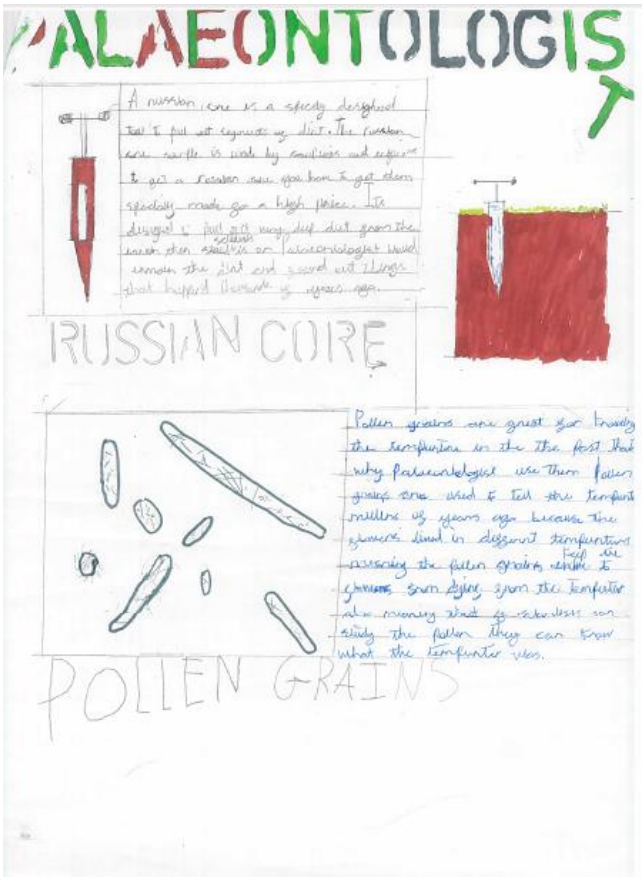
Geography:
Past Present and Future

Impact Report
April 2020



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Summary

The *Geography: Past, Present and Future* project explored climate change and environmental science with primary school children. The project consists of four activities:

- The Palaeontologist Workshop
- The Environmental Modeller Workshop
- The Environmental Planner Workshop
- Encounters Assembly

The workshop series was co-developed by academic staff from Northumbria University's Cold and palaeo-environment (CAPE) research group and NUSTEM and used NUSTEM's Theory of Change[1].

Evaluation shows the project's success in all of its five aims:

- **Increased knowledge**: Children's understanding of environmental science topics improved, particularly among girls.
- **Increased knowledge of environmental science related careers**: Children demonstrated an understanding of the characteristics of all three environmental science careers, and could name relevant attributes of environmental scientists.
- **Improved acceptability of environmental science careers**: Children's responses moved from largely negative and neutral pre-intervention, to more neutral and positive post-intervention.
- **Increased environmentally friendly intentions**: Children report an increased desire to learn about climate change and to act in an environmentally friendly way.
- **Enjoyment**: Children reported to enjoy all three the workshops.

"Thank you so much for the lessons. I know a lot more about the Earth and will try to investigate how it is changing more." (Workshop participant, year 5)

"The most noticeable thing for me as science lead was how inspired the teachers were by the project. They came out of each session buzzing at the science/geography that was being taught and the exciting hooks that were being used. They were particularly inspired by the way pollen analysis was used to predict what temperatures had been in the past. Teachers were definitely motivated to continue using environmental change as a stimulus for learning." (School Science Coordinator)

[1] Davenport, C., Dele-Ajayi, O., Emembolu, I. et al. A Theory of Change for Improving Children's Perceptions, Aspirations and Uptake of STEM Careers. Res Sci Educ (2020). https://doi.org/10.1007/s11165-019-09909-6

Contents

Introduction

The *Geography: Past, Present and Future* project explored climate change and environmental science with primary school children. The project consisted of four interventions:

- The Palaeontologist Workshop
- The Environmental Modeller Workshop
- The Environmental Planner Workshop
- Encounters Assembly

The workshop series was co-developed by academic staff from Northumbria University's Cold and palaeo-environment (CAPE) research group (see pg. 22) and NUSTEM and used NUSTEM's Theory of Change[2].

The project was delivered to children in Year 5 in a North East of England school during Nov 2019 – Jan 2020 and was evaluated to determine its impact.

During the workshops, academics working in relevant themes visited the classroom, supporting and encouraging children to act like researchers. The children found out how environmental science can be used to see what the environment was like in the past, to measure what's happening now, and to predict what might happen in the future.

The workshop series had four specific aims:

1. **Increase knowledge**: Children have a deeper understanding of environmental science topics and meet workshop specific learning objectives.
2. **Improve knowledge of related careers**: Children have a greater understanding of careers within environmental science.
3. **Improve environmentally friendly intentions**: Children feel more empowered towards climate activism.
4. **Increase enjoyment and interest in science**: Children enjoy the environmental science workshops.

The Intervention

This section gives a brief description of the four interventions, along with the aims of each.

- The Palaeontologist (Past): In this session, the children take on the role of a palaeontologist and use fossils to find out about the past. The class discover how and why palaeontologists use the past to predict the future.
  The workshop learning objectives are for children to know: that core samples allow us to see into the past; that microfossils allow us to understand climate in the past; and the characteristics of palaeontology careers.

[2] Davenport, C., Dele-Ajayi, O., Emembolu, I. et al. A Theory of Change for Improving Children's Perceptions, Aspirations and Uptake of STEM Careers. Res Sci Educ (2020). https://doi.org/10.1007/s11165-019-09909-6

- The Environmental Modeller (Future): In this session, the children take on the role of an environmental modeller, learning what a scientific model is, and how data can be used to predict the future.
  The workshop learning objectives were for children to know how to use existing knowledge to make predictions; to learn the uses of scientific models; and the characteristics of environmental modelling careers.
- The Environmental Planner (Past, Present and Future): In this session, the children take on the role of an environmental planner, examining old maps, discovering how land has been used in the past, and learning how this can be used to predict the future.
  The workshop learning objectives were for children to know: that maps change over time and space; that maps allow us to make predictions about the future; and the characteristics of environmental planning careers.
- **Encounters Assembly**: NUSTEM Encounters is a model for supporting people who have a STEM (science, technology, engineering and maths) job to visit local schools to share what they do. The NUSTEM Encounters model provides a structured process through which an industry professional engages in interactive discussions with children in a school, that helps children and adults get the most out of the experience. In this assembly two members from the CAPE research team visited the school to answer children's questions. The assembly learning objectives were that children have a greater knowledge of a STEM job; know what that person does in their job; and what characteristics (attributes) they need for that kind of work.

Attributes-based Approach

NUSTEM's successful attributes-based approach was utilised within the *Geography, Past, Present and Future* project. The approach utilises a nuanced set of attributes (e.g. passionate, self-motivated, creative) that scientists have used to describe themselves, intended to counteract the stereotypical words children commonly use to describe scientists: 'crazy hair', 'explosions', 'lab coats', 'genius', etc. In the Scientist of the Week pilot (nustem.uk/stem-person-of-the-week/)(the foundation for the attributes based approach) we found that one year after the project children were using significantly fewer stereotypes, and significantly more positive attributes to describe scientists.

Evaluation Scheme

The study design is a simple before and after difference in difference evaluation design, which assesses if the project achieved its intended aims (see pg. 3).

A mixed-methods approach was employed, consisting of four strands:

1. *Pre- and post-project questionnaires* utilising smiley Likert scales, covering environmental science/climate change topics (understanding, knowledge and aspirations for related careers, and activism) in broad terms. Pre- and post-project responses are matched for each pupil.

2. *Feedback postcards* following each of the three workshops. Pupils complete a postcard giving feedback on their enjoyment of workshop, accessibility of specific careers presented, and a measure of what they have learnt.
3. *Children's project work*: 2 months after the workshop series pupils will be challenged to produce an A3 poster summarising the things they learnt during the sessions.
4. *Teacher feedback*. Participating teachers in the project will be asked to reflect on the learning and other outcomes children demonstrated as a result of the project.

The table below shows the outcomes, the instruments used to measure them, and the specific related items within the evaluation instruments. See Appendix 1 (pg. 25) for the evaluation instruments used within this project.

Outcomes	**Instrument**	**Items/ *Analysis of***
Enjoyment of Workshops	*Postcards*	How many stars would you give this workshop?
Children have a greater understanding of careers within environmental science	*Postcards*	What does a X need to be good at?
	Pre- and post-project survey	I know some different jobs in environmental science
	Project work	*Analysis of understanding shown in children's posters.*
	Teacher feedback	*Reflections on any changes they have seen in their class.*
Presented careers feel accessible to children	*Postcards*	Do you think you could do this job? Yes, No, Not sure.
		What does a X need to be good at?
	Pre- and post-project survey	I could be a scientist when I am older
		'I would like a science job when I grow up'
	Project work	*Analysis of understanding shown in children's posters.*
	Teacher feedback	*Reflections on any changes they have seen in their class.*
Children have a deeper understanding of environmental science topics	*Postcards*	What new thing did you learn in today's workshop?
	Pre- and post-project survey	I know what climate change is
		I know what environmental science is
		Science can help us understand the past
		Science can help us predict what will happen in the future
		Open question: What new things did you learn in the environmental science workshops?
	Project work	*Analysis of understanding shown in children's posters.*
	Teacher feedback	*Reflections on any changes they have seen in their class.*
		I want to help protect the environment

Children feel more empowered towards climate activism	*Pre- and post-project survey*	Open question: Have the workshops made you think about or do anything differently?
	Project work	*Analysis of understanding shown in children's posters/ project work*
	Teacher feedback	*Reflections on any changes they have seen in their class.*

Analysis of Data

Quantitative Analysis

Quantitative data deriving from the feedback postcards were collected and entered into Microsoft Excel 2016 (Microsoft, 2016) and exported to IBM's SPSS 25 (IBM Corp., 2019) statistical software packages. The software packages used descriptive and inferential statistical analysis.

Quantitative data deriving from the pre- and post-project survey were entered into excel and exported to R Statistics (R Core Team, 2019). Frequency analysis was undertaken for each of the Likert scale statements to determine the number and proportion of children selecting each point on the Likert scale. Likert scale responses were also grouped into knowledge and careers scales for analysis. Positive (4&5) and negative responses (1&2) were grouped.

In order to obtain evidence that the project led to a change in students subject knowledge, knowledge of related careers and environmentally friendly intentions, we used a two-sample Sign Test, a non-parametric test suitable for paired data. The Sign Test assesses the number of observations in the post-intervention data that are greater than the observations in the pre-intervention data, without accounting for the magnitude of the difference (Mendenhall et al, 1989[3]). This test is suitable for ordinal Likert scale data.

The null hypothesis for the Sign Test is that the median of the paired differences, in the population from which the sample was drawn, is equal to zero, i.e. that the project made no difference to students' subject knowledge, knowledge of related careers, and environmentally friendly intentions. We choose to undertake a one-side test, with the alternative hypothesis being that paired differences have a median value greater than zero. We choose to test at the 5% value.

Qualitative Analysis

Qualitative data from the feedback postcards and children's posters were analysed using thematic analysis. Themes extracted from the data were coded, grouped and used to investigate relationships and patterns in the data. Frequency analysis and descriptive statistics were then generated about each of the themes in Excel (Microsoft, 2016) and SPSS 25 (IBM Corp., 2019).

Children's posters were analysed visually, looking to find evidence of children's understanding of the learning objectives from related workshops. Each learning objective was coded and the number of times each learning objective was used was tabulated.

[3] Mendenhall W, Wackerly DD, Scheaffer RL (1989) "Mathematical statistics with applications".

1. Increasing Children's Knowledge:

Children have a deeper understanding of environmental science topics

Survey Statements	Median (Pre)	Median (Post)	Sign Test P-values
I know what climate change is	4	4	.419
I know what environmental science is	3	4	.006
Science can help us understand the past	4	5	.017
Science can help us predict what will happen in the future	4	4	.787
All knowledge questions pooled			.04

The results show that there are statistically significant differences in children's knowledge of environmental science topics, as indicated by the $p<.05$ values of the Sign Test (highlighted in yellow).

Further analysis of the pre and post-project surveys found that:

- **9% more children reported knowing what climate change was**.
    - The increased knowledge in climate change was greatest among girls (+27%) in comparison to boys (-4%).
- **14% more children reported knowing what environmental science was.**
    - The increased knowledge of environmental science was greatest among boys (+17%) in comparison to girls (+8%).
- **91% of children reported positive responses to *Science can help us understand the past*** post-intervention, an increase of 10% from baseline measures.
    - Girls reported knowledge increased by 33%, in comparison to -5% among boys.
- **74% of children reported positive responses to *Science can help us predict what will happen in the future*** post-project, an increase of 7% from baseline measures.
    - Girls' reported knowledge increased by 16% in comparison to 2% among boys.

Analysis of children's posters provides evidence of their deeper understanding of environmental science topics and climate change (n=8). One child wrote: "*global warming is a big problem, these guys are researching how to stop it.*"

- In the poster below, a child describes how Antarctica is melting, and that behaviour needs to change to stop many places from flooding as a result.

Increasing Children's Knowledge.

Evidence against Learning Objectives

Each workshop had specific learning objectives to aid the understanding of environmental science and environmental science careers. Post workshop feedback postcards and children's posters were used to analyse children's learning against these learning objectives.

The table below demonstrates the learning objectives of the three workshops and the number of times they were referenced within the children's posters (n=37). The table also demonstrates learning in other areas. Percentages are given to show the proportional coverage of each type of learning across all demonstrated learning.

Learning Objectives Demonstrated	**No**	**%**
Core samples allow us to see in the past	5	7
Microfossils allow us to understand past climates	6	8
The characteristics of palaeontology careers	11	15
How to use existing knowledge to make predictions	5	7
how a scientific model is different/same as real life	0	0
The characteristics of environmental modelling careers	6	8
Maps change over time and space	0	0
Maps allow us to make predictions about the future	2	3
The characteristics of environmental planning careers	6	8
Other Learning Demonstrated	**No**	**%**
That real people do these jobs	19	25
General geography of extreme environments	4	5
Climate change	8	11
Attributes approach	3	4

Analysis of the results from each of the three workshops is discussed below.

The Palaeontology Workshops

Analysis of workshop feedback postcards and children's posters shows children have demonstrated some learning in all three palaeontology objectives.

To know that core samples allow us to see in the past

5 (of 44) children clearly demonstrated that they had met this learning outcome.

- When asked 'What new things did you learn in today's workshop?' the most common response was '*The further down you dig, the more back in time you go*' (n.5). Variations of this response include: '*I learnt that the further you dig the older the soil is*', '*further down you go older it gets*'. Children also reported to have learnt about core samples (n.4), '*how to tell the different time lines*' and that you '*need Russian made hole-thing*'. These responses demonstrate partial learning about core samples, but have not adequately demonstrated their

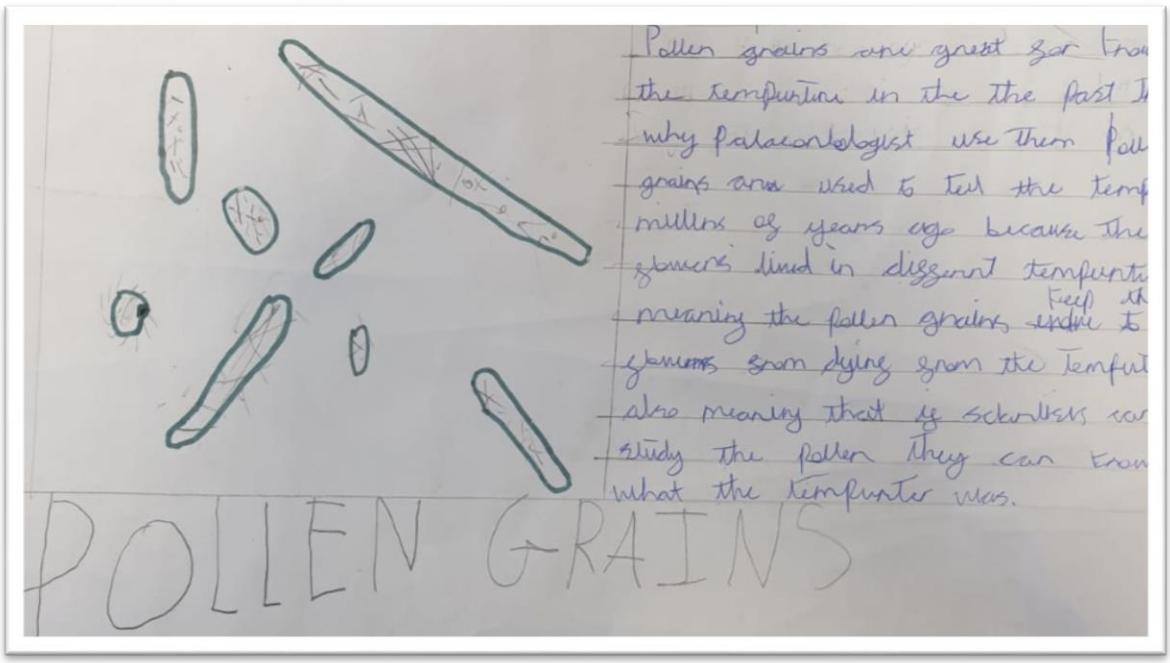
understanding of the link between core samples and how they are used to allow us to see what life was like in the past.

- Analysis of children's poster provided evidence however of deeper understanding among some children. One child writes, "They told us that they took core samples to look at what the place that they took the core samples from was like in the past. We looked at pollen grains that could only be there in a certain climate and then, at the end, we found out that Antarctica was very hot a long time ago".

To know that microfossils allow us to understand climate in the past

6 children clearly demonstrated that they had met this learning outcome.

- In response to 'What new things did you learn in today's workshop?' the second most common response was *'all about different fossils' (n.4)*. Variations to the response include: *'I learnt about a few more types of fossils'* and *'that there are different kind of fossils'*. Children also reported learning *'that fossils are billions of years old'* (n.3), *'where fossils come from'* (n.3) and *'how fossils are found'* (n.2). While children have demonstrated their learning about fossils, it was not clear from the postcard data that children had linked this knowledge to the understanding of climate in the past.
- Analysis of children's posters provides evidence of some deeper understanding in this learning objective. One learner writes, "*pollen grains are great for knowing the temperature in the past that's why palaeontologists use them. Pollen grains are used to tell the temperature millions of years ago because the flowers lived in different temperatures meaning the pollen grains keep the flowers from dying from the temperature also meaning that if scientists can study the pollen they can know what the temperature was.*"



The characteristics of palaeontology careers

11 children clearly demonstrated that they had met this learning outcome.

- Descriptions of palaeontologists and what they do were included on many children's posters, one example includes: "*I'm a palaeontologist I take samples out of the ground and use them to know what happened in the past*".
- '*What palaeontologists do*' (n.4) was a common response to 'What new things did you learn in today's workshop?', additionally children reported to have learnt '*life for scientists in Greenland'* and '*that life in Antarctica is good and bad*'.
- In response to 'What does a palaeontologist need to be good at?', children have named appropriate skills needed for palaeontology careers Other responses to this question included key skills including looking at/finding fossils (n.12), and observation (n.12).

Attributes of palaeontologists

- In response to 'What does a Palaeontologist need to be good at?', children have shown to have embodied the attribute-based approach to learning about careers, commonly reporting communication (n.15), patience (n.8), collaboration (n. 6), open-minded (n.4), and concentration (n.2).

The Environmental Modeller Workshops

Analysis of the workshop feedback postcards and children's posters shows children have demonstrated learning in all three environmental modeller learning objectives.

To know how to use existing knowledge to make predictions

5 children clearly demonstrated that they had met this learning outcome.

- When asked 'what new thing did you learn in today's workshop' on the feedback postcard the most common responses are: 'Learnt about predictions' (n.10). Variations of this response include: '*environmental modellers have to be able to predict*', '*that your prediction can't always work*'. Other common responses include 'learnt about estimations' (n.4). Variations to the response include children confusing predictions with estimations: '*estimating things about the planet*', '*we learnt that estimating from a long way away is hard*' and '*estimating weather*'.
- In response to 'What does and Environmental modeller need to be good at?', a large number of children gave responses linked to making predictions (n.17).
- Analysis of children's posters additionally shows evidence of some children having met this learning objective. One poster reads, "*weather predictions are the jobs of people who have to take a really good guess at what weather will be. It is useful to use the time of year to guess what the weather will be.*"

To learn how a scientific model is different or the same as real life

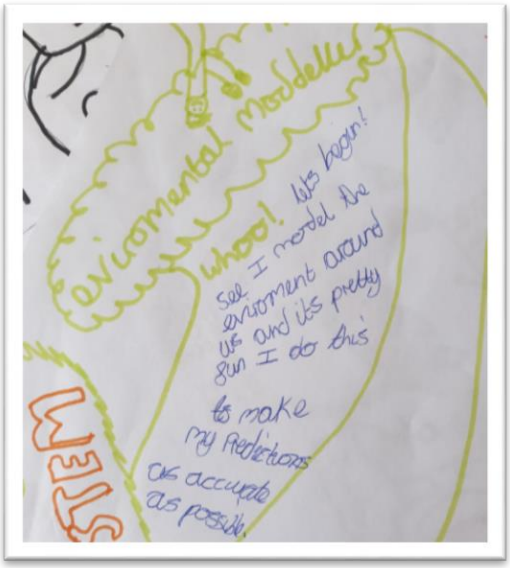
No children demonstrated that they had met this learning outcome.

- In response to 'what new thing did you learn in today's workshop?', one child wrote 'you can use models to help predict the future'.

The characteristics of environmental modelling careers

6 children clearly demonstrated that they had met this learning outcome.

- In response to what new thing did you learn in today's workshop, another common response was 'about an environmental modeller' (n.4). A variation of this response is 'I learnt about what an environmental modeller does'. In response to 'What does and Environmental modeller need to be good at?', children reported important skills for environmental modelling they have learnt from the workshops, including making predictions (n.17), exploring and experimenting (n.3), modelling (n.3), observation (n.2) and problem-solving (n.2).
- Analysis of children's posters further demonstrates learning. On the poster (right) one child writes, *"Environmental Modeller. Wooo! Lets' begin. I model the environment around us and its pretty fun. I do this to make my predictions as accurate as possible."*



Attributes of environmental modellers

- In response to 'What does and Environmental modeller need to be good at?', common responses were collaboration (n.10), communication (n.6), patience (n.6) and resilience (n.5), showing that children have embodied the attribute-based approach to learning about careers.

Environmental Planner Workshops

Analysis of the workshop feedback postcards and children's posters shows children have met the learning outcomes in two of the three environmental planner objectives.

To know that maps change over time and space

No children demonstrated that they had met this learning outcome..

- When asked 'What new things did you learn in today's workshop?' the most common response was *'coastline changes over time' (n=4).* Variations of this response include: 'how the places have changed and how to stop flooding', 'how much the coast has moved' and 'how much the sea-line has moved'. Other related answers that do not demonstrate as much understanding include 'the coast gets smaller' and 'the coastline is getting destroyed'.

To know that that maps allow us to make predictions about the future

2 children clearly demonstrated that they had met this learning outcome.

- From the feedback postcards, there is no evidence that this learning objective was met. Children did not report related answered in 'What new things did you learn in today's workshop?'. In response to 'What does an Environmental Planner need to be good at?' many children reported 'making predictions' (n.7).
- Analysis of children's posters finds some evidence of partial understanding of this learning objective, "*If we carry on this drastic in 2030 many places will be flooded.*"

The characteristics of environmental planning careers

6 children clearly demonstrated that they had met this learning outcome.

- They included descriptions of environmental planners and what they do on many of their posters. One examples given was: "Matt is an environmental planner. He looks at how he can protect land from floods".
- When asked 'What new things did you learn in today's workshop?' some children reported '*what environmental planners do*' (n.2). Children also reported some of the decisions and challenges that environmental planners face in their work: 'thinking about people, lives could be endangered', 'be ready for an idea not to work', 'sea walls are expensive', 'there is a downside to every situation'. In response to 'What does an Environmental Planner need to be good at?' children also answered 'decision-making' (n.3).

Attributes of environmental planners

- When asked 'What does an Environmental planner need to be good at?', children have shown to have embodied the attribute based approach to learning about careers, commonly answering collaboration (n.10), communication (n.5), patience (n.5). One child reported 'smart' which shows how persistence of this stereotype despite attribute and skills based approached.
- One example of understanding of the attributes approach is included on children's posters, "*when doing this job I must be patient, collaborative and ready to listen.*"

2. Improving Knowledge and Aspiration for Related Careers

Survey Statements	Median (Pre)	Median (Post)	Sign Test P-values
I know some different jobs in environmental science	3	4	.001
I could be a scientist when I am older	3	3	.079
I would like a science job when I grow up	2	3	.580
All careers questions pooled			.03

The results of the survey analysis show statistically significant differences in children's knowledge of environmental science careers post- project, as indicated by the $p<.05$ values of the Sign Test (highlighted in yellow). However the statistics do not support an increase in children's aspirations towards environmental science careers.

Further analysis of the pre-and post-project surveys found:

- **67% of children reported to *know some different jobs in environmental science*** post-intervention, an increase of 45% from baseline.
    - There was a 49% increase of girls reporting positive responses, and an increase of 41% among boys.
- **A decline in positive responses to (*I could be a scientist when I am older*)** was noted post-intervention, from 33% to 24%.
    - This decline can be attributed to girls (-12%), in comparison to boys (-1%).
- **There was an increase of 9% of children who could consider a science job post-intervention**, with 56% of children reported neutral or positive responses to (*I would like a science job when I grow up*) post-intervention, in comparison to 47% in the baseline.
    - There is a 14% increase among girls and 3% decrease among boys.

Children were not asked for their knowledge of specific workshop careers pre-project, because it was assumed that children would not yet know about the careers and therefore be able report aspirations towards them. Analysis of post-workshop feedback postcards examines the percentage of children who would consider each of these careers. This data is the sum of (not sure + yes) responses to 'Do you think you could do this job?', and aims to represent the 'zone of acceptable alternatives' available to children[4].

- 67% of children think they could be a palaeontologist
- 48% of children they could be an environmental modeller
- 36% of children they could be an environmental planner

The most popular career among children was that of palaeontologist. This is also shown by 15% of children choosing to include information about palaeontology careers within their posters.

[4] Gottfredson, L (1981) "Circumscription and compromise: A developmental theory of occupational aspirations". Journal of Counseling psychology, 28(6), 545.

3. Increase Environmentally Friendly Intention

Survey Statements	Median (Pre)	Median (Post)	Sign Test P-values
I want to help protect the environment	5	5	.94

We find no statistical evidence to demonstrate children's increased environmentally-friendly intentions post- project, although other evaluation instruments have evidenced this change among children.

Analysis of the related pre-and post-intervention surveys found that:

- Levels of intention to protect the environment was already high in the pre-survey, with 86% of children reporting positive responses (*I want to protect the environment*). Post-intervention 84% of children reported positive responses to this statement, this can be attributed to a (-5%) drop in positive responses among boys, and a +2% increase among girls.

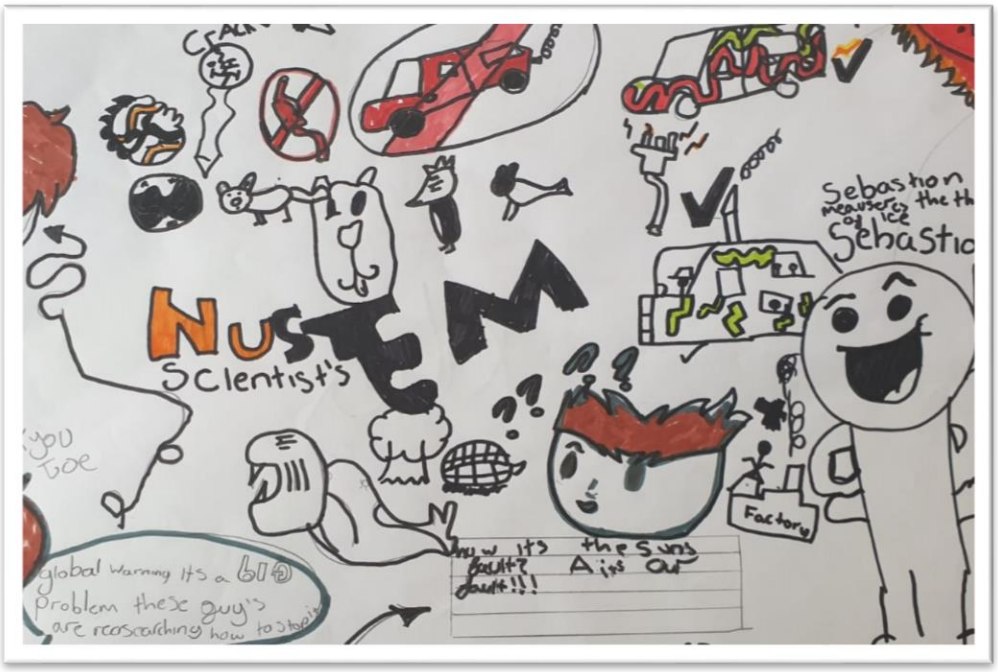
However, analysis of the open question 'Have the workshops made you think about or do anything differently?' on the back of the survey, shows that children do report change in behaviour and intention following the intervention.

Frequency analysis of the responses (n=44) is presented below alongside representative quotes from children's surveys.

- **It has made me think about the environment changing and climate change** (n=9).
  "*It made me care about nature more and how Antarctica used to be a rainforest and then it turned into ice and now the ice is melting and the ocean will rise.*"
- **It made me care about nature and the environment more** (n= 13).
  "*The world is changing so we need to start and look after our world more. The workshop has made us look at what we are doing by killing the world.*"
- **It has made me take action to protect the environment** (n= 11).
  "*The workshops have made me take much better care of the environment and to encourage people to stop using fossils fuels. I have started to use a bike more often instead of using a car."*
  "Me and my family have started walking more places. We have also recycled more."
  "Me and my family walk everywhere and I convinced my nanna and granda to walk more often."
- **We did our chosen class project on climate change due to our interest in it** (n= 11).
  "*We are doing a project on climate change because of the workshops*"
- **Didn't do anything differently** (n=4).
  "*No I learnt a lot but I haven't done anything differently or thought differently, but at school we are doing a project about climate change to help the environment.*"

Equally children have used their posters to show their developing understanding of how their behaviours affect the environment and what they will do about it (n=8).

- One child writes, *"When we learned about Antarctica we learned that if people keep polluting, global warming would melt Antarctica and penguins would die and other animals and sea levels would rise."*
- Children's posters show their understanding of the types of behaviours (n=4) that should be avoided such as petrol cars and alternative behaviours such as electric cars, as below.



3. Enjoyment and Interest in Science

Survey Statements	Median (Pre)	Median (Post)	Sign Test P-values
I think science is interesting	4	4	.975

We find no statistical evidence to demonstrate an increased interest in science following the intervention, however children show enjoyment of all three workshops.

Analysis of data from the pre and post survey shows:

- Children's responses to (*I think science is interesting*) show has declined (-9%) among the intervention period, from 67% - 58%. This is attributed to a decrease of (-25%) among girls and an increase of +2% among boys.

Analysis of the open-questions from the survey finds evidence of increased interest in one participant.

- One child writes, "*I have started to watch scientific programmes on TV and wonder more about what it would be like to work or live in Antarctica.*"

Analysis of this data from the workshop feedback post-cards showed that children enjoyed all three of the workshops, but the most popular was the palaeontology workshop.

- 85% of children gave the palaeontology workshop either 5 stars or 4 stars.
- 67% of children gave the environmental modeller workshop either 5 stars or 4 stars.
- 50% of children gave the environmental planner workshop either 5 stars or 4 stars.

Feedback from School Staff

Class teachers were asked to reflect on the learning and other outcomes children demonstrated as a result of the project at the project's competition.

"The most noticeable thing for me as science lead was how inspired the teachers were by the project. They came out of each session buzzing at the science/geography that was being taught and the exciting hooks that were being used. They were particularly inspired by the way pollen analysis was used to predict what temperatures had been in the past. Teachers were definitely motivated to continue using environmental change as a stimulus for learning." (School Science Coordinator)

Lessons Learnt

Terminology is important

This study finds that boys and girls reported their learning development differently: girls knowledge about climate change increased by 27% while boys decrease by 4%, while boys knowledge of environmental science increased by 17% in comparison to an 8% increase among girls.

This seems to provide evidence that the term 'environmental science' has wider recognition and appeal among boys, while the term 'climate change' has wider recognition and appeal to girls.

The value of real-life experiences

In their poster assignment children had free choice to report 'what they had learnt' from the workshops on their posters. 16 children (48%) chose to structure their posters around the individuals they met in the workshops rather than around the science or geography, and included the names of the researchers as headings and descriptions of what they do in their jobs, or what they told them. This demonstrates the value children held in meeting real people and hearing about what they do.

Additionally 14 children (36%) included a drawing or a description of the Russian Corer used within the Palaeontology workshop on their posters, which may demonstrate the interest children had in 'real' scientific equipment being brought into their classrooms.

There may be unintended consequences

We found that some children (n=3) expressed concerns after participating in the environmental planning workshop, writing on their feedback postcard's that 'the sea could take over the world' and another 'people's lives and homes are endangered'. Children's concerns about the immediate danger to life were also raised in the initial round of these workshops, and the workshop had been adapted to mitigate this. This was done by talking specifically about how environmental planners make medium to long-term decisions and plan for the future, and by explicitly stating that people involved are in no immediate danger, that the risks for them would be they may need to move house. That this finding is still present in the revised workshops, shows how children can mis-interpret information, which can lead to unintended negative consequences and this needs to be accounted for by workshop leaders.

The attributes approach seems to work

On the feedback postcards following each workshop, children were asked what a person in each job role needs to be good at e.g. 'what does an environmental modeller need to be good at?'. We find only two occasions where children reported 'smart/clever'. Instead children seem to have embodied the attributes approach, listing communication (n.26) a key attribute named in two of the workshops, and collaboration (n. 26), and patience (n.19), skills they learnt when doing the workshops, as the most important knowledge/skills of environmental scientists across the three workshops.

Importance of triangulation in evaluation of children's learning

This study demonstrates the value of using a mixed methods approach to evaluating the impacts of an educational intervention with children. While some impacts of the intervention could be captured through quantitative survey, without the open

responses questions (analysis of children's posters and feedback postcards) we would have not been able to capture the clear impacts on children's environmental intentions.

Children like palaeontology

Out of the three workshops the palaeontology one was clearly the most popular with children. 85% rated the workshop 4 or 5 stars, with 67% of children reporting that they would consider a career as a palaeontologist. In future research it would be worth exploring whether this is because of the content of the workshop itself, or because of a prior interest and recognition of dinosaurs and palaeontology, a popular interest for children.

Cold and Palaeo-Environments Research Group (CAPE)

Academic staff from the Cold and Palaeo-Environments (CAPE) Research Group at Northumbria University have inspired and led the development of this project.

CAPE carry out world-leading research across the globe, investigating modern and ancient environments, from the tropics to the Polar Regions and many places in between.

The CAPE group includes two main research themes:

- Ice, Snow and Permafrost
- Past Climate and Environment

Activities are focussed around two interlinked themes: (1) Reconstruction of climate change, vegetation, palaeoseismicity, environmental pollution and sea level at decadal, millennial and million-year timescales using a variety of biological and geochemical proxies, including pollen, diatoms, dinoflagellates, stable isotopes and biomarkers; (2) Response of the contemporary cryosphere (where the world is frozen) to recent and future climate change through geophysical investigations, micrometeorological measurements on mountain glaciers; measurement and modelling of snow properties over land, under trees and on sea ice; analysis of carbon release from Siberian permafrost and modelling of ice sheets and high mountain hydrology. Field data collection involves a range of state-of-the-science techniques including ground-penetrating radar, seismics, eddy covariance systems, and terrestrial laser scanning (TLS). Find out more about the group at: research.northumbria.ac.uk/coldandpalaeo/.

* some pictures drawn by school children on this project.

Dr Kate Winter
Kate uses ice penetrating radar and remotely sensed imagery to comprehend and characterise the subglacial environment and flow dynamics of ice streams in Antarctica.

Dr Matthew Pound
Matt is interested in how climates and environments have changed through geological time. Creating large datasets of fossil information he produces global maps of vegetation and climate distributions.

Dr Nick Rutter
Nick is interested in the hydrology of cold environments and how the frozen land surface interacts with the atmosphere.

Dr Sebastian Rosier
Sebastian's research focuses on understanding the processes controlling ice flow in Antarctica, with the goal of improving computer model predictions of the continent's contribution to future sea level rise.

Dr Leanne Wake
Leanne models the elastic, viscous and gravitational response of the Earth to redistribution of ice and water on the Earth's surface and predicting the variation in sea-level change in the past.

Professor John Woodward
John uses glaciological and geophysical evidence to investigate subglacial lakes and ice/sediment/water interactions at the glacier bed.

NUSTEM is an outreach team based in the faculty of Engineering and Environment at Northumbria University. We support children and young people to make informed decisions about possible STEM careers. Our work is focussed on engaging and supporting children and families from groups that are currently under-represented in the STEM landscape, particularly girls and those from low socioeconomic backgrounds. Unusually for a University, the majority of NUSTEM's work is with pre-school and primary age children, supporting them at a crucial time for their aspirations and learning identity development.

NUSTEM project delivery staff:

- Dr Carol Davenport – NUSTEM Director
- Joe Shimwell – NUSTEM Outreach Specialist: Primary and Early Years
- Melanie Horan – NUSTEM Primary Outreach Officer
- Sonia Singh Chahal – NUSTEM Outreach Assistant

NUSTEM research and evaluation:

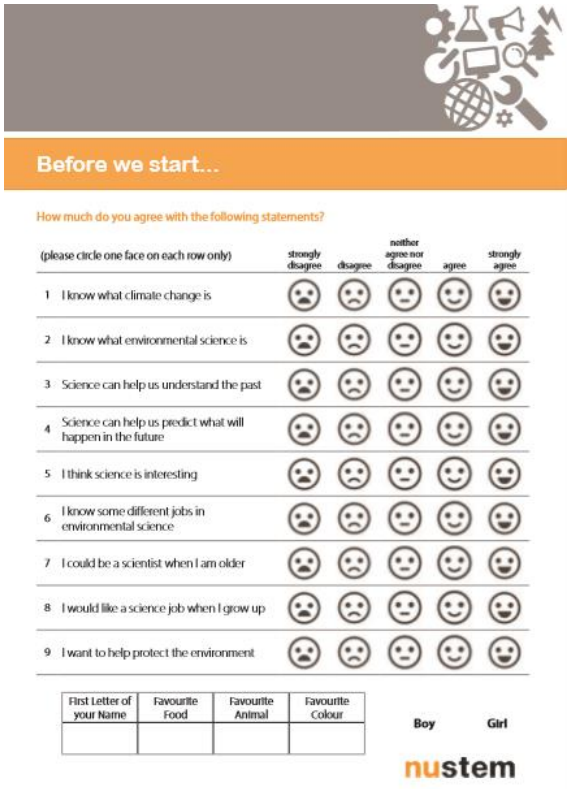
- Annie Padwick – Senior Research Assistant
- Itoro Emembolu – Senior Research Assistant

Dr Richard Morton
Evaluation was also supported by Dr. Richard Morton. Richard is a member of Northumbria University's Solar Physics Research Group and part of Northumbria University's multidisciplinary research theme Extreme Environments[5].

[5] northumbria.ac.uk/research/changing-challenging-world/extreme-environments/

Appendix 1: Evaluation Instruments

Pre-intervention Survey for Children



Before we start...

How much do you agree with the following statements?

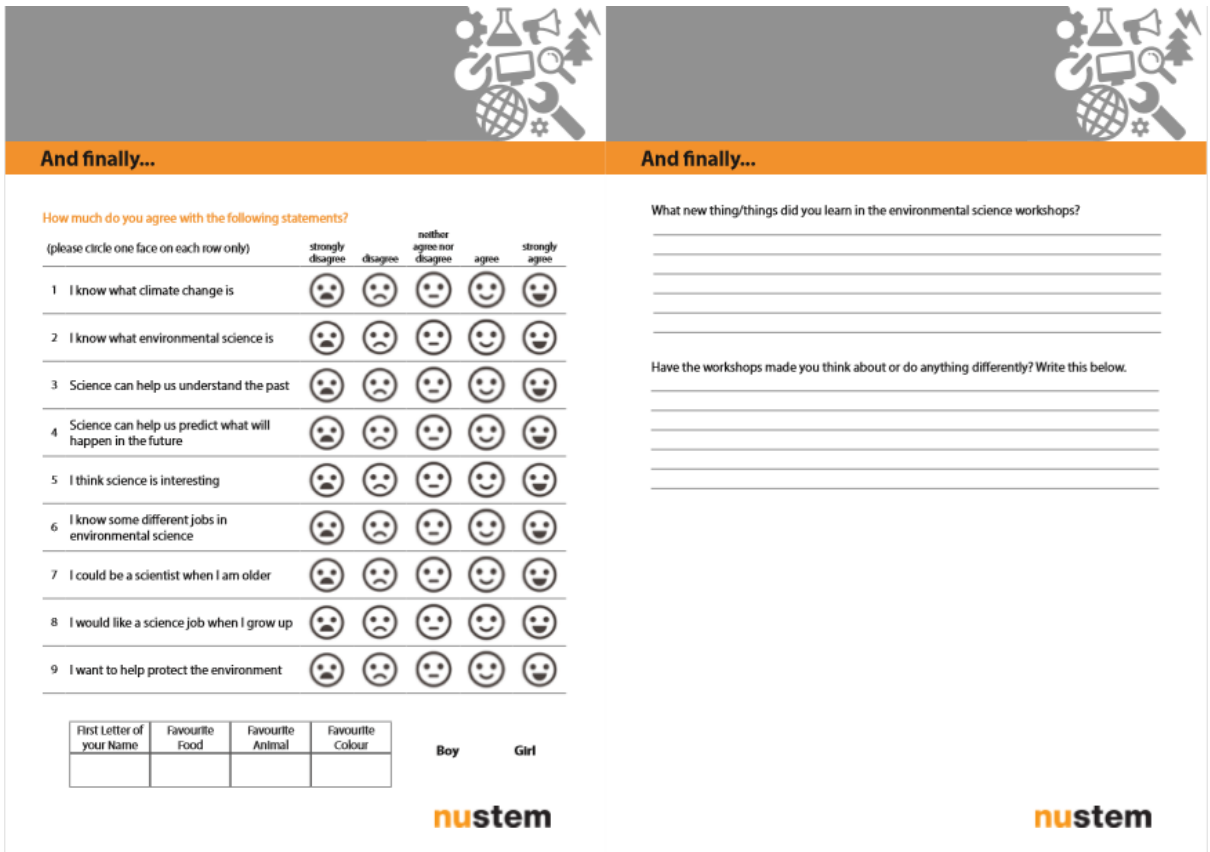
(please circle one face on each row only)	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1 I know what climate change is					
2 I know what environmental science is					
3 Science can help us understand the past					
4 Science can help us predict what will happen in the future					
5 I think science is interesting					
6 I know some different jobs in environmental science					
7 I could be a scientist when I am older					
8 I would like a science job when I grow up					
9 I want to help protect the environment					

First Letter of your Name	Favourite Food	Favourite Animal	Favourite Colour

Boy Girl

nustem

Post-intervention Survey for Children



And finally...

How much do you agree with the following statements?

(please circle one face on each row only)	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1 I know what climate change is					
2 I know what environmental science is					
3 Science can help us understand the past					
4 Science can help us predict what will happen in the future					
5 I think science is interesting					
6 I know some different jobs in environmental science					
7 I could be a scientist when I am older					
8 I would like a science job when I grow up					
9 I want to help protect the environment					

First Letter of your Name	Favourite Food	Favourite Animal	Favourite Colour

Boy Girl

nustem

And finally...

What new thing/things did you learn in the environmental science workshops?

Have the workshops made you think about or do anything differently? Write this below.

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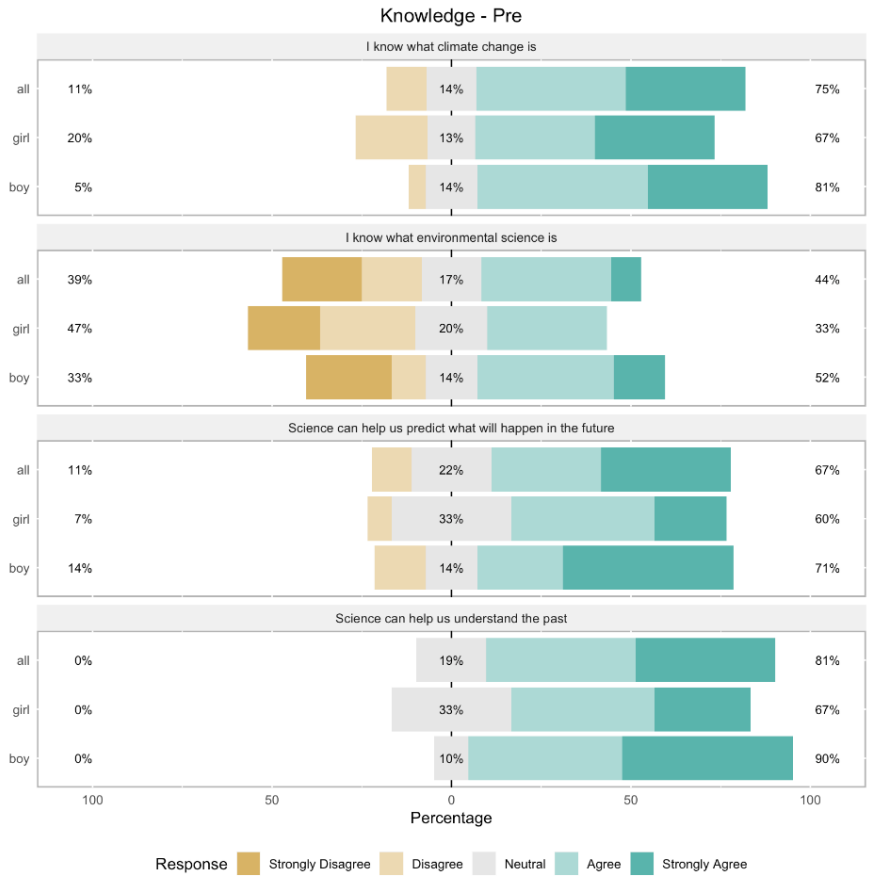
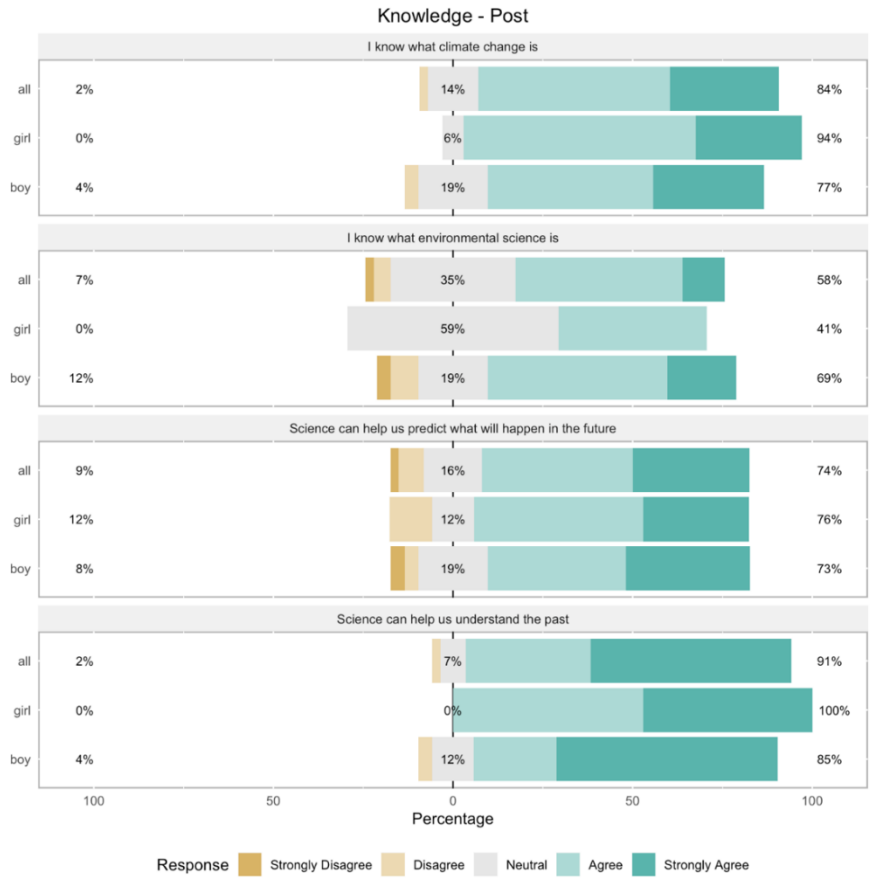
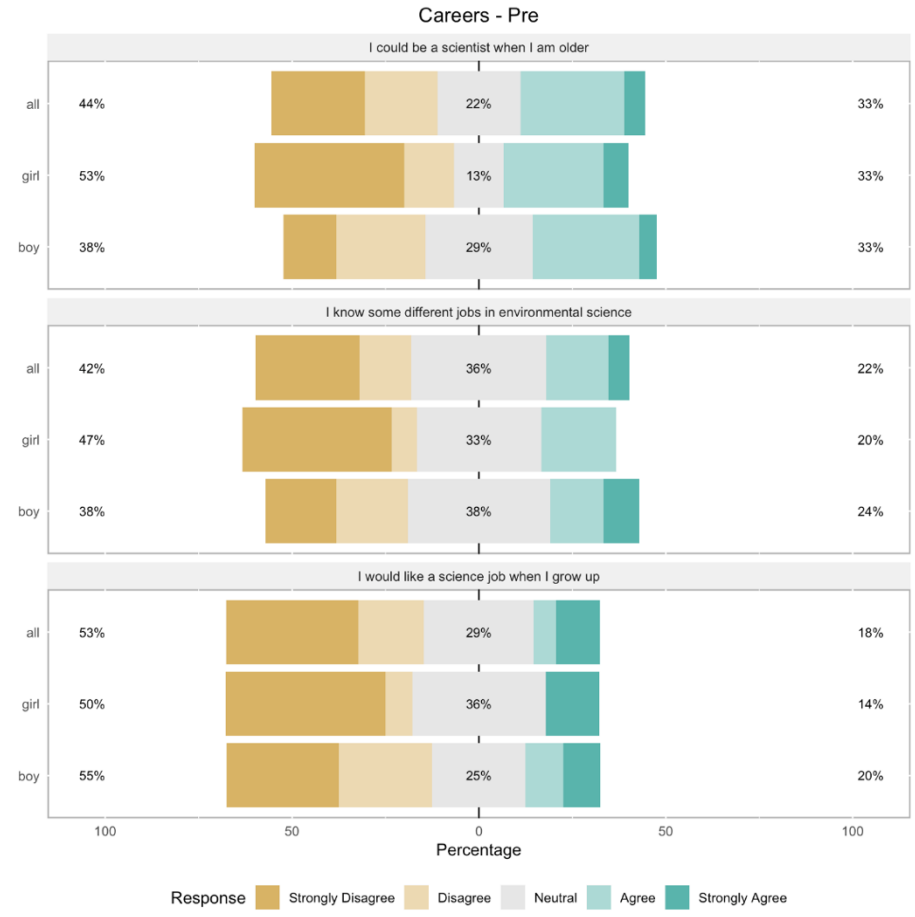
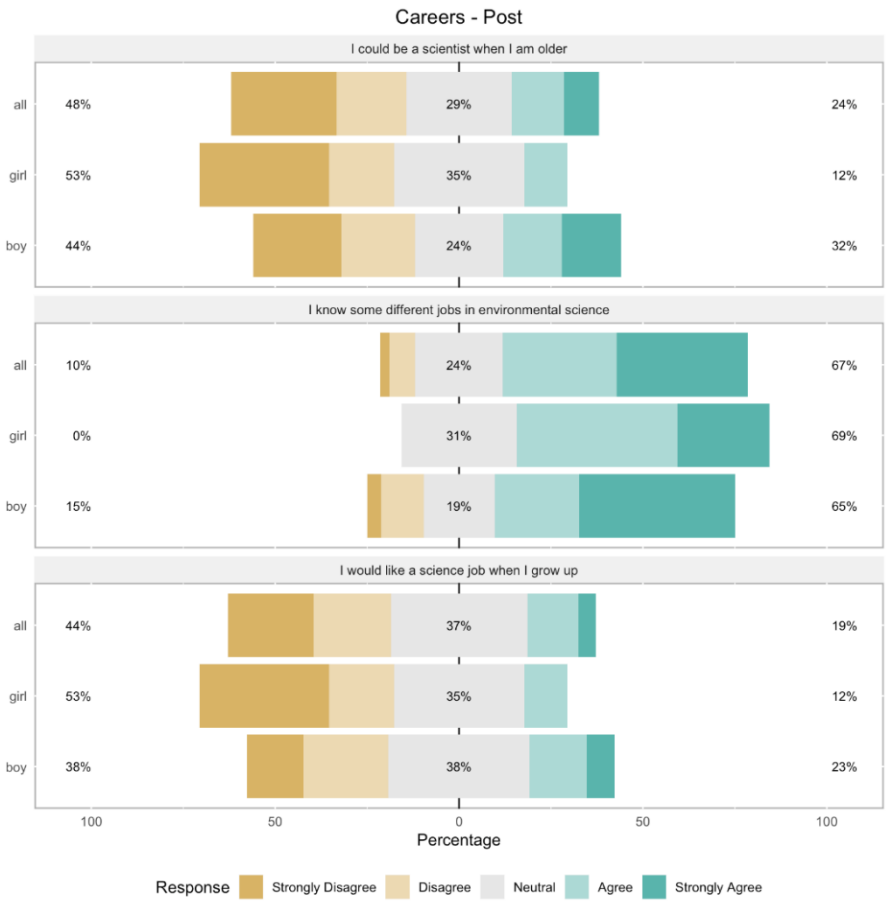
Workshop Feedback Postcards

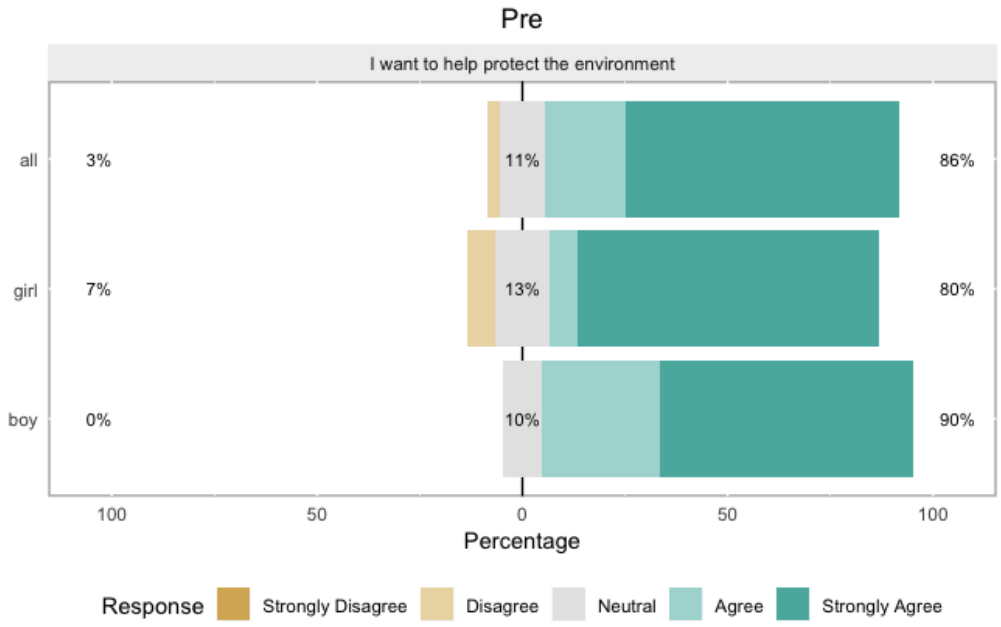
Appendix 2: Pre- and Post- Survey Analysis Graphs

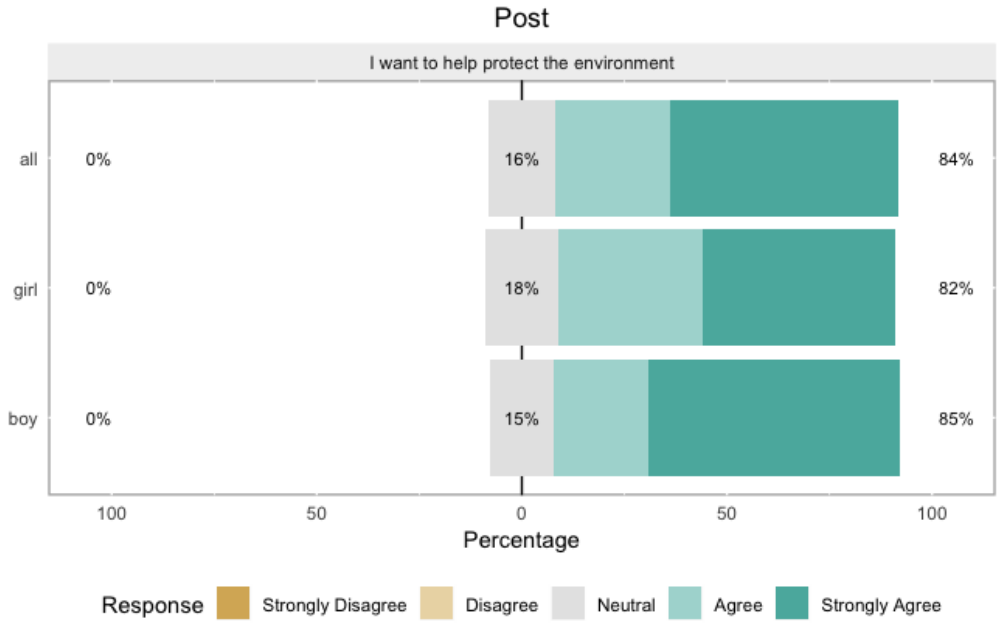


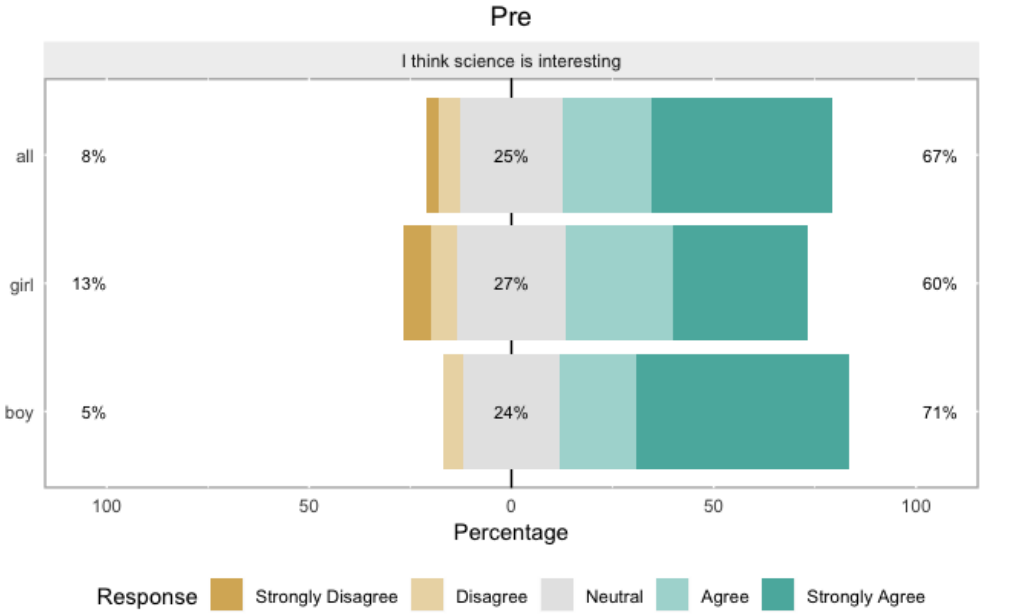


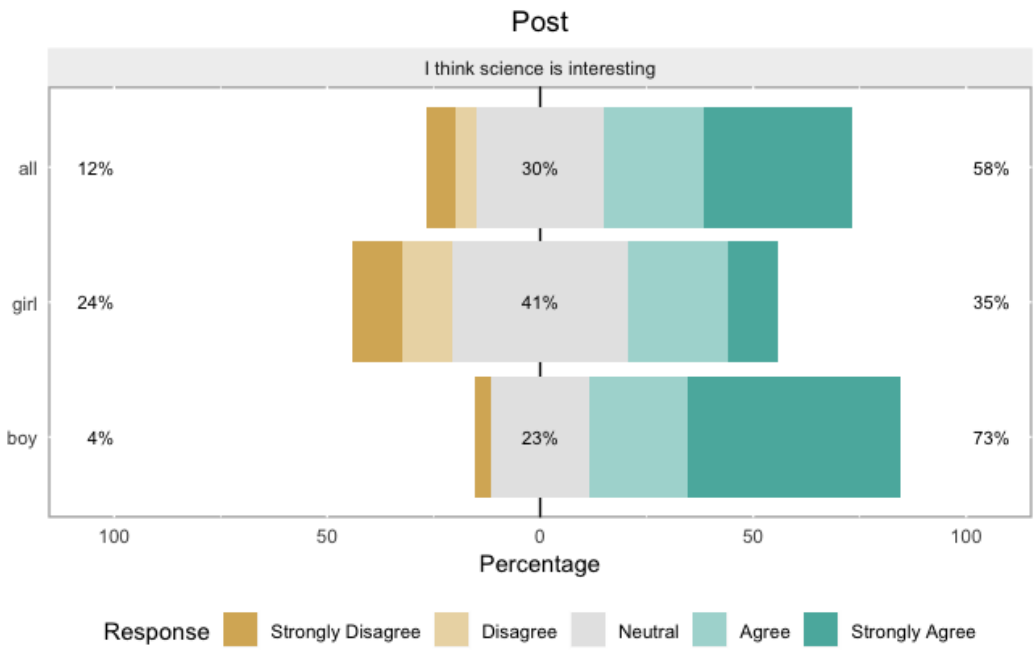

Careers - Pre
I could be a scientist when I am older
all
girl
boy
44%
22%
33%
53%
13%
33%
38%
29%
33%
I know some different jobs in environmental science
42%
36%
22%
47%
33%
20%
38%
38%
24%
I would like a science job when I grow up
53%
29%
18%
50%
36%
14%
55%
25%
20%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree


Careers - Post
I could be a scientist when I am older
all
girl
boy
48%
29%
24%
53%
35%
12%
44%
24%
32%
I know some different jobs in environmental science
10%
24%
67%
0%
31%
69%
15%
19%
65%
I would like a science job when I grow up
44%
37%
19%
53%
35%
12%
38%
38%
23%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree


Pre
I want to help protect the environment
all
girl
boy
3%
7%
0%
11%
13%
10%
86%
80%
90%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree


Post
I want to help protect the environment
all
girl
boy
0%
0%
0%
16%
18%
15%
84%
82%
85%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree


Pre
I think science is interesting
all
girl
boy
8%
13%
5%
25%
27%
24%
67%
60%
71%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree


Post
I think science is interesting
all
girl
boy
12%
24%
4%
30%
41%
23%
58%
35%
73%
100
50
0
50
100
Percentage
Response
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree