From Five to Thirty-Five: Fostering the Next Generation of Arctic Scientists

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Abstract. Out-of-classroom Education and Outreach (E&O) initiatives can improve the uptake of Science, Technology, Engineering and Maths (STEM) courses at higher education and can help address gender balances within the fields. Arctic Frontiers, a non-profit organisation based in Tromsø (69.65 N, 18.96 E), Norway, has been running various projects under the Young Program banner since 2012. Through their four programs, ranging in levels from Kindergarten to Early Career Professionals (and ages from 5 to 35), over 3000 individuals have been exposed to Arctic research and science through workshops, mentoring, career seminars and excursions. With the rate of climate change in the Arctic and the geopolitical changes in the region, E&O initiatives focusing on Arctic science are now even more crucial, but potentially more challenging to run. This study outlines the main educational activities and the best practices from the last decade, to provide a template for science communication and outreach. Additionally, a first analysis of the reach and success of the program is provided, by identifying trends in participant numbers, geographical interest and demographic identifiers.

1 Introduction

At both the education and career level, Science, Technology, Engineering and Maths (STEM) subjects are typically still characterised by an imbalance in gender and lack of minority groups across the globe (Gibney, 2016). Greater numbers of skilled and educated people (especially women) in STEM fields will benefit many nations which are struggling to find skilled workers, as well as increasing innovative potential and readdressing gender imbalances (Bøe et al. 2011).

The Arctic nations are no exception. In Norway, where more women are studying at university than men, only 30% of full professor positions are held by women (Lekve and Gunnes, 2022). In Canada, only 4% of Indigenous Peoples pursue an education in STEM (Cole et al. 2022). Therefore, there are still large inequalities in access to STEM education for minority groups, and a lack of support for women continuing their careers in academia (Pew Research Center, 2021).

In the Arctic and northern regions of the Arctic nations, there is an additional issue facing STEM fields. Out-migration of skilled workers to southern urban centres and capital cities (all located outside of the Arctic Circle) is a common trend across

the Arctic (Nilsson and Larsen, 2020). We observe that Arctic science has a double 'Leaky Pipeline' problem. The Leaky Pipeline is a common term to refer to individuals from under-represented communities who journey away from STEM education or careers due to pressures and inequalities in the field (Cole et al. 2022). In the Arctic, there is the additional leakage of highly skilled, young (often minoritised genders and ethnicities) people to the south. Therefore, it is crucial that young people residing in the north and the Arctic can develop an interest for, and skills in, STEM subjects, which make them highly employable and invested in remaining in the north.

In studies in the USA and Europe, it has been documented that out-of-school outreach projects lead to an increase in students' motivation to continue with STEM education and enhance their appreciation for STEM in real-life applications (Vennix et al. 2018). Consistent within the literature, is the knowledge that mentors and role models that reflect the students' identity (here, early-career, Indigenous or local northern residents), are key for increasing equality in the STEM fields (Krikorian et al. 2020; Cole et al. 2022). In Alaska, museums have been highlighted as crucial STEM outreach facilitators for Arctic youth. The retention of teachers in Alaska is poor: 60% of Alaska's teachers leave the Arctic after just two years of teaching (Anderson et al. 2017). Out-of-school outreach provides informal learning and, when combined with industry visits or interactions, students feel more relaxed about learning complex subjects (Vennix et al. 2017).

Scientists and researchers are now encouraged or required to engage in science communication and outreach as part of the requirements of funding agencies, due to the use of public money. However, non-academic engagements are often transient, ad-hoc or unsuccessful (Peters et al. 2024). Even scientists who actively highlight the importance and benefits of outreach and science communication for both the public and the science, are unlikely to engage in non-academic dissemination (Roberts et al. 2009). The burden and additional work for scientists to propose and organise their own outreach and science communication is large. This highlights the need for other organisations working at the forefront of science and local communities to provide the structure for scientists to engage with the public.

Whilst the broad scope of Arctic science includes not only STEM subjects, but also social sciences, anthropology, sociology and politics, the focus of the Education and Outreach (E&O) programmes run by Arctic Frontiers is often on the physical and environmental sciences, especially climate and oceans. Arctic Frontiers is a private, non-profit organisation based in Tromsø (69.65 N, 18.96 E), Norway and owned by Akvaplan-niva, an aquaculture and environmental research and consultancy company. Arctic Frontiers aims to be a catalyst for decision-making and network-building within the Arctic and consists of a partnership of over 20 public and private institutions which include many universities and research institutions in Norway, such as the Norwegian Polar Institute, as well as private companies with interests in the Arctic. Founded in 2007, Arctic Frontiers has been gathering Arctic stakeholders from science, business, politics, and local communities for discussions regarding a range of Arctic-relevant themes, such as climate change, geopolitics, energy transition and demographic changes. A number of E&O projects, aimed at all ages between five and thirty-five, have been developed and run both nationally (in Norway) and internationally. With at least 10 years of experience in developing and implementing E&O activities, and both qualitative and quantitative feedback, four key projects now feature in the annual running of Arctic Frontiers.

The aims of running a comprehensive 'Young Program' (as it is broadly termed at the company) are four-fold: 1) To encourage a greater number of students to take further education in STEM subjects, 2) to highlight opportunities for STEM careers within the Arctic, 3) to inspire generations of Arctic enthusiasts, who will go into science, research, policy-making and sustainable industry careers, and 4) to engage scientists in regular, impactful science communication with the public.

The aim of the paper is to evaluate the significance of continued and sustained E&O projects at all stages of education and early career development, to provide a template and motivation for conducting Arctic-related E&O projects also outside of the Arctic, and to ensure interested and inspired scientists remain working on, and living in, the Arctic. The first section of the paper describes the various programs, to create a template and best practices for others wishing to engage in E&O programs, especially with harder-to-reach communities in the rural Arctic. The second part of the paper investigates the impact and reach of the four programs over the last decade, as well as a discussion on the limitations and future improvements.

2 Program Descriptions

The various young programs at Arctic Frontiers were developed since the beginning of the company in 2007 (Dahle et al. 2019), however funding difficulties meant that the activities were more consistent and structured after 2012, forming a complete Young Program. There are four key projects which occur annually as part of the Arctic Frontiers Young portfolio (Figure 1): Science for Kids, Science for Schools, Student Forum, and Emerging Leaders. These programs have been developed and improved over the years, and interannual changes reflect funding priorities, geopolitical circumstances, and evaluation of the program. The details of the standard programs are provided in detail below, however larger changes have occurred due to the COVID-19 pandemic and the Russian invasion of Ukraine. Therefore, between 2020 and 2024, some of the activities were suspended or altered due to the extenuating circumstances. Additionally, some information has been lost due to lack of consistent archiving practices prior to 2020, and GDPR regulation changes in 2018. Since 2021, a full archiving and reporting system is in place for competent monitoring of projects.

All four projects within the Young Program are based on scientific knowledge and cognitive understanding as an educational approach to learning about the Arctic. This is the most common basis for climate change educational programs in a study of 220 publications focusing on E&O projects (Rousell & Cutter-Mackenzie-Knowles, 2019). The second most common educational approach is curriculum and pedagogy, which is the basis of the two programs with the youngest target audience at Arctic Frontiers (Table 1).

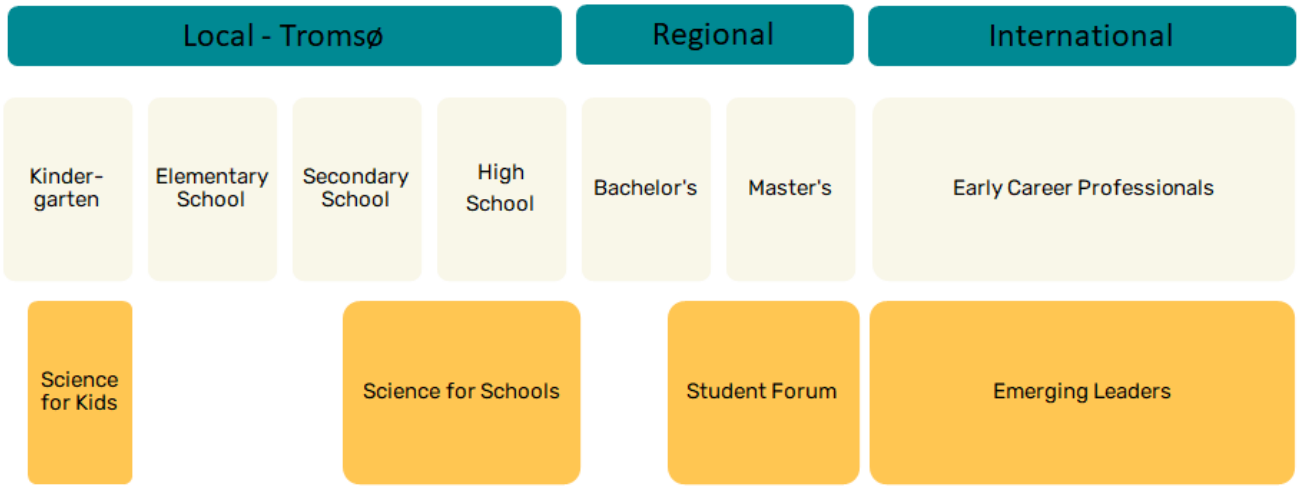

Figure 1: Arctic Frontiers Young portfolio programs with respect to educational and professional development stages. Early career professionals includes PhD candidates and those in professional employment in industry, policy or public office.

2.1 Science For Kids

'Science for Kids' is the early-years project for children in the earliest years of formal education (here termed kindergarten for international translation), between the ages of four and five. This project is currently run in collaboration with the Science Centre of Northern Norway (Nordnorsk vitensenteret) and the Arctic University of Norway, Tromsø (UiT). The aim of this project is to initiate an interest in science, create positive associations with science, and to encourage the children to question the world in which they live. Furthermore, it is a goal to encourage the kindergarten teachers to run inquiry-based projects and to support them in building experience on how to guide children based on their curiosity for knowledge.

The project begins with Inspiration Days, where children visit the science centre to hear about how scientists study the ocean, atmosphere and ecosystem. This is an inquiry-based class, where the children's curiosity and exploration are encouraged. The kindergarten teachers are then invited to the Science Centre of Northern Norway for a course, where they are given skills, information and resources to lead the children in inquiry-based exploration about Arctic science. After a period of investigations carried out by the children, the Science Centre arranges a meeting with an expert, to provide support for the teachers in the kindergarten, and trigger further curiosity in the children. The children showcase posters of their research in a 'poster festival', which concludes with a science show from centre staff.

2.2 Science for Schools

The 'Science for Schools' project is aimed at secondary and high school level (Figure 1). The project has been running since 2014 and is organised in connection with the Science Centre of Northern Norway. The project aims to show pupils the steps of research, including deciding a hypothesis, conducting experiments and showcasing results via a conference.

Scientists are invited to provide engaging career and science talks as part of 'Inspiration Days'. The aim is to initiate thought about which theme the pupils would like to investigate for their science project. For example, in 2022, speakers included marine biologists, meteorologists, aquaculture specialists, glaciologists and oceanographers.

Pupils then devise a hypothesis related to Arctic science (very broad in order for the pupils to investigate their main interests) and decide on a method or experiment to complete the research project with three months. To conclude, they create an A0 poster of their project, results, and conclusions. The final stage of the project is a three-day science conference, hosted at the Science Centre of Northern Norway, for the students to listen to oral talks from early career scientists, and they present their posters to a number of judges (Figure 2). The judges are often master's students or PhD Candidates, so that they have the experience of evaluating scientific posters and providing constructive feedback to students (Figure 2). The format replicates an actual science conference, where oral talks, poster presentations and awards for presentations are provided.

Figure 2: High school students visit the Science Centre of Northern Norway and interact with scientists and educators (left). The school pupils present their posters to the judges during the Science For Schools program (right). Photo credit: Arctic Frontiers.

The awardees of the poster prizes are invited to present their poster at the Arctic Frontiers annual conference, as part of the science poster session. This allows the students to experience a scientific conference and interact with scientists. In 2022, pupils were also given an additional opportunity to visit the Kronprins Haakon Ice breaking research vessel, owned and operated by the Norwegian Polar Institute, Institute of Marine Research and UiT – The Arctic University of Norway.

2.3 Student Forum

The Arctic Frontiers Student Forum (AFSF) gathers Bachelor and Master students from various Arctic nations (depending on funding) for one week in Tromsø, to build a cross-border and cross-sectorial learning experience and networking arena.

The group usually consists of approximately 15-20 students and the project has been running since 2016. Applicants are chosen based on the criteria that they must be students with an interest in learning more about the Arctic and sharing their Arctic experiences (see Supplement for more details). Considerations for gender-balance and geographic diversity are also taken into account.

There are four aspects to the AFSF: 1) Workshops for informal learning, 2) Social and cultural program, 3) Group project, 4) Mentoring. The theme of the informal learning workshops varies by year but topics have previously included the importance of science diplomacy, ocean preservation and management, mental health in the Arctic and climate change mitigation. The social and cultural program includes museum tours, art exhibitions, youth receptions and science communication evenings.

Students are asked to devise a question related to sustainable development of the Arctic which they will explore throughout the week and create a proposal for project funding to address the question, which they work on in groups. The mentoring part of the forum has two aspects: case guidance mentoring and career mentoring. The former should support the group projects, and the career mentoring aspect is more traditional mentoring, where students receive guidance on career options.

Since the beginning of the project, the shift from lecture-based to informal learning has taken place. The student forum now places emphasis on peer-to-peer learning, independent goal setting and projects (Table 1). The reason for this transition is two-fold: Firstly, through feedback and evaluation of participants over the years, it has become clear that students wanted the ability to learn from each other. Secondly, informal and peer learning techniques have been shown to promote interest and involvement of students notably in STEM fields (Goff et al., 2019; Roberts et al., 2018).

2.4 Emerging Leaders

Emerging Leaders is more of a mentoring and career development project than strictly E&O, however there are many aspects of this which overlap with E&O and also align with the aims of Arctic Frontiers to support Arctic scientists and professionals throughout the beginning of their career. The Emerging Leaders program evolved out of a former project called 'The Young Scientist Forum', run in connection with the Arctic Marine Ecosystem Research Network (ARCTOS), which took place in 2007. However, from 2012 onwards, these became two separate events.

The program sees approximately 30 PhD Candidates and Early Career Professionals each year travel through northern Norway in January and attend the Arctic Frontiers annual conference. This is an international program (see Supplement), with over 15 countries participating in 2023. Participants must apply for the program in September, and a team of three evaluates the applications and selects candidates (see Supplement).

The selected participants meet in Bodø, northern Norway, embark on a 5-day travel and learning excursion via boat and bus across 530 kilometres to Tromsø (Figure 3). Whilst travelling, participants meet a number of local business leaders, scientists and other professionals, for workshops, lectures and mentoring meetings, and peer-to-peer learning is incorporated. Since 2022, there has also been an alumni program developed, to allow the Emerging Leader participants to keep in touch with their peers and previous cohorts and digital workshops have regularly been offered.

Figure 3: Graphical representation of the Emerging Leaders route from Bodø to Tromsø in Northern Norway. Graphic created by Reibo AS. This figure is taken from www.arcticfrontiers.com/emergingleaders/emerging-leaders.

Table 1: Summary of the Young Program components and the approaches taken for public E&O. The Educational Approach is based on the categories by Rousell and Cutter-Mackenzie-Knowles (2019).

Program	Audience	Key Activities	Educational Approach
Science For Kids	Kindergarten children (approximately 4-5 years old) and Kindergarten teachers in Tromsø.	Poster party with science experiments, kindergarten teacher workshops.	Curriculum/pedagogy, experimental/participatory, child-framed, knowledge-based/cognitive.
Science For Schools	Secondary and high school students (approximately 14-17 years old) in Tromsø.	Inspiration days, 3-month research project, poster presentation at youth science conference, selected few attends Arctic Frontiers science poster session.	Curriculum/pedagogy, experimental/participatory, child-framed, knowledge-based/cognitive.
Student Forum	Bachelor and Masters students (approximately 20-26) from Norway and Finland. *	Workshops for informal learning, social and cultural program, group project, mentoring, attending Arctic Frontiers annual conference.	Public communication, knowledge-based/cognitive, experimental/participatory.
Emerging Leaders	Early Career Professionals and PhD Candidates (upper	Digital leadership workshops, alumni network,	Public communication, ethical/philosophical/critical,

	age limit of 35) from international backgrounds.	career mentoring, business and science talks, attending Arctic Frontiers annual conference.	knowledge-based/cognitive, experimental/participatory.

*2022-2024 program was focused on students from Northern Norway and Finland, but this is dependent on funding.

3. Data and Methods

3.1 Quantitative Data

The number of participants in each program, as well as certain demographic data (country of residence, age bracket, career level, gender) have been collected each year. The particular demographic data depends on the project and is largely a reflection of the funding agency requirements (e.g requirement that a certain number of places are reserved for Arctic residents).

For the youngest programs (Science for Kids and Science for Schools), the only data which are collected are number of participants and number of kindergartens/schools. Tracking of individual children throughout their further education and careers has not been systematically carried out. Capacity of the Arctic Frontiers secretariat prior to 2021, the high number of students, and limitations to contacting children whilst under the age of 18, have all restricted the quantitative evaluation of how the Science for Kids and Science for Schools programs are performing. Data are from 2018-2024 for Science for Kids and 2014-2024 for Science for Schools.

For the Student Forum program, the education level (bachelor or masters), gender, country of residence and university of study (which infers some additional information such as Arctic/Northern resident and/or belonging to an Indigenous community). Collection of this data is also for evaluation of the applications, to ensure that those meeting the requirements of the program and the funding agencies are selected. Data are from 2016-2024.

For Emerging Leaders, the largest amount of data is collected: gender, age, career or educational stage, field of study or work (e.g energy, policy, oceanography), country of residence, and self-identification of belonging to an Indigenous community or organisation. Data are from 2012-2024.

3.2 Qualitative Data

Feedback surveys following the programs and informal collection of opinions and reflections of the programs have provided the qualitative data. Feedback from the events has not been collected every year, and since 2021 the collection of data via surveys has been formalised and/or required for certain programs. This was due to the requirement of funding agencies and

for the Arctic Frontiers secretariat to analyse the goals of the programs and improve the offerings to meet evolving student and young peoples' requests.

From the surveys, videos and requests for feedback, the quotes have been combined and translated to English when necessary (see Supplement for more quotes). Data have been collected anonymously when provided on feedback surveys. Participation in the feedback survey is optional. A number of Student Forum and Emerging Leader participants were invited to participate in videos and providing oral feedback with their name/affiliation attached. This was not a requirement of those on the program and the public nature of the videos was made clear prior to participants before they were recorded. Student Forum and Emerging Leader participants consent to being recorded, photographed and documented prior to joining the program, and understand that their statements could be used publicly.

3.3 Analysis of Qualitative Data

Sentiment analysis is often used to reveal the general positive, negative and neutral tone of quotes and opinions, and has widely been used to analyse social media posts (e.g Scheibmeir and Malaiya, 2021). Analysis of sentiment and word frequency can be subjective. One must make a binary decision on whether a word is positive or not, the process can under-represent neutral words and oversimplify the intention (e.g very good is more positive than good but is counted similarly). However, sentiment analysis can be used to provide the overall opinion of the group and to look at the ratio of positive to negative sentiments. We've used sentiment analysis on quotes from participants of the four programs and used the WordNet lexicon dictionary (Princeton University, 2010) to define positive and negative words.

4. Impacts of the Young Program

The Young Program as a whole is evaluated with respect to the four aims of the program: 1) To encourage a greater number of students to take further education in STEM subjects, 2) to highlight opportunities for STEM careers within the Arctic, 3) to inspire generations of Arctic enthusiasts, who will go into science, research, policy-making and sustainable industry careers, and 4) to engage scientists in regular, impactful science communication with the public.

In addition, specific elements of the Young Program are evaluated in terms of total number of participants, increased accessibility and diversity of participants, and satisfaction of the participants.

4.1 Continued Education in STEM

The first aim of the Young Program is to encourage more students to take further education in STEM subjects. In its latest phase (2023-2024), children from five kindergartens in Tromsø are gathered at the Science Centre as part of the Science for Kids project (Figure 4). This project has seen a variable number of children participating (from 83 to 235). The number of kindergartens involved has fluctuated between five and thirteen since the program started in 2018. In total, over 1000 children and 90 kindergarten teachers have participated in the project. There was an increase in the number of children

taking part in the program between 2018 and 2022, and an increase in the number of kindergartens involved in 2018 to 2020 (Figure 4). Thereby meeting the first aim of the Young Program, which is to encourage a growing number of students to take STEM subjects. However, the most recent years have seen a decrease in the number of both total children and kindergartens involved. The year with the highest number of children participating (2022) saw a large decrease in the total number of kindergartens (Figure 4). Fluctuations in number of children in particular age groups at kindergarten can skew the evaluation of the success of the programs. Nevertheless, there was a decrease in individual kindergartens attending the program too. This depends on available resources at the Science Centre and some kindergartens withdraw during the program, citing illness and staff shortages.

From 2022 to 2024, over 400 pupils from Tromsø have joined the Science for Schools Inspiration days from 5-8 different schools each year (Figure 5). In most years, information on the number of pupils is available but not the number of schools, as students from smaller schools are combined on a number of the days. However, there has been an overall increase in the number of pupils and schools attending between 2015 and 2024, which has largely been attributed to greater visibility of the event within the local newspapers, broader networks of those involved in organising the event, and more consistent funding. Therefore, Science for Schools is considered successful in terms of increasing the number of participants exposed to STEM education through E&O projects.

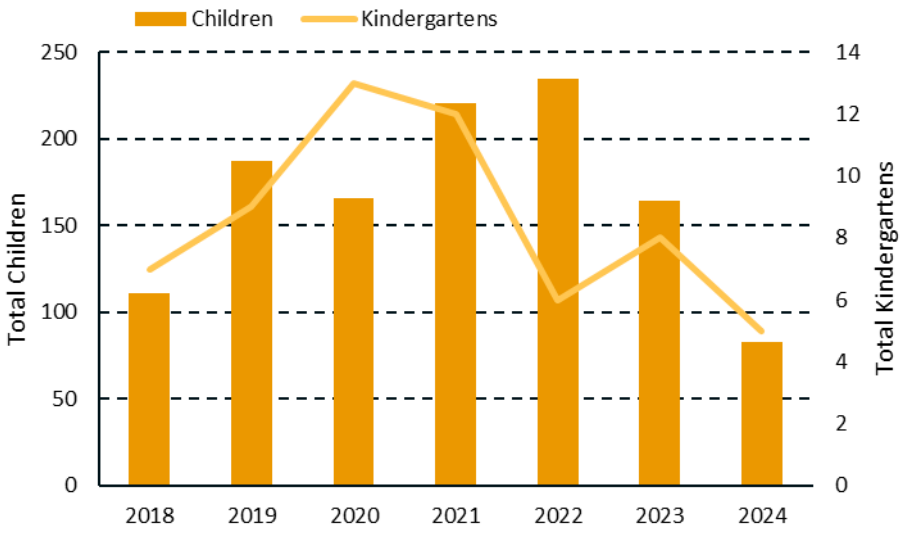

Figure 4: The total number of participants in the Science for Kids program each year and the number of participating local kindergartens Null years represent data gaps as explained above. 2021 and 2022 estimates of participating children are underestimates taken from video and picture evidence of the events.

The number of participants and the participating universities in the Student Forum program depends on the focus of the granted funding. In this particular project, an increasing number of students does not necessarily reflect the success of the program. In more recent years, the number of students each year has decreased (see Figure 6), as the program has become more intensive, taken on a more structured format, is now better connected with the Arctic Frontiers annual conference, and has received varied funding. Additionally, in 2019 the program was adapted under the Barents Young Programme which was largely supported by Russian institutions, and saw fewer overall students attending. Between 2016 and 2023, the Student Forum has connected over 140 students from across Russia and the Nordic countries, and provided mentoring, career development opportunities and out-of-classroom learning experiences.

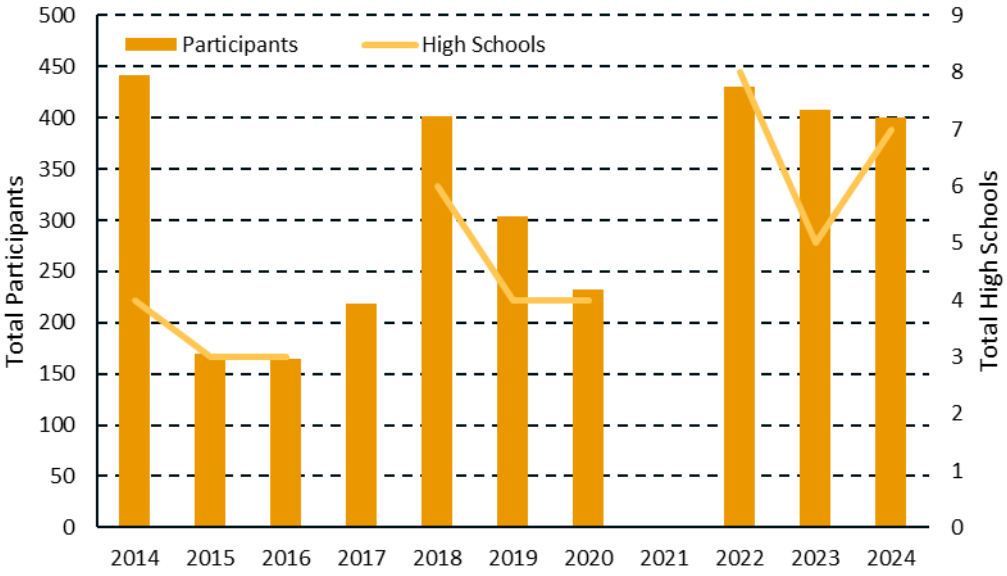

Figure 5: The total number of participants in the Science for Schools program each year and the number of participating local high schools. Null years represent data gaps as explained above.

Qualitative data from participants of the earliest phases of the Young Program and Student Forum (Table 2) show additional support that the first aim of the program is being met. Students and teachers were not directly asked what impact the program has had on their educational path. Feedback questions have been largely dictated by funding requirements or to allow the project to be evaluated (and then improved). Therefore, there are many additional quotes which focus on other aspects of the program than the four aims (see Supplement).

Some students mention the impact that attending the program had on their study choice (quote 2 and 4, Table 2) or thoughts about the process of research (quote 3, Table 2). In addition, a kindergarten teacher (quote 1, Table 2) confirms a positive interest in science from the pupils who attended.

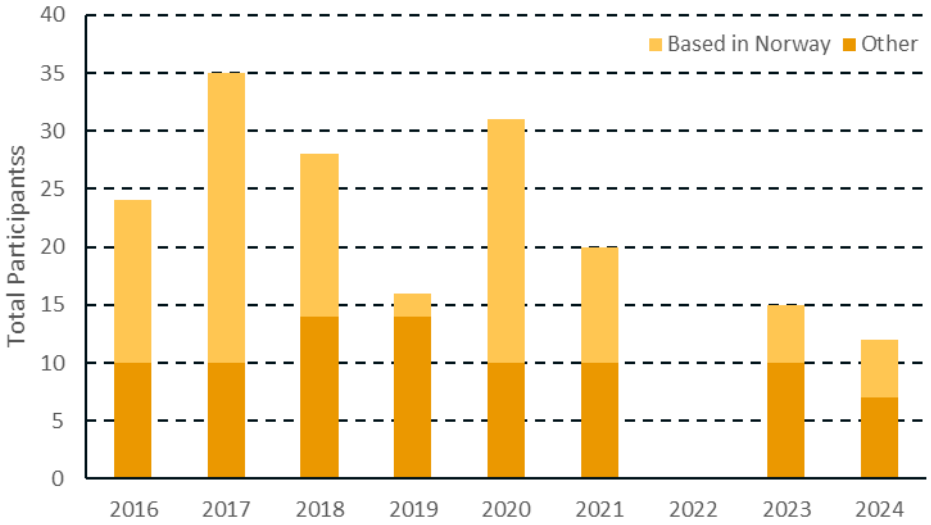

Figure 6: The total number of participants in the Student Forum program each year divided by origin. Note that the program was not held in 2022 due to the suspension of financial collaboration between Norway and Russian institutes.

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Table 2: A selection of quotes from participants of the Young Programs which mention the interest in STEM subjects.

	Aim 1) To encourage a greater number of students to take further education in STEM subjects	
	Program	Quote
1	Science for Kids – Kindergarten Teacher	The children have expressed that it has been both educational and fun. They have been involved in many different things and learned a lot. They now ask and inquire about how things are and work.
2	Science for Schools Pupil	Arctic frontiers motivated me to further pursue scientific subjects, and aim for studies involving these.
3	Science for Schools Pupil	I was already interested in science before doing the Arctic Frontiers, but the project gave me some hands-on experience on what it was like to do research on the Arctic in a similar way that the actual scientists do it.
4	Student Forum Participant	I think maybe my study direction is a bit clearer now.

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4.2 STEM career opportunities

Both aim two and three of the Young Program focus on career opportunities. Aim two is to highlight opportunities for STEM careers within the Arctic, and aim three is to inspire future generations of Arctic enthusiasts, who will go into science,

research, policy-making and sustainable industry careers. The selected quotes from Table 3 and 4 showcase the impact that the programs have had on some individuals. There is a greater understanding of what a career in STEM is like in reality (e.g quote 3, Table 3) and a clear connection between attending the program and a future job opportunity is made in quotes 5 and 6 of Table 4.

Table 3: Select quotes from participants of the Young Program which reflect aim two.

	Aim 2) To highlight opportunities for STEM careers within the Arctic	
	Program	Quote
1	Science for Schools Participant	I liked that you had to think quite a lot for yourself, and that you had to find a problem and do a project on it. It gave me an insight into what real science work is.
2	Science for Schools Participant	Good way to acquire knowledge as we got to try and see what it's like to do research. We got the opportunities to work interdisciplinary and that we get time to immerse ourselves in a topic.
3	Science for Schools Participant	It was very nice to work with researchers and to carry out practical work to collect data myself, and the poster exhibition was also a lot of fun.
4	Student Forum Participant	The mentoring sessions were extremely useful. Seeing the perspective from someone who is already within the world we want was a light of guidance among all the questions and uncertainty that surrounds our path already.

Table 4: Selected quotes from participants of the Young Program which reflect aim three.

	Aim 3) To inspire generations of Arctic enthusiasts, who will go into science, research, policy-making and sustainable industry careers	
	Program	Quote
1	Science for Kids – Kindergarten Teacher	I left the course with renewed vigour and feeling very inspired. I learned more about the theory around scientific method, concrete tips on how to let the children lead a research project. I have a better understanding of research and how to carry it out in the best possible way in kindergartens.
2	Emerging Leaders Participant	This experience made it clear—youth voices are essential, but still underrepresented. We cannot wait, we need more young, diverse leaders at the decision-making table.

3	Emerging Leaders Participant	[The program] provided insightful and new perspectives and motivated and energized me to work towards these issues in the future.
4	Emerging Leaders Participant	The networking aspect of EL, especially from North America has a great value and potential for future cooperation.
5	Student Forum and Emerging Leader Participant	My summer experience with [job provider] would never have been possible without my participation in the Arctic Frontiers Young & Emerging Leaders program.
6	Emerging Leader Participant	The Arctic Frontiers Emerging Leaders program was a pivotal experience in my professional development as an environmental scientist.

Whilst the quotes selected in the Tables 2,3 and 4 are ones which reflect the aims of the programs, a large number of quotes reflect the positive impact that participation has had on their thoughts, opinions, careers and future prospects (see Supplement for more quotes). Upon analysis of all quotes, words specifically connected to aims two and three are mentioned 154 times. These words include opportunities, learned, research, collaboration, education etc. (see supplement for full list). Many of these words are repeatedly mentioned, for example 'opportunity' or 'opportunities' is said by 10 participants. The importance and appreciation of the mentoring aspect of the Student Forum and Emerging Leaders programs is highlighted seven times by the participants, and 'networking' is mentioned six times. The word cloud (Figure 7) highlights the high frequency with which career-related words were quoted by participants, as the words with the highest frequencies are presented largest on the figure.

4.3 Engage Scientists in Science Communication

Scientists, especially Early Career Scientists (ECS) are incorporated into the Science for Kids and Science for Schools program systematically, through the 'Inspiration Days' aspect (see Section 2). In the most recent years (2021 onwards), at least six scientists have been invited to speak with students and teachers each year, with many more asking for opportunities. ECS are also engaged to evaluate the student projects and posters, which provides additional science communication possibilities each year for another two scientists. From 2021 to 2024, 36 individual ECS have been involved in the Science for Schools program.

ECS and senior scientists are also engaged in the Student Forum program through mentoring the students and occasionally running workshops, although this varies each year depending on funding. In the Emerging Leaders program, PhD candidates and ECS who take part in the program are tasked with presenting their research and career highlights to their peers during the program, and select individuals are invited to speak at the Arctic Frontiers conference, to an audience of scientists, business leaders and Arctic experts.

Figure 7: **Word cloud (generated by wordclouds.com) to reflect the frequency of words collected in the quotes from participants of the four programs.**

4.4 Additional Evaluation Measures

There are additional measures, not reflected in the four aims of the program, which are considered highly important by the Arctic Frontiers secretariat, funding agencies and of growing importance across academia.

4.4.1 Diversity of Participants

The diversity of participants in the Student Forum and Emerging Leaders programs has increased over the years, due to a specific effort of the secretariat to consider diversity in the evaluation of applications (see Supplement) and due to increased marketing to hard-to-reach communities. The Emerging Leaders program strives for diverse participants in terms of gender, country of residence (Figure 8, Table S1), profession and when all other factors are similar, prioritising Indigenous Peoples and Arctic residents. In addition, many funding agencies now require that a certain portion of the funding is provided to Indigenous, northern or Arctic residents (e.g funding received from Global Affairs Canada). The Student Forum participants are more restricted by country- or region-specific funding however, the international aspect of the program has remained though, with over half of the students affiliated to universities outside of Norway (Figure 6). Whilst specific demographic data are not collected, Indigenous peoples have been involved in the Student Forum for at least the last three years, through the inclusion of the Sámi University of Applied Sciences in the program.

Since 2012, when the Emerging Leader program began, the annual cohort has increased to a maximum of 33 in 2023. The total participant numbers, as well as gender balance and Arctic vs non-Arctic country split are presented in Figure 8. The number of Indigenous peoples participating in Emerging Leaders has only been counted in the most recent years. Since 2022, Indigenous participants represented 12-13% of the Emerging Leaders cohort. Whilst Arctic relevance is the main criteria for attending the Emerging Leaders program, Figures 9 and 10 highlight the interest of non-Arctic nations in attending the program. The majority of those from non-Arctic nations are PhD candidates or researchers who are focusing on the Arctic in their research. The percentage of non-Arctic nations attending each year has decreased relative to Arctic nations. This is partly due to the funding for approximately 15 spaces (roughly half of the annual cohort) being ring-fenced for those from Canada and Norway. The total number of attendees each year has been between 25 and 30 for the last 7 years (excluding 2021 due to COVID19). This is seen as the maximum size which allows for good connections within the group and logistically possible for travel along the remote Arctic coast.

Table 5: Quotes from the participating kindergarten teachers in Science for Kids. These quotes are translated from Norwegian into English, and therefore not direct quotes.

	Science for Kids – Kindergarten Teachers
1	The project has helped to start philosophical conversations with children and has helped us to ask more questions together with the children.
2	The children have expressed that it has been both educational and fun. They have been involved in many different things and learned a lot. They now ask and inquire about how things are and work.
3	I left the course with renewed vigour and feeling very inspired. I learned more about the theory around scientific method, concrete tips on how to let the children lead a research project. I have a better understanding of research and how to carry it out in the best possible way in kindergartens.

4	We have included the children's thoughts and input in a different way than when we adults set up a problem for them. What should we research? It was the children who decided.

The number of Emerging Leaders participants identifying as women has fluctuated between 41% in 2014 and 74% in 2022. Both the number of applicants and selected participants has been dominated by people identifying as women since 2015. The higher percentage of participants identifying as women is a reflection of the significantly higher number of women than men applying to the program.

Whilst those in academia and research (including PhD candidates) dominate the annual cohort of Emerging Leaders in all years since 2014, the number of participants who work in policy and business sectors has been increasing since 2020 (Figure 9). Since 2023, an anonymous feedback survey has been sent to the participants. Whilst only two years of data are available, the average score for 'satisfaction of the variety of the program' was 86/100 in 2023 and 71/100 in 2024. The decrease in satisfaction in 2024 was not related directly to the program, but instead a reflection of extreme weather causing last-minute changes to the logistics. Storms along the northern coast of Norway meant that boats and flights were cancelled and hotels fully booked due to stranded travellers. This was seen by some as a negative on the whole experience.

4.4.2 Benefit for Teachers

The feedback from the kindergarten teachers also reflects an additional positive impact of the Science for Kids program: enhanced science understanding by the teachers and integrating this into the classroom (Table 5). Whilst this does not directly contribute to the four aims of the program, integrating more high-quality education into the classroom at an early age has been shown to have a positive impact in later life in numerous countries (Campbell et al. 2018). In addition, McClure et al. (2017) reported that early-years teachers in the US require more training on how to engage young children in STEM and need advice on how to counteract anxieties and negative attitudes towards STEM subjects.

4.4.3 Sentiment of Participants

Sentiment analysis of the quotes from all programs revealed positive words (good, amazing, interesting etc.) were counted 111 times compared to 5 negative words (boring, disappointed, bored etc). The word cloud (Figure 7) showcases many of these positive sentiments of the young programs. Non-emotive words (e.g different, people and work) dominate the frequency of words used, and upon further analysis the word 'different' is often used to reflect the backgrounds and opinions of people they interacted with. Whilst diversity of opinions is not an aim of the program, it is a key aspect of understanding Arctic peoples.

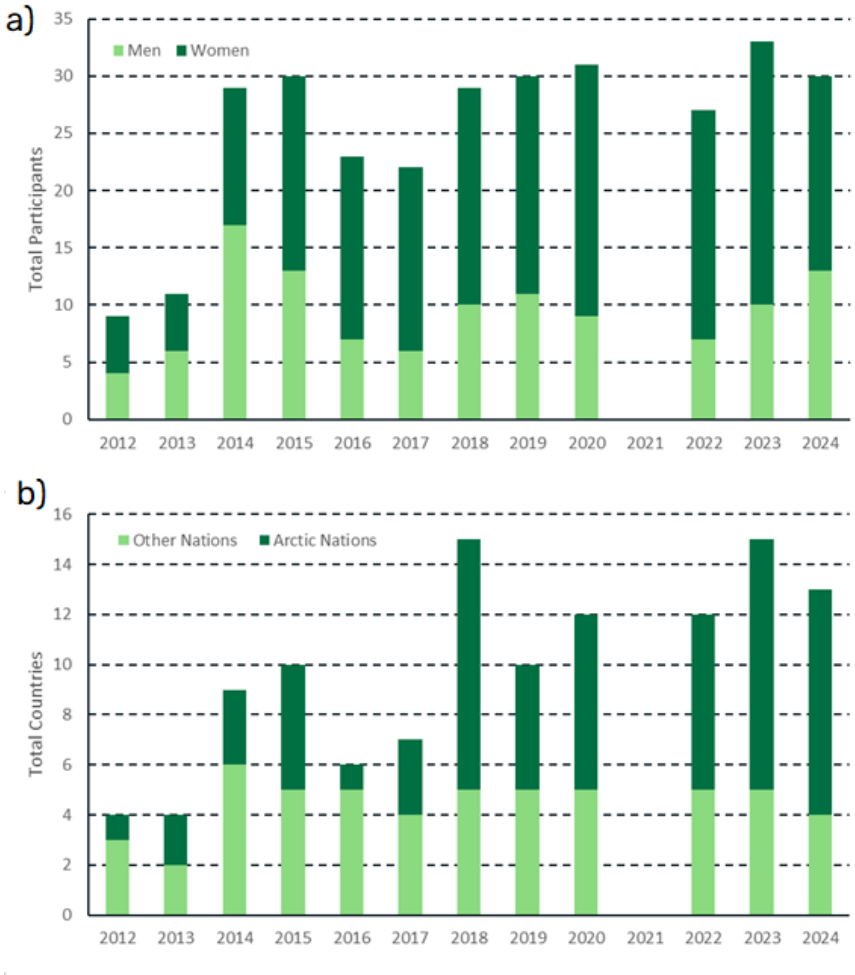

Figure 8: a) The total number of participants in the Emerging Leaders program each year, split by gender. Gender was in some cases assumed from name and photograph, as gender information was not collected for all years. b) The total number of countries represented in each Emerging Leader program (where the individual is residing, not their nationality), split into non-Arctic and Arctic countries. In 2021, the program was run online with participants from the past 5 years due to COVID19 restrictions. In 2012 and 2013, records were incomplete, with information on participant gender and affiliation for just 9 people in each year.

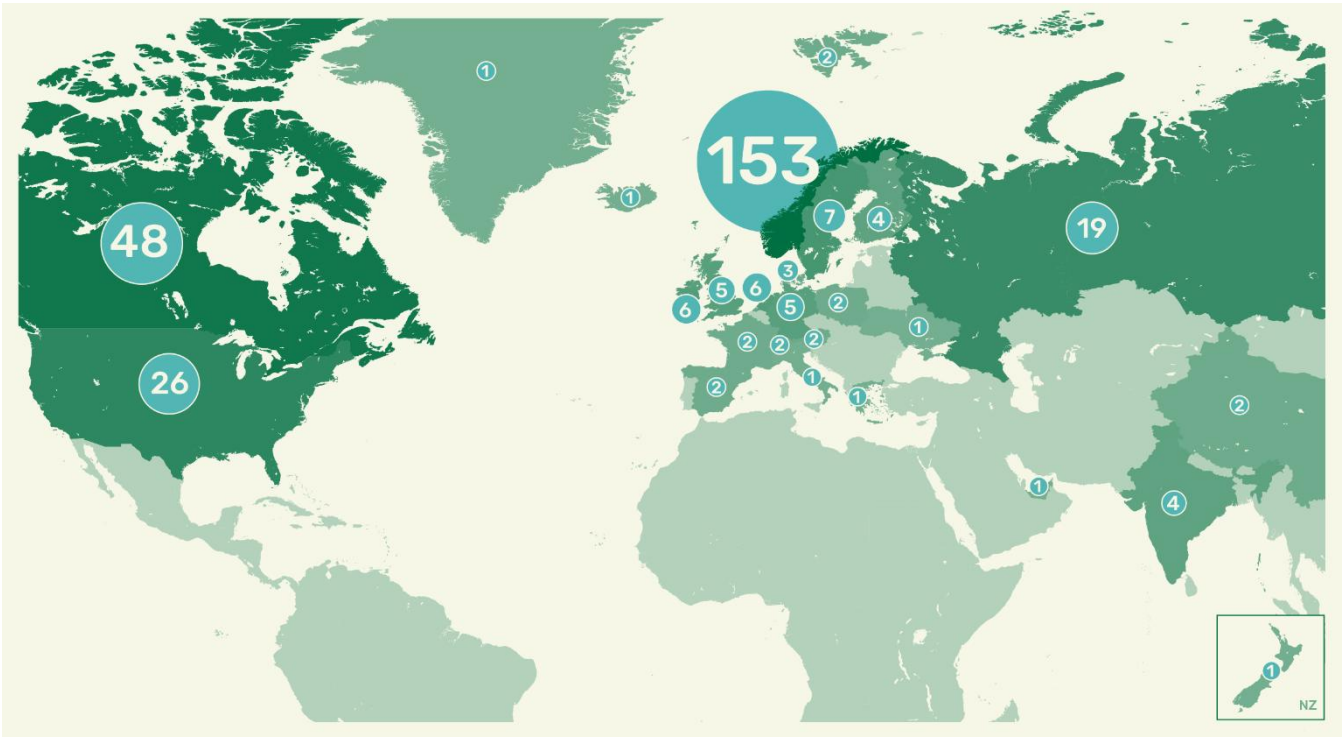

Figure 9: Graphical representation of the country of residence of all known Emerging Leaders between 2012 and 2024 (location when they applied for the program). Figure created by Reibo AS graphic design company.

400

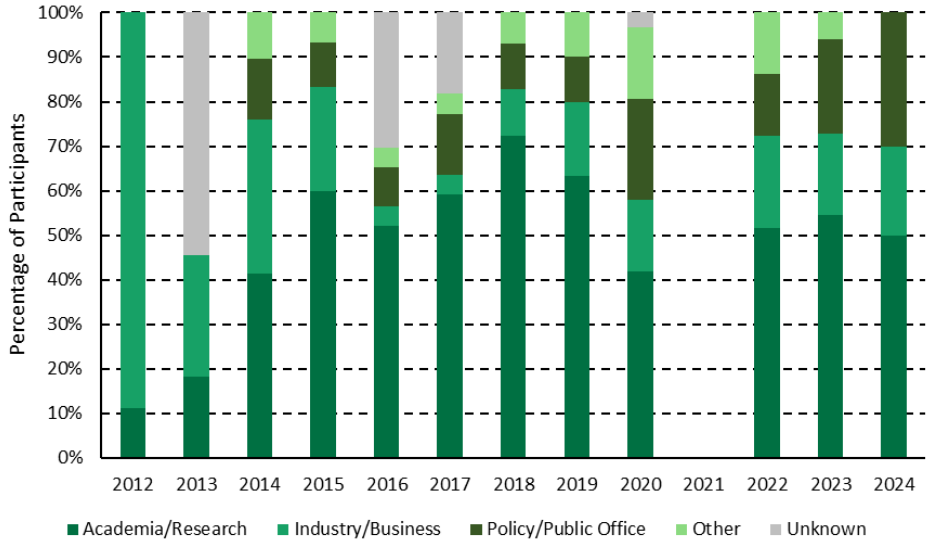

Figure 10: The split between employment sectors within the Emerging Leader participants in each year. Academia/research includes PhD candidates.

5 Limitations of the Young Program

Data availability is poorest for both the Science for Schools and Science for Kids programs, as the project is a collaborative effort between the schools, kindergartens, the Science Centre of Northern Norway and Arctic Frontiers, with key information known by the teachers. Demographic data on the children are not collected (e.g gender) and some information on the number of schools and kindergartens is unknown. Due to the high number of children participating, it is difficult to track their further development or trajectory within STEM subjects, however qualitative feedback discussions with teachers and students have revealed that many children are inspired by the program and do decide to take STEM subjects at university level (Table 2).

Science for Schools is impacted by teacher availability and funding. Some schools have communicated the importance of this project in their annual curriculum, and pupils from these schools present their research each year. For other schools, attendance is dependent on the availability of teachers and the interest of pupils in extra-curricular groups.

There are barriers and limitations to the programs which reduce the attractiveness to many, including Indigenous Peoples. The applications for Student Forum and Emerging Leaders must be submitted in English, as the working language of Arctic Frontiers is English, and the majority of events take place during the annual international conference, which is an English-language conference. This is also a necessity due to the international mixture of the participants and mentors. However, whilst the proficiency of the English language is particularly high in the Nordic countries (Bonnet et al. 2004), English can be the third language of Sámi children, providing an additional barrier to Indigenous participants. To enhance engagement, advertising of the programs and application forms in different Arctic languages could be considered, however the program will likely remain in English due to the internationality.

The Science for Kids program is conducted fully in Norwegian, and the Science for Schools program is a mixture between English and Norwegian depending on the requirements of the schools (Norwegian public schools and an International School are included). However, the students selected to present at the Arctic Frontiers conference are expected to present their work in English, both in written (poster) and oral format. This is a limitation to the program and can be a barrier or discomfort for the pupils, which actively works against some of the objectives of the program (to inspire and encourage greater interest in STEM and Arctic subjects). The Inspiration Days talks from scientists are largely conducted in Norwegian – at the request of many public schools whose pupils find it difficult to have a scientific lecture in an alternative language to their mother tongue and main language at school.

The programs are negatively impacted by the short-running cycle of many funding sources for such activities. Most of the funding for the programs require an annual application and funding covers just one cycle of the program (e.g Student Forum), and longer funding periods still require new applications each third year (e.g Science for Schools). The Emerging Leaders program is particularly vulnerable to funding changes, as the project is the costliest to run and only half of the spaces on the program are supported through funding sourced by Arctic Frontiers. Short-lived funding additionally effects the capacity of the Arctic Frontiers secretariat, as few funding agencies provide money for salaries of those organising the programs. This is not a unique problem. In a study of 48 STEM programs, Rincon and George-Jackson (2014) identified that

low staffing rates and lack of long-term stability of projects due to frequent funding reductions had a negative impact on the ability of the programs to function.

5 Discussion

The Arctic Frontiers Young Program fosters the next generation of scientists with a passion for Arctic issues, from the age of 5 to 35, through the four programs: Science for Kids, Science for Schools, Student Forum, and Emerging Leaders. Over 3000 individuals have passed through the Arctic Frontiers Young Program since its inception in 2012. Whilst no formal monitoring of the participants has been conducted to identify a long-lasting impact of the program (e.g continuation of higher education in STEM subjects for the Science for Schools participants), qualitative surveys, LinkedIn updates and informal conversations with some previous members has resulted in positive feedback. The quotes of the participants from surveys positively support aims 1 and 3 (see Introduction), with numerous participants mentioning the impact of the program(s) on their study and job choices. Additionally, numerous participants reflect on the challenges and issues that the Arctic face, which includes climate change and ocean developments. From informal contact with previous participants, many participants of both Student Forum and Emerging Leaders continue onto careers or further education in STEM following the programs, however the exact figures are not collected.

For E&O activities of this scale to be successful and impactful, close collaborations with research institutes, science centres, museums, small businesses, early career networks and civil servants are required. Additionally, the numbers of applications (for Student Forum and Emerging Leaders) have both increased over time, showing the importance of marketing, word of mouth and legacy for the international programs. The high levels of participation in the Science for Kids and Science for Schools activities can also partially be attributed to the high scientific literacy of Tromsø. A high number of research institutes are located in Tromsø including the Norwegian Polar Institute, UiT - The Arctic University of Norway, Tromsø, Institute of Marine Research, Norwegian Institute for Nature Research (NINA), Air Research (NILU), Water Research (NIVA) and aquaculture (Akvaplan-niva), to name a few. This results in many students with parents or family members working within the research field, and numerous science-based school and E&O projects. It also provides an ample number of experts for the Inspiration Days part of the Science for Schools program.

The multi-generation Young Programme is similar to the k2i (Kindergarten to Industry) approach taken by York University in Canada in their engineering department (Cole et al. 2022). Qualitative results seen from other studies (e.g Cole et al. 2022; Vennix et al. 2018) are reflected in the Arctic Frontiers Young Program, whereby students reflected that they had a greater understanding of STEM and developed their professional skills early in their career. However, active tracking of the educational and career choices of the participants of the Science for Schools and Student Forum programs has not taken place. It is therefore challenging to say whether the programs are meeting their objectives, especially objectives 1 (to encourage a greater number of students to take further education in STEM subjects) and 3 (to inspire generations of Arctic enthusiasts, who will go into science, research, policy-making and sustainable industry careers). With limited capacity within

the Arctic Frontiers secretariat, plus within the organisations such as museums and schools which collaborate on the programs, it is difficult to continue communication with a high number of individuals, especially children. The most active monitoring of careers is with the Emerging Leaders, due to dedicated funding and efforts to establish an 'alumni network'. This is a closed LinkedIn group, which was selected as the optimal platform for correspondence by the previous participants in a survey. However, this network does not include all previous participants, and knowledge about careers and opportunities relies on the individuals sharing their development on the social media site.

For the two programs which require applications (Student Forum and Emerging Leaders), the last few years have been characterised by significantly higher numbers of women than men applying to participate, and measurably higher quality applications coming from women too (applications are evaluated anonymously, with no information to identify the participants disclosed to the selection committees). This is then reflected in the selected participants (e.g Figure 8). Similarly, despite funding to support the inclusion of 8-10 participants from Norwegian Universities in the Emerging Leaders program, the vast majority of those who apply are international students living in Norway, rather than Norwegian nationals. Whilst there is limited research looking into these aspects, some parallels can be drawn from studies which identify gender and nationality gaps in internship work, networking and mentoring programs.

Mickey et al. (2022) identified that women in the technology profession typically seek out formal networking and mentoring events, conferences and seminars, to engage in more 'strategic networking' than men, who tend to use 'strategic socializing' by building informal networks through social events and sports. Mentoring and networking were highly appreciated aspects of the Student Forum and Emerging Leaders programs, with frequent mentions of them within the qualitative data. Demographic data were not connected to the answers of the feedback surveys; therefore we are not able to investigate whether male or female attendees focused more heavily on the mentoring and networking side of the programs.

Over-representation of women in unpaid internships compared to men have been found in a number of studies in the USA and Canada (Hora et al. 2022) and attributed to the normalization of low wages for the work that women do (Shade and Jacobsen, 2015). Similarly, a wage gap exists between white American young people and first-generation immigrants or international students in the internship and apprenticeship fields too (Hora et al. 2022). A recent journalistic investigation of the Norwegian University of Science and Technology (NTNU) identified that just 10.8% of applicants to 43 advertised PhD positions (in the field of sustainability) were Norwegian citizens (Vartdal, 2022). Upon interviewing the Rector of the university, Professor Tor Grande, he expressed that many young Norwegians are employed in jobs following their bachelor's or master's degrees due to competitive labour markets (Vartdal, 2022). This fact could also reflect the reduced number of Norwegian nationals joining the Student Forum and Emerging Leaders programs, despite a high number of Norwegian institutions participating.

It is challenging to secure Norwegian-speaking scientists to present their science and career developments. Partly, this could be attributed to the high number of international PhD candidates and post docs in Norway, as outlined by Vartdal (2022). Therefore, the scientists who provide the Inspiration Days talks often participate for a number of years, which provides some stability to the program but does have a negative impact on how many early career students have the opportunity to

participate. Other English-speaking science communication opportunities are provided for those who want to be involved in the education and outreach programs, when possible. The fourth objective of the Young Program (to engage scientists in regular, impactful science communication with the public) is therefore being met, but has room for improvement.

With over 4 million Indigenous Peoples in the Arctic, representing almost 9% of the Arctic's population, it is important to include young Indigenous peoples in the E&O programs. The Student Forum and Emerging Leaders programs have both historically included participants who self-identify as belonging to an Indigenous Community, however demographical records are only available recently. Since 2022, Indigenous participants represented 12-13% of Emerging Leaders participants. The Student Forum program includes students studying at the Sámi University of Applied Sciences in Guovdageaidnu/Kautokeino, Norway. No demographic data are available to monitor diversity of the children and high school students in the two younger programs, however no specific Sámi schools or kindergartens are currently included in the program. To ensure that harder to reach communities continue to engage in the Young Program, efforts are made to create specific marketing and simplified application forms due to digital infrastructure difficulties in some remote locations.

The timing of the call for applications and activities can also be a barrier to small and Indigenous communities, who have limited capacity and additional responsibilities in combination with their job and/or studies, such as harvesting, reindeer herding and hunting. Informal discussions with community members in the Yukon, Canada, have highlighted that the deadline for Emerging Leaders coincides with hunting and harvesting season in northern Canada, meaning eligible Canadian citizens (both First Nation and non-indigenous locals) are not able to prioritise applying for the program. Due to the wildfires in northern Canada during the 2024 Emerging Leaders application phase, a deadline extension was provided to those coming from affected areas. One potential way of increasing the accessibility of the program is to introduce flexible deadlines.

Ruesch and Sarvary (2024) investigated the impact of a two-tier, flexible deadline approach in assignment deadlines for students. In this case, an 'ideal' deadline and an 'extendable-without penalties' deadline were communicated to students, and 78% of students handed the assignments in using the extended deadline. Students reported that the extension provided a more inclusive environment and was helpful for first-generation students, with accompanying data suggesting that there was no negative impact on student grades (Ruesch and Sarvary, 2024). Whilst this is a different situation than a university, a flexible deadline approach could be considered for future participants.

5 Conclusions

Here we have presented the first analysis of the four components of the Arctic Frontiers Young Program, with a focus on trends of participants (number, geographical reach, gender, demographics) over the last decade, as well as gathering feedback from participants, to assess the success of the projects aims. Qualitative feedback from the participants of Emerging Leaders and Student Forum points to increased interest in STEM subjects and continuing education and/or careers in STEM fields. Furthermore, the success of the program can be seen through increased applications for Emerging Leaders and Student Forum, as well as consistently high numbers of children taking part in the two earlier-years activities. The

programs are therefore meeting objective 2 (to highlight opportunities for STEM careers within the Arctic). Quantitative monitoring of participants entering study programs/careers in STEM following participation in the programs is not undertaken – a current limitation of the programs, which also inhibits the analysis of how well objective 1 (to encourage a greater number of students to take further education in STEM subjects) and objective 3 (to inspire generations of Arctic enthusiasts, who will go into science, research, policy-making and sustainable industry careers) is being met. Qualitative feedback from participants does however point to increased interest in Arctic and/or STEM fields, as well as the programs having a positive influence on their future decisions (Table 3).

Aspects of the Arctic Frontiers Young Program have been running since 2012, which has fostered new generations of Arctic enthusiasts and scientists. With changes in company structure and staff and differing reporting requirements depending on the funding source, demographic data and monitoring of participants was patchy until recently. Going forward, demographic data and the long-term impacts of the Young Program will be collected and analysed, to further improve the diversity and inclusivity of the project. The continuation of the Young Program is heavily dependent on accessible funding. Short term funding, and funds which only cover 50% of the total costs or includes funding only for travel and project activities, but does not allocate staffing costs, are limitations to the program. Additionally, international E&O programs and the funding which supports them, are impacted by geopolitical challenges. Long-term funding for E&O programs should be provided by more sources, such as national research councils, to ensure the continued support of out-of-classroom learning experiences for young people in all education stages.

Ethical Statement

All quotes were received voluntarily through feedback surveys, videos and interviews. For public feedback, participants were asked for prior consent before recording. For feedback from surveys, quotes were anonymous, and all quotes have been anonymised for analysis in this publication. We adhere to GDPR rules, do not name any individuals, and all participants at the education and outreach activities have signed a consent form that states that we can store and use their data.

When engaging with Indigenous peoples, we adhere to many written principles e.g from the Inuit Circumpolar Council and Sámi Council including clear communication, valuing Indigenous knowledge, and building and maintaining relationships.

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Competing Interests

The contact author has declared that none of the authors has any competing interests.

References

Bonnet, G.: The assessment of pupil's skills in English in eight European countries 2002, The European Network of Policy Makers for The Evaluation Of Educational Systems, 2004.

Bøe, M. V., Henriksen, E. K., Lyons, T., and Schreiner, C.: Participation in science and technology: young people's achievement-related choices in late-modern societies. Studies in Science Education, 47(1), 37–72, doi:10.1080/03057267.2011.549621, 2011.

Campbell, C., Speldewinde, C., Howitt, C., and MacDonald, A.: STEM Practice in the Early Years, Creative Education, 9, 11-25, doi:10.4236/ce.2018.91002, 2018.

Cole, L., Goodyer, J., and Ironside, V.: k2i academy: An Innovative Ecosystem Addressing System Barriers in STEM from Kindergarten to Industry. Proceedings of the Canadian Engineering Education Association (CEEA), doi:10.24908/pceea.vi.15876, 2022

Dahle, S., Lindefjeld, O. and Brekke, P.: Emerging Leaders. 2019.

Gibney, E.: Women Under-Represented in World's Science Academies. Nature. doi:10.1038/nature.2016.19465, 2016.

Goff, E. E. et al. The effects of prior informal science and math experiences on undergraduate STEM identity. Research in Science & Technological Education, 38(3), pp. 272–288, doi: 10.1080/02635143.2019.1627307, 2020.

Hora, M., Jang-Tucci, K., and Zhang, J.: Gatekeeping at work: a multi-dimensional analysis of student, institutional, and employer characteristics associated with unpaid internships. Centre for Research on College-Workforce Transitions. https://ccwt.wisc.edu/wp-content/uploads/2022/11/Unpaid-Internships_Hora-Jang-Tucci-Zhang_Nov-2022.pdf, 2022.

Kricorian, K., Seu, M., Lopez, D. et al. Factors influencing participation of underrepresented students in STEM fields: matched mentors and mindsets. IJ STEM Ed 7, 16, doi: 10.1186/s40594-020-00219-2, 2020.

Kyrre, L., and Hebe, G.: Gender Balance in Norwegian Academia: Present State and Future Scenarios. Frontiers in Education, 7, doi: 10.3389/feduc.2022.809116, 2022.

Mickey, E. L.: The Organization of Networking and Gender Inequality in the New Economy: Evidence from the Tech Industry. Work and Occupations, 49(4), 383-420, doi: 10.1177/07308884221102134, 2022.

Nilsson AE, and Larsen JN. Making Regional Sense of Global Sustainable Development Indicators for the Arctic. Sustainability. 12(3):1027, doi:10.3390/su12031027, 2020.

Peters, C.: Children's books for research-based outreach and science communication pedagogy. Geoscience Communication. 7: 81-90, 2024.

Pew Research Center: STEM jobs see uneven progress in increasing gender, racial and ethnic diversity, , 2021.

Princeton University "About WordNet." WordNet. Princeton University. 2010.

https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2024.1324506/full

Rincon, B. and George-Jackson, C.: STEM Intervention Programs: Funding Practices and Challenges, Studies in Higher Education, 41(3), 429-444, doi:10.1080/03075079.2014.927845, 2014.

Roberts, M. R.: Realizing Societal Benefit from Academic Research: Analysis of the National Science Foundation's Broader Impacts Criterion, Social Epistemology, 23, 199–219, https://doi.org/10.1080/02691720903364035, 2009.

Roberts, T., Jackson, C., Mohr-Schroeder, M.J. et al. Students' perceptions of STEM learning after participating in a summer informal learning experience. IJ STEM Ed 5, 35, doi:10.1186/s40594-018-0133-4, 2018.

Rousell, D., & Cutter-Mackenzie-Knowles, A. A systematic review of climate change education: giving children and young people a 'voice' and a 'hand' in redressing climate change. Children's Geographies, 18(2), 191–208. https://doi.org/10.1080/14733285.2019.1614532, 2019.

Ruesch, J.M. and Sarvary, M.A.: Structure and Flexibility: Systemic and Explicit Assignment Extensions Foster an Inclusive Learning Environment, Frontiers in Education, 9:1324506, doi:10.3389/feduc.2024.1324506, 2024.

Scheibmeir, J.A. and Malaiya, Y.K.: Social Media Analytics of the Internet of Things, Discover Internet of Things, Brief Communication, 1(16), doi:10.1007/s43926-021-00016, 2021.

Shade, L. R., and Jacobson, J.: Hungry for the Job: Gender, Unpaid Internships, and the Creative Industries. The Sociological Review, 63(1_suppl), 188-205, doi:10.1111/1467-954X.12249, 2015.

Vartdal, R.: 90 prosent av søkerne til nye NTNU-stillinger bosatt utenfor Norge. Khrono News Paper Article, https://www.khrono.no/90-prosent-av-sokerne-til-nye-ntnu-stillinger-bosatt-utenfor-norge/666514, 07.03.2022.

Vennix, J., den Brok, P. and Taconis, R. Perceptions of STEM-based outreach learning activities in secondary education. Learning Environ Res 20, 21–46, doi:10.1007/s10984-016-9217-6, 2017.

Vennix, J, den Brok, P., and Taconis, R.: Do Outreach Activities in Secondary STEM Education Motivate Students and Improve Their Attitudes towards STEM?" International Journal of Science Education 40, no. 11, 1263–83. doi:10.1080/09500693.2018.1473659, 2018.