition, the vast majority of grantees report that the funding has helped them strengthen existing partnerships, rather than create new ones and that the program plays a catalytic role, which has likely contributed to the success of their projects.

Findings also highlight how PromoScience-funded projects fit into the philosophy of informal science learning by providing hands-on, interactive activities. Young people who participate in the activities, among other things, express enthusiasm, joy, curiosity, demonstrate an ability to make connections between science and everyday life, and show a willingness to explore kinesthetically through the use and handling of objects. In addition, students generally demonstrate persistence when performing tasks, an ability to articulate arguments and critical thinking, and a willingness to use scientific tools and language and to share and explore ideas.

While the majority of grantees report targeting one or more of the under-represented groups, the evaluation cannot accurately describe how programming is tailored to the reality of the participants, with the goal of making activities accessible to all, without barriers related to the identities, beliefs or interests of Canadian youth. However, the literature review highlights the sense of exclusion that youth from underrepresented groups may experience, the feeling that science is difficult, inaccessible, in other words "not for them."

Many grantees are also providing tools to teachers conducting STEM education activities in Canada. Three main support strategies are implemented: access to tools and resources (lesson plans or experiment kits); general training and, in a lesser capacity, dedicated training. The distinction respondents make between dedicated and general learning remains somewhat unclear, and strategies common to informal STEM learning in general are found in both types of training. Although the evaluation recognizes that tailoring and structuring activities are key to the inclusion of underrepresented groups, the fact remains that what distinguishes general learning from dedicated learning, and what the two entail, remains unclear and varies among respondents. Despite methodological limitations, the impact appears to have been greater on teachers with specialized training and, according to the teachers, on students.

Recommendations

Recommendation 1

Regarding the need to support informal STEM learning opportunities for all young Canadians, this evaluation recommends the continuation of the program. PromoScience 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 indicates 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.

Recommendation 2

Measuring the impact of the program remains a challenge, particularly in documenting some key aspects of the program such as tailoring activities for a diverse group of participants and the level of impact that can be reasonably expected from these funded activities. The evaluation recommends that NSERC, in consultation with the ISL community, explore the possibility of providing more support to grantees to enhance their monitoring activities. Such support could take different avenues such as developing and making available a standardized method/tool of tracking some performance indicators related to the funded activities. This information would be easily transferable into Final Activity Reports and would support consistency and continuity in data collection. Such support should be sensitive to the differences existing among funded organizations (e.g., size of organization, realities, capacities, scope of reach, history, years of activities, expertise) in order to avoid creating unnecessary burden and/or financial pressure. Such support should also take into account the targeted audiences and the fact that reported may need to be adapted for interactions through teachers vs. direct interactions with youth.

Recommendation 3

PromoScience funds may be used by grantees to provide training and/or resources to elementary and/or secondary school teachers in Canada. In fact, teachers are found to play a significant role in encouraging youth to pursue STEM education. Enhancing the capacity of teachers to implement meaningful and impactful teaching strategies related to STEM is part of the PromoScience funded projects and three main strategies are used with teachers: access to tools and resources, general training and specialized/comprehensive training that provides support to teachers in how to engage members of underrepresented groups. At the time of the evaluation, few organizations were focusing on delivering comprehensive training activities. This evaluation recommends placing greater emphasis on offering comprehensive and high impact training for teachers and other educators/facilitators involved in informal science learning.

In consultation with the ISL community, NSERC should consider the following actions:

- Design and disseminate criteria for what comprehensive training should include and make it accessible to organizations.
- Identify what expertise should be required from applicants in order to submit a proposal focused on training teachers.
- Identify avenues to support collaboration among the science learning community, and between the ISL community and other key community players in order to share best practices and resources.
- Encourage applicants to describe their strategies to build meaningful partnerships with the ISL community and other community partners that can enhance the reach and the impact of their proposed projects and activities.

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