

Response to Reviewer 1

Dear reviewer,

Thank you for taking your time to expertly review the manuscript and study. We have addressed your individual comments below. Author responses are in black and reviewer comments are in red italics.

It is unclear if any of the authors listed are Indigenous. In the Introduction, the authors include statistics about "lack of minority groups" in the STEM field. They do address the gender imbalance. There is a saying among Indigenous scholars, "Nothing about us, without us." In their Ethical Statement, there are a number of ethical guidelines even for privately owned non-profit organisations (see <https://www.arcus.org/resources/northern-communities>).

Diversity is an important aspect of all programs run by Arctic Frontiers and the authorship represents a diverse group when factoring gender, career stage, nationalities and minority groups. Arctic Frontiers has worked with numerous Arctic Indigenous peoples over the years and different programs. However, it is not the aim of any programs to directly research or address Indigenous peoples, but rather to ensure that Arctic citizens are given access to education and outreach programs. We work with Indigenous peoples from across the Pan-Arctic when advertising the programs to ensure that every voice can participate in the programs. Funding for a number of positions in the Student Forum and Emerging Leaders is ringfenced to ensure Sámi and other Indigenous groups can attend the programs without costs.

In line with many of the guidelines you shared, a long-term relationship has been developed with numerous stakeholders and rightsholders. Arctic residents (whether Indigenous or not) who are mentors or contribute to the programs are able to share their history, culture and knowledge as they see fit, and thereby influence the programs. We again reiterate that the aims of the programs are not specifically designed to increase Indigenous peoples in STEM (the same way that the aim is also not to increase woman in STEM). The aims of the programs are thus: 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.

Increasing diversity of those accessing STEM and especially providing ring-fenced participation and funding for minority groups is an important aspect of all programs. The introduction provides a basis for why education and outreach activities such as these are necessary, in which we specifically reference minority groups due to published evidence.

Scientific significance: The four key projects sponsored by Arctic Frontiers include audiences as outlined in the authors introductions (gender and minorities): Science for Kids, Science for Schools, Student Forum, and Emerging Leaders (please note the serial comma as adopted by many writing style guides);

Thank you for pointing this out, we have amended the grammar.

Scientific quality: the authors provide quantitative data and translated qualitative data to support their article;

Presentation quality: the article is clearly written without jargon and reads well for its intended audience.

Thank you for your feedback.

Minor corrections:

"Sámi" should include the accent throughout the paper (see <https://samas.no/>) and Line 268 should be "...Sámi University of Applied Sciences."

We have now amended this throughout, thank you.

Response to Reviewer 2

Dear reviewer,

Thank you for taking your time to expertly review the manuscript and study. We have addressed your individual comments below. Author responses are in black and reviewer comments are in red italics.

While this is an important societal topic (STEM, technical labour challenges of Arctic regions, education), and the Arctic Frontiers approach is worthwhile evaluating in this regard, in its current form the academic rigour is not up to standards to be accepted for publication. The paper generally is well written and structured. The paper contains interesting insights with regards to the various educational programmes that Arctic Frontiers has been running over the last 10 years.

Thank you for your feedback. We hope that the changes to the manuscript structure and additional methods and evaluation of the limitations of the programs can increase the academic rigour.

The key weakness of the current version of the manuscript is its lack of methodological explanation. Half-way the paper in the results section it is mentioned suddenly that the programmes are evaluated based on different types of performance criteria. What these criteria are, and how they have been determined, remains largely hidden. To be acceptable for publication the paper would require a solid methodological section in which the various steps of the evaluation methodology, the choice for particular criteria, should be clearly presented

Thank you for your feedback. The paper has undergone significant structural changes and a methodology and data analysis section are provided. Please see the full manuscript for details.

In its current form the discussion section of the paper fails to link the results of the paper to the existing literature on the topic, to conceptual choices made in the study, or to the methodology chosen for evaluation. To be acceptable for publication a more serious attempt should be made to discuss the research results to clarify what is common or distinctive about these results.

More connection to existing research has now been provided, please see the full manuscript.

Page 3, line 69-71: explains the main objective of the paper ("highlight the importance of E&O projects"), which sounds more like an advocacy objective than an academic research paper objective (i.e. understand, assess, evaluate, etc). It could be that the analysis could lead to a greater appreciation of such E&O projects, but it sounds too preconceived to assume that they are before evaluation.

Thank you for your feedback, we have amended the aims to reflect the recommendations of multiple reviewers and due to the changed structure of the paper.

(Line 70-76) 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.

Since the authors of the paper seem to be strongly affiliated with Arctic Frontiers and their programmes, they would have to be very careful with mixing academic independence/neutrality and rigour with their interests in the success of their programmes. In the acknowledgement of the paper it is stated that the authors or Arctic Frontiers as a private company have no interests in the outcomes of the research. I find this not convincing at all. The authors are advised to not shy away from their interests in this issue, and to be more clear on how the methodology has enabled them to produce reliable, valid outcomes on this issue regardless. Page 3, line 76: It is mentioned that Arctic Frontiers is a private company. Please make this more clear in the introduction of the paper, what Arctic Frontiers is, what its mission is, and why as a private entity it engages with public educational institutions.

Arctic Frontiers is a private non-profit organisation, which is a partnership of the largest Norwegian institutions working towards Arctic research and challenges within the northern regions. This [partnership](#) includes numerous Norwegian public institutions, such as Norwegian Polar Institute and five major universities, who partner with Arctic Frontiers in order to use the activities and events as a way of showcasing and communicating research – a requirement of public funded research projects. Additionally, public institutions such as municipalities and county councils also provide funding and partnership with Arctic Frontiers, in order to highlight the thriving communities who live and work in the Arctic. The aim of the company is to encourage knowledge-based sustainable development of the Arctic and science/research is at the core of the events being organised and projects run. This aim can't be met without the voices of young and engaged people.

Arctic Frontiers makes no profit on the activities, and the aim of holding the extensive E+O projects is truly to encourage more young people to thrive in STEM communities within the Arctic and to see more knowledge of the Arctic integrated into programs outside of the Arctic. Our parent company, Akvaplan Niva, is also a non-profit aquaculture and water research company, who actively contribute to the academic community through their research. We hear from many organisations and researchers that they do not have the capacity to invent and innovate E+O programs, and we hope that this publication can also serve as a template for others to use. In addition, there are many private organisations whose sole mission is to provide E+O opportunities – for example APECS, International Polar Foundation, Polar Educators International.

The following is now in the manuscript, however reviewer 4 requested that less space be dedicated to describing the company, therefore we hope that the extended description above provides more information.

(Line 55-63) Arctic Frontiers is a private, non-profit organisation based in Tromsø, 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 institutes 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.

Response to Reviewer 3

Dear reviewer,

Thank you for taking your time to expertly review the manuscript and study. We have addressed your individual comments below. Author responses are in black and reviewer comments are in red italics.

This paper outlines a very large outreach program run through the Arctic Frontiers organization out of Tromsø, Norway. The authors have investigated who the program reaches, and assessed whether the program is meeting its objectives. The paper reads rather like a prospectus for the outreach program and the impressive number of persons and educational institutions involved, as well as some next steps the organization is taking. There are some missed opportunities to discuss key issues in reaching local Arctic residents in these kinds of programs, in recruiting local and Indigenous researchers more generally, and what the stakes are for Arctic representation in research and policy.

Thank you for your feedback. We have now amended the structure of the paper and removed more descriptive elements to reduce the 'prospectus' feeling and ensure more analysis is included.

As the authors mention, it is a challenge securing local and Indigenous participants in the lower levels, as well as participants from Norway in the higher levels of the Arctic Frontiers program. What is the significance of this on the impacts of the Arctic Frontiers program? What is the significance of this for Arctic research more generally? The program has expanded over recent years, reaching even more participants, showing an impressive effort at outreach, but the paper could show more clearly whether this has helped the program reach their objectives. Overall, more critical reflection on the program and study could help contextualize the efforts better.

Thank you for these recommendations. We have now included more critical analysis of the programs and their limitations 'Limitations of the Young Program' section 5.

Evaluation and related amendments of the programs each year has led to improvements in some aspects of diversity and inclusion. Arctic Frontiers have increased their network by which they advertise the various programs. One method of this was through hiring people who directly work towards the young program and Emerging Leaders. They are able to invest more time in connecting with previous attendees, their own professional network and others in the Arctic community. Connecting with Norwegian Embassies overseas and applying for funding which focuses on various nations has seen an increase in diversity of those attending the programs. Applying for funding from various sources (which often has very short periods) does cause increased workload and demands on the secretariat. Furthermore, the short-lived nature of the funding calls makes it challenging to maintain focus on one nation or region of the Arctic, and therefore see long-term engagement. The program must therefore adapt each funding cycle.

The significance on research more generally is hard to say, and as we can't say if our experiences are reflected in other mentoring/youth programs in Norway or across the

Arctic. However, we do point to the NTNU study and the impacts of reduced numbers of Norwegian scientists applying for PhDs.

There are a number of dedicated Arctic research projects which actively work towards improving the inclusion of Indigenous scholars and Indigenous knowledge, for example ArcticNet in Canada. There are many oral reports of research fatigue and capacity issues for Indigenous peoples to engage with researchers. However, few of these are analysed in peer-reviewed papers. This is discussed regularly at conferences and during meetings between Indigenous leaders and researchers.

We have now provided more analysis and reflection of the programs themselves based on multiple reviewers' suggestions. Due to such large changes, we don't provide a copy of this here, but ask you to look at section 5 and 6 of the manuscript.

A suggestion might be structuring the paper more around the objectives of the program, spending less time describing the program, detailing the methods used and their limitations, and to return to the references outlined in the introduction in the discussion of the results.

Numerous reviewers recommended that we re-structure the paper to focus more on the objectives, methods and evaluation. We have now changed the structure of the manuscript and hope that the objectives and methods are clearer. A separate section with data and methods is included and the results are now structured based on the objectives of the program. We have cut down the description of the programs too. Due to the length of these changes, please see the full manuscript.

The conclusion would be improved by referring back to the objectives.

Thank you for the suggestion to restructure and focus more on the objectives. These have been included in the conclusion now too.

Response to Reviewer 4

Dear reviewer,

Thank you for taking your time to expertly review the manuscript and study. The feedback and suggestions have greatly improved the substance and structure of the manuscript. We have addressed your individual comments below. Author responses are in black and reviewer comments are in red italics.

The manuscript 'From Five to Thirty-Five: Fostering the Next Generation of Arctic Scientists' aims to address the challenge of out-of-classroom education and outreach (E&O) initiatives in Arctic science by analyzing Arctic Frontiers' framework and programs since 2012. The project include four projects, targeting a wide range of audiences from children to early-career professionals. The paper is well-presented, aligned with the scope of the GC journal, and will be of benefit to readers interested in conducting similar activities in and beyond the Arctic. The paper also emphasizes the importance of raising public awareness of scientific outreach activities within Arctic and beyond, which is a valuable contribution. However, I concur with other reviewers that the manuscript currently reads like a project report rather than a research paper, and requires improvement in several areas. Below, I provide detailed feedback.

Thank you for your positive feedback on the benefit of the paper for the community. We have now amended the structure and content of the paper based on all reviewer comments and we provide details below.

Major Comments:

1. There needs to be a clear separation between methods, results and discussions. There is no clear method section, and some discussion content is in the results section. For example, I suggest moving some of the content from Part 3: Impact and Evaluation (e.g., lines 244, 260, and 276) into Part 4: Discussion. This includes explaining why data availability is poor, why participant numbers have decreased, and addressing the need for continued funding and marketing efforts. These points could lead to interesting discussions and provide deeper insights into the program's successes and challenges.

Based on a number of suggestions from other reviewers, the structure of the paper is now quite different, with the objectives analysed clearly, limitations of the program stated and the discussion has been amended. Due to the large changes, please see the full manuscript.

2. The data and analysis supporting the results should be strengthened, especially to bolster claims of program success. For example, the quotes from attendees used in Table 2 are minimal, which may raise concerns about the credibility and robustness of the conclusions. I recommend that the authors classify the quotes and consider applying some form of text-analysis, such as keyword frequency, to lend more rigor to the findings. Including both positive and negative feedback could make the analysis more balanced and informative.

Thank you for your comments. The quotes in the tables are a small sample of the collection, due to the limited space in the manuscript and the request of other reviewers to limit the

quotes or move them all to the supplement. In addition, many of the quotes are provided by children, who provide limited written feedback when requested – even in their mother tongue. We have now included a lengthier version of the quotes in the supplement. We have also now included a keyword frequency, as you suggested, which is also included in the results section. Thank you for making the results more robust.

3. Some of the more descriptive sections can be shortened to make them easier to read. This includes, for example, the introduction of the company. Some content, such as the detailed feedback in tables, could be moved to supplementary materials and only referred to in the manuscript text.

Thank you for your suggestions and examples. We have now removed parts of the descriptions to shorten this aspect. The introduction to the company is kept however, due to the request of reviewer 2 to understand more about the companies interests in working with public institutions.

There are now supplementary materials which further support the results. However, we do keep the tables with quotes due to the largely qualitative evaluation of the performance of the programs and how they meet their goals.

Additionally, it would be helpful to readers to see what a typical schedule or activity arrangement (as templates perhaps) looks like.

Thank you for this suggestion. We have now added a typical week schedule for Student Forum to the supplement.

Adding sub-sections to Part 3: Impact and Evaluation would enhance understanding. Sub-sections could include topics like “Factors for Success of E&O Activities” or “Gender-related Issues,” allowing the reader to navigate the manuscript more easily.

As the manuscript structure has now changed quite significantly, we hope that these issues are now clearer, but please see the full manuscript.

Minor Comments:

1. Line 69: The manuscript highlights the importance of E&O initiatives to inspire Arctic scientists. However, it may serve a broader purpose by offering insights into conducting E&O activities in non-Arctic regions. This could be further emphasized.

The E+O activities organised by Arctic Frontiers are all taking place within the Arctic – Tromsø is located well above the Arctic Circle at 69 degrees north, and the Emerging Leaders program also begins in the Arctic. We hope that the programs can be adapted and run in non-Arctic regions, especially as outmigration from the north to the south is commonplace across the Arctic, and one of the reasons for focusing on the descriptions of the events is that it could be used as a form of template for future activities. We have now included this in the aim of the paper, and included the latitude/longitude of the regions we work in.

(Line 70-72) The aim of the paper is to highlight the importance 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.

2. Line 200: The manuscript mentions that participants from over 15 countries joined in 2023. Can the authors give a specific number? Providing precise figures would increase accuracy and clarity.

We have now included a supplementary table with the list of countries involved in each year of the Emerging Leaders program.

3. Line 234: The number “550 children” is questionable, as summing the values from Figure 4 results in a higher total. Please verify this figure.

Thank you, this number has now been changed to reflect the figures.

4. Line 299: The reference to “Figures 4b and 5” may be incorrect. Is this intended to be “Figure 7b and 8” instead? Please check the numbering.

Numbers have now changed due to structural changes.

5. Part 3 (Impact and Evaluation): While the paper assesses the programs’ success through participant growth and feedback, the figures show a decline in participation. I recommend explaining this discrepancy in the discussion and enriching the overall analysis.

We have now included a more in-depth analysis of how the aims of the project are being met and which factors account for success. This varies depending on the project, and increasing numbers are not always a success factor.

6. Line 316: The average satisfaction score dropped from 86/100 in 2023 to 71/100 in 2024. As a reader, I would like to know the reasons behind this decline. A deeper analysis of the factors influencing participant satisfaction is warranted.

Thank you – this has now been included. However, please note that with just two years of data (and a voluntary survey where the number who chose to respond decreased), it is hard to draw wider conclusions.

7. Line 329: The manuscript claims to assess the impact on participants’ study and career choices, but this is difficult to discern from the data in Table 2. Clarifying how this table supports aims 1 and 3 would strengthen the argument.

We have now more critically reflected on the programs and how well the objectives are being met. The structure of the paper has also been amended to reflect this. Additional analysis of qualitative data is also provided. Please see the manuscript due to significant changes.

8. Line 331: The activity of following participants on social media is mentioned in the discussion without prior reference in the results section. Social media data should be introduced in Part 3 and elaborated upon in Part 4 to maintain consistency.

The activity of participants on social media is visible to the Arctic Frontiers team, but due to privacy reasons, we do not include this data in the manuscript – only prior-consented data from surveys and videos is used. Therefore, we do not include this in the data section, it is merely used as a discussion point to reflect on the career development of the groups.

Technical Comments:

- 1. Line 229: The section number should be 3.1, not 3.3.*

Fixed – thank you for spotting.

- 2. Line 271 : “Note held in 2022 due to...” should read “Not held in 2022...”.*

Fixed – thank you.