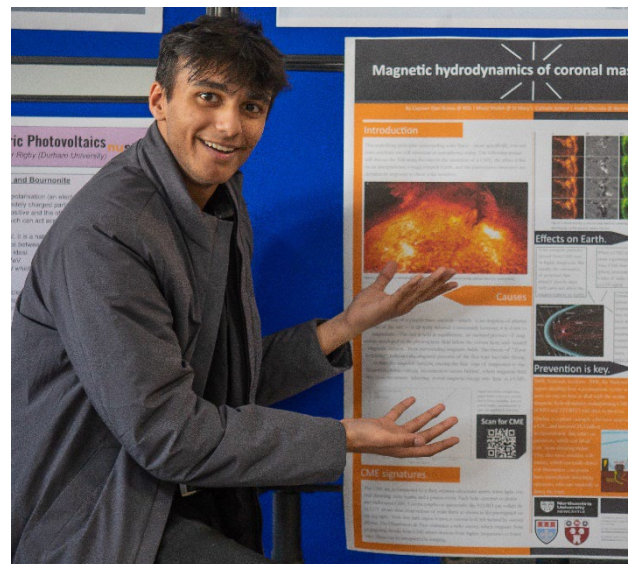
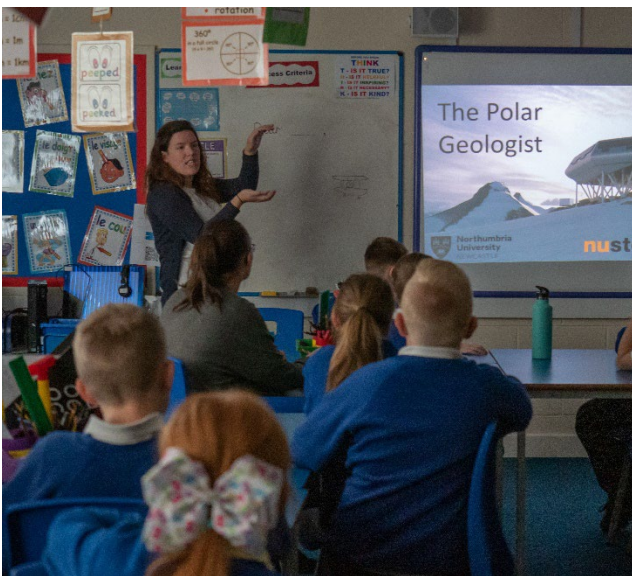


NUSTEM ANNUAL REPORT

July 2020



**Northumbria
University**
NEWCASTLE

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Executive Summary

This report provides an overview of the work of NUSTEM in the academic year 2019 – 2020.

A focus for this academic year was on disseminating our approach and influencing STEM engagement more widely. We have spent several years developing our Theory of Change and carrying out research and evaluation to measure the impact of that approach on children's career knowledge and aspirations. This year, the Theory of Change was published and we are now in a position to share this work, helping other organisations benefit from the thinking and development we have already done. This can be seen in our work with the North of Tyne Combined Authority around their STEM and Digital Skills Programme, our collaboration with Museums Northumberland, and our engagement with external organisations such as the Institute of Physics, the Reading Agency, and the Department for Education.

NUSTEM's innovative approach has been recognised by external bodies. We were shortlisted in three awards this year: for Career-related Learning in Primary Schools at the UK Career Development Awards, for Community Engagement Award (University sector) at the Educate North Awards, and for the Airbus GEDC Diversity award. As of July, we're still waiting to hear the outcome for the Educate North Award, but were delighted to be chosen as a finalist in the Airbus GEDC Diversity Award. The judging panel were impressed with the comprehensive nature of the Theory of Change and very interested in considering how this could be adapted for use by employers. As a finalist, we will receive coaching from an Airbus executive manager and \$1500 to support dissemination of our Theory of Change.

Within the university we are collaborating with a wider set of our colleagues to strengthen Northumbria's outreach activities, and help academic colleagues share their research with young people through our partner schools.

As with many organisations, the COVID19 global pandemic meant we had to reconsider how we support our key audiences. Our STEM at Home activities, and the inclusive principles which informed their development, allowed us to work with our partner Primary Science Coordinators to support parents and carers with home learning. In the coming months we will be considering this further, and looking at how we can improve and extend our impact in times of challenge.

Dr Carol Davenport

Director, NUSTEM

July 2020

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2019/20 in numbers

11811

Interactions with Children and Young People

1049 875

Families Teachers

44 **SCHOOLS**
34 Primary
10 Secondary

22

Activities delivered with researchers from Northumbria University

Engaged with

62

external organisations

NUSTEM included in

7

University research funding applications

8

Conference presentations

£305k

Grants and Funding obtained

Supporting 13178
Individual primary school
children in STEM since 2014



Our vision

NUSTEM’s vision is for a vibrant and sustainable STEM sector which meets the needs of learners and employers, reflecting the diversity of wider society.

We believe that by supporting children, families and teachers to identify how their personal characteristics align with the characteristics of people who work in STEM, children (and their influencers) will feel more confident that a career in STEM is for ‘people like them’. Alongside this, NUSTEM shows the breadth and application of STEM in the world around us. Together these should lead to an increase in the number and diversity of young people choosing a career in STEM once they leave compulsory education.

We recognise that changing the diversity of different STEM sectors requires systemic change and a focus on improving workplaces for those who have traditionally not been included. Employers need to show young people, and their families, that STEM is indeed for ‘people like them’, and that they will be supported and valued in the STEM sector they have chosen.

Objectives

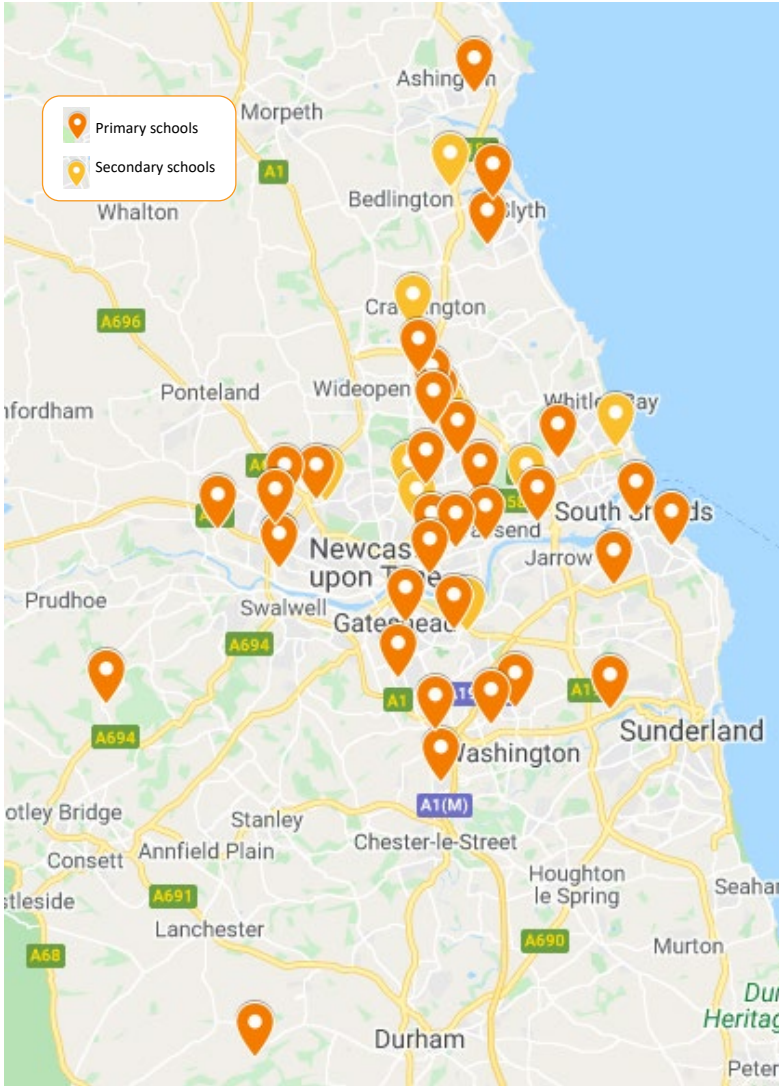
In order to realise this vision, NUSTEM will:

1. Develop, deliver and enable high-quality STEM interventions for key stakeholders.
2. Support and influence STEM outreach and widening participation work within Northumbria University
3. Influence STEM careers and engagement policy at local, national and international levels.
4. Work in partnership with organisations to develop, disseminate and embed effective practice in STEM engagement.
5. Produce high quality research on topics related to young people’s STEM learning and career choices and produce evidence of impact of the work of NUSTEM
6. Contribute to Teaching and Learning in Engineering and Environment & Health and Life Sciences.

Alongside these objectives, NUSTEM hold a set of underpinning principles and values. These are given in Appendix 1.

In the following sections, we will highlight some of our activities this year which relate to each of these objectives.

1 Develop, deliver and enable high-quality STEM interventions for key stakeholders



Map showing location of NUSTEM partner schools in 2019/20

11811
Interactions with Children
and Young People

1049 875
Families Teachers

44 **SCHOOLS**
34 Primary
10 Secondary

358 activities
61 venues

483
Hours of delivery

The number of deliveries to children, young people and families this year were curtailed in March 2020 as the covid19 pandemic closed schools and the university. Appendix 2 contains the detailed breakdown of interactions by different audiences.

We were able to deliver CPD online, and also ran a workshop for the virtual Marra weekend organised by Northumberland Scouts. To support families in our partner primary schools, we developed STEM at Home activities available on the NUSTEM website (nustem.uk/stem-at-home). Primary Science Coordinators were able to share the web links to these simple activities directly with families either through email or their own website.

1.1 Me, You and Science Too (MYST)



SHINE



MYST is a STEM and literacy engagement project funded by the SHINE Trust. NUSTEM is working with Battle Hill Primary School to support families of children in Early Years. MYST is also a research project, adopting an action research methodology to explore the most effective ways of securing family involvement.

The project will last for two years. During that time, we're bringing families together in school, sharing a variety of young children's fiction in ten tailored story-reading and STEM activity sessions. The aim of the project is to improve outcomes in reading and science for the children through regular interactions, carefully chosen books, and engaging, replicable STEM activities.

The first three books were *Violet the Pilot* (ISBN: 9780425288191), *Look Up!* (ISBN: 9780241345849) and *Little Cloud* (ISBN: 9781405290821).

"One little boy who stands out is Tom [not his real name]. Tom has a difficult home life. He has four younger siblings and one older sibling. Mum does her best, but they don't have any books at home. The very first book we read was Look Up and Tom took it home and mum read it over and over again to him. We can tell that because he has been making up his own stories at school and they are all very much focused on that book. Tom has taken his own ideas from the story, which is lovely. We would never have got that if he hadn't taken part in this project."

Joanne Smith, Battle Hill Primary School

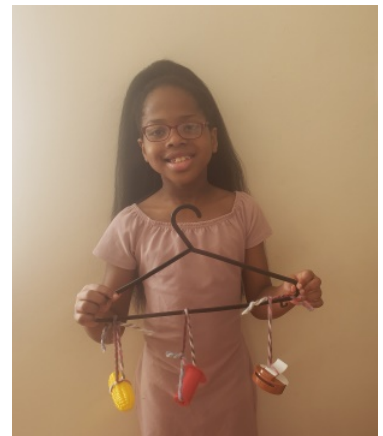
Weblinks: <https://nustem.uk/myst/> and <https://shinetrust.org.uk/case-study/me-you-and-science-too/>

1.2 STEM at Home

When schools closed to most pupils in March, many organisations quickly shared pre-prepared activities with parents.

Although NUSTEM wanted to continue to support schools and families, we felt it was important not to rush into providing activities without first considering what the purpose was, where it would fit within our Theory of Change, how to meet the needs of families in our partner schools, and the difficult circumstances in which many families found themselves.

After some careful thought, and discussion with our primary school partners, we established a set of principles that we have used to develop our materials. These are given in Appendix 3 of this report.



New activities were shared with primary science coordinators each week from April to July: 21 new activities overall. These were then sent out by the schools to families via their preferred communication channels.

The web stats for each activity was tracked to monitor the uptake. The most visited activity was *Indoor Bubbles* with over 600 unique visitors. Appendix 3 contains more information about the page views for each activity.

The principles were also shared on social media and directly with organisations (such as the Institute of Physics) who were developing similar materials.

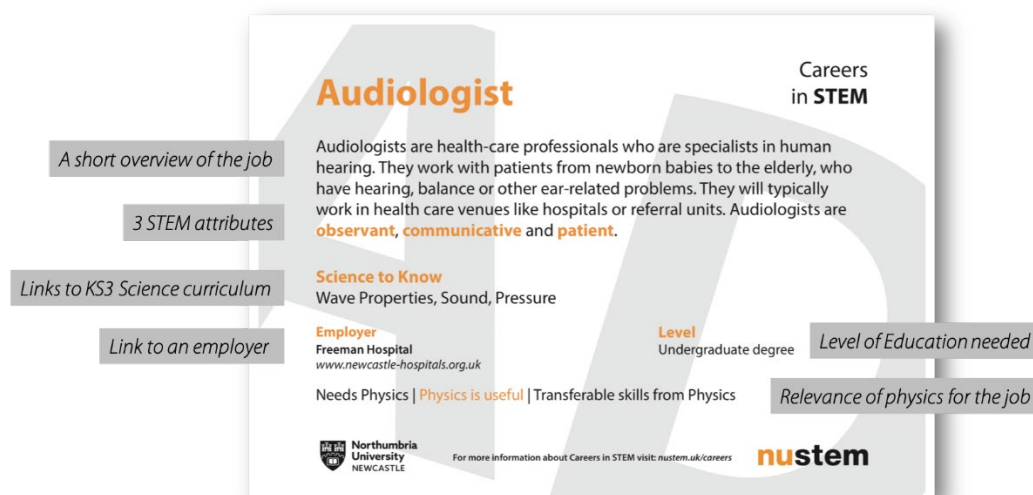
Weblink: <https://nustem.uk/stem-at-home/>



1.3 STEM Careers postcards

We've been developing resources for secondary school teachers to help them quickly embed careers and employers in their curriculum teaching. The STEM careers postcards are a set of 16 postcards which link physics topics with different careers. The postcards also introduce employability characteristics – attributes that people working in the career might need. A full list of the attributes chosen are given in Appendix 4. This helps students to identify with the job through the attributes chosen: focussing on 'being', rather than the 'doing'. Many students will already have some of the attributes, so by talking about these attributes, the careers become seen as more achievable.

The diagram shows the 'anatomy' of the postcards.

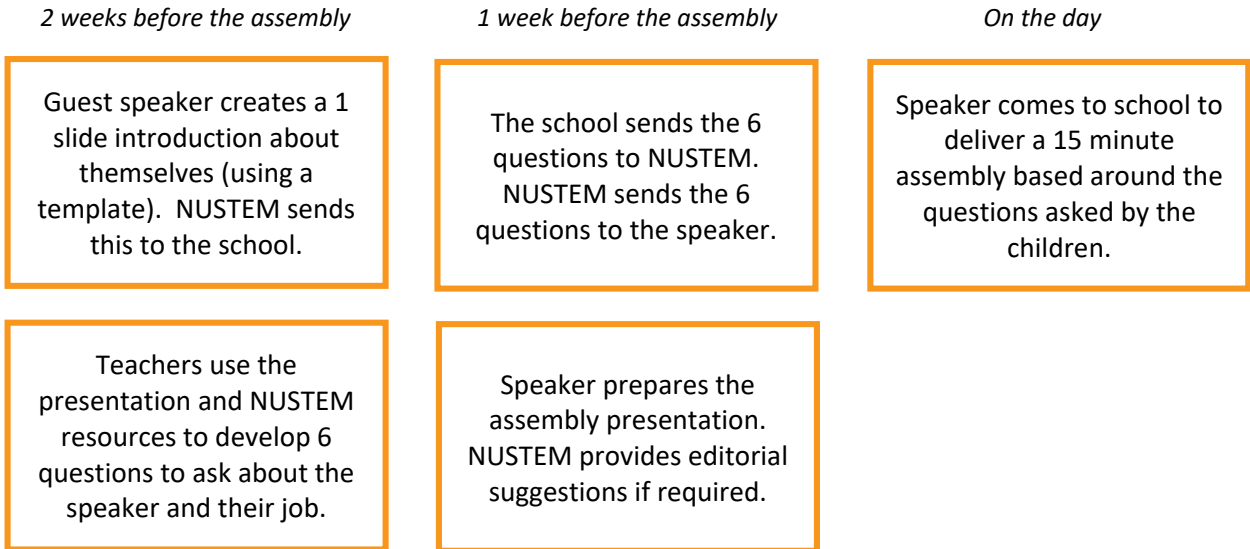


The postcards have been distributed nationwide to around 1600 schools by the Institute of Physics through their 'Classroom Physics' newsletter. They have also been used and adapted by 11 other universities across the North, London and the South East of England.

Weblink: <https://nustem.uk/careers-postcards/>

1.4 NUSTEM Encounters

The NUSTEM Encounters model provides a structured process through which a guest speaker (industry professional or academic) can engage in interactive discussions with children in a school. The diagram below outlines the process an encounter.



The schools are provided with resources to help the teachers introduce the idea of open and closed questions to the children, along with the slide from the guest speaker. This means that the children are more invested in the visit because they have ‘met’ the speaker before they arrive, and have spent time thinking about what they would like to know about the person. We have trialled the model in partner primary schools with Northumbria University academics as guest speakers. As part of the development we obtained feedback from the teachers involved, to find out if it was an improvement on the usual standard of guest speaker presentations and if it was onerous for them to take part. All the teachers thought that the NUSTEM Encounters model led to higher quality presentations and interaction with the children, as can be seen from the quotes.

“The children were asking their own questions which made it more engaging to them. It was better as they all wanted to see what the answer was to their question. Being ... prepared for the questions helped with giving the children a real understanding.”

“The children had prior knowledge of who was coming and were able to discuss and generate questions about what they wanted to know. Far more successful outcome – for everyone involved.”

“It didn’t add extra workload at all. Even if it did, I feel the outcome would be well worth the effort.”

Teachers from the NUSTEM Encounters pilots

1.5 Extending the Primary Careers Tool to cover Maths topics, and into Secondary Schools

The Primary Careers Tool (PCT) is a web database of over 100 STEM careers, sorted by Key Stage 1&2 National Curriculum topics in science. This year we have extended the PCT to include the Mathematics National Curriculum.

The screenshot shows the Primary Careers Tool interface. On the left is a sidebar with navigation options: Algebra, **Geometry - Position and Direction** (highlighted with a black box), Geometry - Properties of Shapes, Measurement, Number, Ratio and Proportion, and Statistics. The main content area displays a grid of career profiles, each with a title, a brief description, and a 'Read more >' link.

Colour Technologist A colour technologist uses the science and technology of colour... Read more >	Mechatronic Engineer Mechatronic engineers combine aspects of both mechanical engineering... Read more >	Robotic Technician Robotic technicians work with a team of robotics professionals... Read more >	Automotive Engineer Automotive engineers are involved with the building, designing... Read more >
Civil Engineer Civil engineers are responsible for the designing and building... Read more >	Structural Engineer Structural engineers are focused on all aspects concerned with... Read more >	Astronomer Astronomers are a type of scientist that study objects in space... Read more >	Satellite Communications Engineer Satellite communications engineers work with the satellite systems... Read more >
Astronaut Astronauts are trained by different space agencies such as NASA... Read more >	Crystallographer Crystallographers study atomic and molecular structures. They... Read more >	Robotics Engineer A robotics engineer is responsible for creating robots and robotic... Read more >	Taxidermist A taxidermist stuffs and mounts deceased animals to be displayed... Read more >
Geologist Geologists work to understand the history of our planet so they... Read more >	Surgeon A surgeon cuts the human body to remove diseased tissue or organs... Read more >		

Although initially developed for primary teachers, the broad nature of the National Curriculum topics in science means that they are still relevant for secondary schools for children aged 11 – 14. As a result of a conversation on Twitter, Carol Davenport was invited onto The Physics Teaching Podcast to talk about careers and the Primary Careers Tool, bringing the tool to a wider audience.

Listen here: <https://the.physicsteachingpodcast.com/2019/09/12/37-nustem-matching-physics-topics-with-careers-and-more/>

2 Support and influence STEM outreach and widening participation within Northumbria University

NUSTEM included in

7

faculty research
funding applications

22

Workshops delivered with
researchers from
Northumbria University

NUSTEM has continued to support academics with public engagement and outreach. One of the strengths of having long-term partnerships with local schools is that it allows academics to build on the outreach work of the faculty as a whole, rather than targeting schools piecemeal. NUSTEM works with academics from the start of the bid writing process, helping them to think about how they can share their research with our community. When successful, we then co-create workshops with them. We are sensitive to the level of confidence that different people have in interacting with younger children, and tailor the sessions accordingly. This means that some academics are happy to be the 'expert in the room' and the session is led by NUSTEM, while others are happy to co-lead or even lead workshops themselves.

2.1 Geography: Past, Present and Future

Geography: Past, Present and Future is a series of three workshops co-designed and co-delivered by academic staff from Northumbria University's cold and palaeo-environment (CAPE) research group and NUSTEM.

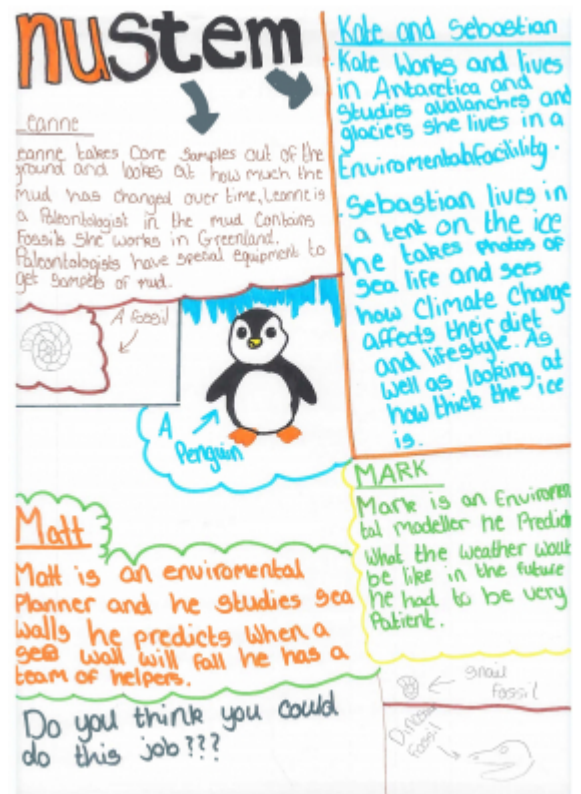
In the workshops, CAPE academics visit the classroom and support children to consider how environmental science can be used to see what the environment was like in the past, measure what's happening now, and predict what it will be like in the future.

The aims of Geography: Past, Present and Future were:

- children have a deeper understanding of environmental science topics
- children have a greater understanding of careers within environmental science
- children feel more empowered towards climate activism
- children enjoy the environmental science workshops.

The workshops were delivered in one NUSTEM partner school and the aims evaluated using a pre- and post-intervention methodology.

The evaluation found that children's understanding of environmental science topics improved, they knew more about different environmental science careers, and could name relevant attributes and characteristics of people working in those careers. Children also said that



they had more desire to learn about climate change and act in an environmentally friendly way following the intervention.

“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

Appendix 5 gives more details of the findings of the evaluation, and a full impact report about the project is available: <https://nustem.uk/impactreport-geographypastpresentfuture-apr-2020/>

Weblink: <https://nustem.uk/geography-past-present-future/>

2.2 MANAPRE: International collaboration

Mexico City and Newcastle Partnership on Health and Air Pollution Research and Engagement (MANAPRE) is a Newton Fund project which aims to increase institutional links between organisations in Newcastle and Mexico. The organisations involved are Northumbria University, Newcastle University, Universidad Nacional Autonoma De Mexico, Instituto Mexicano Del Seguro Social, and Secretaria Del Medio Ambiente.

The project aim is to develop a research and engagement collaboration focussed on air quality and health in the two countries. Schools engagement is integral, and forms one of the work packages. NUSTEM have been working with colleagues to develop ‘lesson inserts’ which can be used by teachers and researchers to share key messages about air quality in both countries.

Some of the resources we are developing are adapted from other NUSTEM work, e.g. STEM Person of the Week. As a team, we’re finding the use of a language which has gendered grammatical forms an interesting exercise, when trying to tackle unconscious gender biases in STEM!

Unfortunately, the covid19 pandemic meant that we were unable to visit Mexico City to run training workshops for Mexico colleagues, but we have been working remotely with regular meetings between all partners.



3 Influence STEM careers and engagement policy at local, national and international levels

Engaged with
62
external organisations

3.1 Ogden Trust Primary Physics Training

The Primary Careers Tool is a database of over 100 STEM careers, sorted by Key Stage 1&2 National Curriculum topics in science. It is a well-established part of NUSTEM support for primary teachers and has now been embedded within the physics training packages of The Ogden Trust. Up to December 2019, 402 teachers from 296 schools across the country have received training from Ogden which includes the use of the Primary Careers Tool.

“The Primary Careers Tool is an excellent addition to the primary teacher training that we offer at the Ogden Trust. Introducing careers ideas at primary is a subtle problem and the tool carefully and deliberately avoids potential pitfalls, offering something that can be of genuine benefit in classrooms. It’s taken real expertise to develop a tool that allows large numbers of classroom teachers to broaden the careers language and ambition of their students.”

National Teaching and Learning Lead, Ogden Trust

Weblinks: <https://nustem.uk/primarycareers/> and <https://www.ogdentrust.com/about-us/news/careers-capital>

3.2 Reading Sparks

Reading Sparks is a project led by the Reading Agency and jointly funded by STFC and the Arts Council. The project will work with 10 library sites around the UK and enable children aged 4 – 11, and their families, to discover science and do more reading through STREAM (science, technology, reading, arts and maths).

Following discussions with NUSTEM staff, the original focus of the project was changed from children to families – directly influenced by the NUSTEM Theory of Change.

Carol Davenport, NUSTEM Director, is also a member of the Steering Group for the Reading Sparks programme.



Weblink: <https://readingagency.org.uk/news/media/science-and-reading-a-powerful-combination-that-will-create-opportunities-for-the-uk.html>

3.3 Theory of Change workshops

NUSTEM developed a Theory of Change which provides the theoretical underpinnings and context for the complex mix of interventions necessary to lead to a significant change in the number and diversity of young people choosing STEM careers. We used an iterative, backward planning model to identify our overall goal, and the attitudinal and behavioural changes that would be required to attain that goal. We found this process very helpful and shared both the Theory of Change and the process with other organisations in the North East and beyond.

As a result, the NUSTEM team was asked to facilitate Theory of Change workshops for two regional organisations: The Common Room of the Great North, and Success4All.

3.4 STEM Strategy Unit Briefing

In early March, Carol Davenport led a briefing for the Department of Education's STEM Strategy Unit about the NUSTEM Theory of Change as a model for STEM Engagement across the sector. As well as members of the Strategy unit, there were also attendees from BEIS and external organisations. Although covid interrupted further work with the DfE, we will be following up with the Strategy Unit in the new academic year.

Weblink: 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>

4 Work in partnership with organisations to develop, disseminate and embed effective practice in STEM engagement



Location of organisations engaging with NUSTEM during 2019 – 2020

4.1 Careers in Initial Teacher Education (CITE)

NUSTEM and North East Local Enterprise Partnership (NELEP) are collaborating on the CITE project funded by the Careers and Enterprise Company. CITE is a feasibility study which looked at whether it was possible to incorporate careers-related learning into student primary teachers' training. As part of the study, a suite of three training sessions were developed, along with associate gap tasks. The training draws on NUSTEM's research into children's career aspirations. These training materials will be available on the Careers and Enterprise Company Primary Toolkit site. The three sessions are:

1. Careers Education and Unconscious Bias.
2. Career Aspirations in primary school.
3. Employability characteristics and role models.

The three sessions will be part of the Northumbria University BA (Hons) Primary Education course from 2020/21 and will be shared with other teacher training organisations.

We will also be offering the training materials for use in CPD (online or face-to-face) for other teachers.

Weblink: <https://nustem.uk/cite/>

4.2 Chat Physics – Careers in the Physics Classroom

Another twitter conversation about Physics led to the opportunity for Carol Davenport to present at the #ChatPhysics conference in June – which was unfortunately cancelled due to COVID.

However, the team behind #ChatPhysics decided to make something positive out of a negative situation, and created chatphysics.org: A platform for teachers of Physics to come and share ideas, advice, resources, news and opinions. They asked the original presenters to create a short video which summed up what they would have talked about, had the conference gone ahead. NUSTEM contributed a video about careers in the physics classroom.

Watch here: <https://chatphysics.org/careers-in-the-physics-classroom/>

4.3 Virtually Social – Science Capital

During Lockdown a number of informal online support and CPD meetings were developed amongst the Science Communication Community, many of whom were furloughed or freelance. Virtually Social, organised by Jamie Gallagher, was one such meeting. NUSTEM contributed to a session on Science Capital which outlined what science capital was (Prof Louise Archer), how it was used by funders (Clare Harvey, Ogden Trust), and how it could be used to shape public engagement (Carol Davenport).

Watch here: https://youtu.be/jDztDMO6_sM

5 Produce high quality research on young people's STEM learning and career choices

Produce evidence of impact of the work of NUSTEM

5.1 NUSTEM impact on primary school children

NUSTEM carried out an evaluation of the long-term impact of sustained engagements with primary partner schools between 2014 and 2019. Analysis of this data was completed during 2020.

Broadening aspirations for STEM careers

Baseline data in 2015 showed that more boys aspired to STEM jobs than girls, and were more focused on physical sciences and technology careers. Girls with STEM aspirations were more inclined towards health and life-sciences jobs.

After at least two years of partnership we see a broadening of children's aspirations for STEM jobs particularly amongst girls. Compared with the baseline cohort, children were more likely to consider:

- A range of 13 STEM related jobs¹ (+12%), with an increase of 12% among girls, and 8% among boys;
- Jobs in the physical sciences (+14 %), with an increase of 17% among girls and 12% among boys;
- Careers in engineering (+27%), with an increase of 23% among girls (p=.001) and 31% among boys (p=.001).
- Careers in digital technology (+17%), with an increase of 20% among girls and 9% among boys.

In the 2019 data there was still a gendered preference shown for biological/healthcare or physical science careers amongst girls and boys. However, as all students from lower socioeconomic backgrounds are under-represented in STEM careers, we feel that the broad increase is a strong positive finding from our evaluation.

Improving children's perceptions of scientists

In partner primary schools which had received 2 or more years of NUSTEM interventions, the perception of scientists has changed amongst girls. Compared to children of the same age in the baseline cohort, girls were:

- Less likely to rank scientists as clever (-24%)
- More likely to rank scientists as kind (+ 17%)
- More likely to rank scientists as sensible (+ 19%)

This data is very promising because it brings girls' perceptions of scientists closer to their perception of themselves. Changes in boys' attitudes were not statistically significant.

Further reading: Emembolu, I., Padwick A., Shimwell, J., Sanderson, J., Davenport, C., Strachan, R. (2020) *'Using Action Research to design and evaluate sustained and inclusive engagement to improve children's knowledge and perception of STEM careers'*, International Journal of Science Education, DOI: 10.1080/09500693.2020.1729442

¹ The 13 STEM jobs were: astronaut, banker, doctor, engineer, farmer, game tester, mechanic, nurse, pilot, surveyor, technician, vet, zoologist.

5.2 Dr Itoro Emembolu

We're very pleased that NUSTEM's PhD student, Itoro Emembolu, successfully defended her PhD thesis this year, and has now earned her doctorate. Itoro's thesis was titled 'Impact of academic research through Northumbria's Physical sciences, technology and engineering outreach activities on improving the uptake of STEM disciplines by young people'.

During her PhD, Itoro adopted an action research approach, and used NUSTEM's Theory of Change to develop an effective evaluation framework to assess the impact on children's interest in STEM of a range of intervention activities in primary schools.

Itoro worked with academics from computer science, engineering materials science and geography to collect data on children's aspirations, career knowledge and understanding, subject knowledge and inclination to the different careers introduced. Together Itoro and colleagues created engaging and interesting workshops which were delivered in NUSTEM partner primary schools.

After the workshops, children showed an increase in both career knowledge and subject specific vocabulary. Itoro's work showed that using an iterative model allowed workshops to be designed and refined over time to improve the desired outcomes.



5.3 Exploring Extreme Environments research

As part of the STFC-funded Exploring Extreme Environments (E3) project, NUSTEM have been carrying out further research into children's career aspirations. As part of this we asked children about their own aspirations and compared them with their parents and carers jobs.

There is often a narrative around aspirations which suggests that children from lower socio-economic backgrounds have low aspirations², but our research has shown this is not the case.

As part of the baseline data collection 622 children aged 7 – 11, from five of the eight E3 schools, completed an in-class survey. Some of the children also attended focus groups to explore career aspirations further.

We categorised the children's aspirations and parent/carer jobs according to Standard Occupational Classifications (SOC). Table 1 shows the categorisation of jobs and the number of children saying that they would like those jobs. We then compared the children's aspirations with their parents' actual jobs.

We found that children had higher aspirations for their future jobs than the job their parent/carer currently did.

Only 3% of children's desired jobs could be classified in the bottom two categories of the SOC (where no formal education is required) compared with 21% of parents/carers jobs being in those categories.

It is worth noting that SOC3 category includes the majority of culture, media and sports occupations, along with protective services occupations, and therefore encompassed some of the most popular jobs.

² See for example Tony Sewell (2020) '[A culture of low aspiration wrecks the hopes of both white and black working class kids](#)' 6.1.20 The Telegraph

TABLE.1. Percentage of children reporting aspirations in SOC categories with examples of popular responses. There were 1229 responses in total, with children being asked to give up to three careers aspirations.

<i>SOC Major Groups</i>		<i>% of responses</i>	<i>Popular responses</i>
1	Managers and Senior Officials	2	military commander, business owner, shop owner
2	Professional Occupations	26	teacher, vet, scientist, doctor, nurse, programmer
3	Associate Professional and Technical Occupations	52	footballer, youtuber, teacher, police, sport other, artist, actor, musician, firefighter
4	Administrative and Professional Occupations	1	civil servant, cashier
5	Skilled Trade Occupations	6	chef/cook, builder, farmer, baker, mechanic, electrician
6	Caring, Leisure and Other Service Occupations	9	hair and beauty, animal care, child care, carer
7	Sales and Customer Service Occupations	1	shop worker
8	Process, Plant and Machine Operatives	1	bus driver, train driver, taxi driver, delivery driver
9	Elementary Occupations	2	fast food worker, café, bartender

Further reading: Padwick, A. et al. (2020) Tackling the digital and engineering skills shortage: Understanding young people and their career aspirations. (In press)

6 Contribute to Teaching and Learning at Northumbria University

NUSTEM staff continue to contribute to Teaching and Learning within the University. Carol Davenport has continued as the Programme Leader for the Mathematics and Physics Foundation year, and teaches the 'Applications of Physics' module alongside Antonio Portas. This module embeds the careers approach seen across NUSTEM's school work into a university context. The physics concepts in the module are introduced through a 'real-life' application, and undergraduate students are shown a range of different careers that make use of the physics and maths they are studying.

In Geography, both Joe Shimwell and Carol Davenport have contributed science-communication focussed sessions to two modules. In Computer and Information Science Jonathan Sanderson has joined the teaching team for a web technology module.

As mentioned previously (section 4.1) we have been working with the Education Department at Northumbria University so that the resources from the CITE project will become part of the BA (Hons) teacher training programmes from next September. We have also been supporting a local primary SCITT (School Centred Initial Teacher Training) on science and careers-related learning in primary schools.

NUSTEM has continued to deliver unconscious bias training to University colleagues, both face-to-face and online. We have also developed and delivered unconscious bias and diversity training for postgraduate students as part of the RENU Centre for Doctoral Training.

As part of the university support to new and returning undergraduate students, NUSTEM is developing a 'Celebrating Diversity' short course. This will be available online for students and will help them to 'settle-in' at the beginning of their studies.

7 External funding

We continue to bid to external organisations for funding to support or extend our work.

7.1 NUSTEM led bids

Successful bids led or supported by NUSTEM in 19/20 were:

Project and funder	Amount	Project summary
connect <i>North of Tyne Combined Authority</i>	£214,160	In collaboration with Life Science Centre the 'Connect' project will develop and delivery digital making family workshops in both the Life Science Centre and school venues.
Inventive Podcast <i>EPSRC</i>	£21052	NUSTEM is included in an EPSRC Public Engagement Fellowship project with Professor Trevor Cox (Salford University) to create podcasts about Engineers. NUSTEM will be responsible for careers-related curriculum materials linked to the podcasts.
Engineering capital for families <i>EPSRC</i>	£7274	NUSTEM is acting as a consultant for a second EPSRC Public Engagement Fellowship project with Dr Helen Bridle (Heriott-Watt University) on a project which will co-create resources to showcase the diversity of engineering careers to 3-7 year olds and their families.
Science training <i>NE PESCIIT</i>	£1600	NUSTEM has developed science training sessions for initial teacher trainees.
Union Chain Bridge <i>Northumberland County Council</i>	£41,293	NUSTEM will support the development and delivery of the STEM Learning programme linked to the Union Chain Bridge project. This project is led by Museums Northumberland.
Total	<i>£ 285,379</i>	

7.2 Successful faculty led bids

Faculty Member	Outreach costs	NUSTEM activity
Jane Entwistle	£5518	Development of school resources and activities to support the MANAPRE project between organisations in Newcastle and Mexico City.
Richard Morton	£14026	Supporting the development of 'First Light', a school and family engagement projects linked to Richard's Future Leader Fellowship.
Total	<i>£19544</i>	

8 Looking ahead

Advance planning for 2020-21 has, of course, been affected by the somewhat fluid nature of the national and education situation through the second half of 2019-20. While hoping for a return to normality, we nevertheless must face a coming year where face-to-face delivery is challenging if not impossible. Accordingly, we have been planning:

- Adapting and improving delivery for a blended world – combining face-to-face and digital delivery. This could include working more closely with a group of teachers to co-create workshops they would deliver in their own classrooms.
- Work with teachers to explore how to adapt current approaches and materials to different age groups e.g. STEM Person of the Week for secondary schools, introducing STEM in Early Years.
- Expanding our research base to look in more detail at the role parents and carers play in the development of young children’s career aspirations.
- Supporting Museums Northumberland to implement the NUSTEM model in two projects.
- Expanding the Theory of Change to include employers by working with Airbus (as part of the GEDC Airbus Global Diversity Award prize) and other organisations.
- Build relationships with more local companies through the expansion of NUSTEM Encounters.

Appendix 1: Underpinning principles and values of NUSTEM

Underpinning principles

- **Sustained Engagement:** Interacting with key stakeholders from our partner schools, and the wider North East region, on an ongoing basis from early years to sixth form and beyond. We are not concerned with 'one off' activities in their own right.
- **Holistic approach:** Children and young people do not make career decisions in isolation; they are influenced by those around them – families, teachers and the wider community. We therefore work with these wider circles of influence.
- **Targeting 'under-represented' groups and communities:** Resources are limited, and so we choose to target those groups and communities that have traditionally been under-represented in science, technology, engineering and maths, particularly girls and those from lower socioeconomic backgrounds.
- **Gender Inclusive:** Our approaches and methods are designed to support females whilst still ensuring a gender inclusive approach.
- **Career Inspired:** Resources and activities incorporate careers and work-related attributes to ensure that young people are made aware of the pathways that science can lead to.
- **Partnership working:** The challenge of improving diversity and increasing inclusion in STEM must be tackled by organisations working together. NUSTEM seeks to work in partnership, formal and informal, with others who share the same goal.
- **Research Rich:** NUSTEM's work is informed by the latest research thinking and practice, from ourselves and from others. Additionally, we work with colleagues to bring academic STEM research into the classroom.

Values

- **Teamwork.** We believe that each member of the team brings talent and skills that enhance the work of the team and allow us to be greater than the sum of our parts. Working together as a team also allows us to share the load and to develop individually.
- **Partnerships and relationships.** Diversity in STEM will only be improved by system-wide action at all levels. NUSTEM is outward looking and works with a range of partners including education, industry, public sector, and professional bodies. Building relationships across these sectors will ensure that we have a broad view of the STEM ecosystem.
- **Evidence based.** Our ideas, actions, and interventions are underpinned by research and informed by social science and education research methodologies. Theory may be drawn from our own research programme, from the literature, and through action research.
- **Transferability.** It is our intention that ideas, research and initiatives developed through NUSTEM can influence and inform practices in other organisations and sectors. Disseminating our ideas is key to this influence.
- **Adaptability.** We appreciate the ability to respond quickly to circumstances, whilst recognising the growing importance of developing flexible processes as the group grows to ensure quality in all we do. We trial our activities and approaches, and adapt our work as a result of testing and review.

Appendix 2 Yearly Interactions

Total Interactions to date

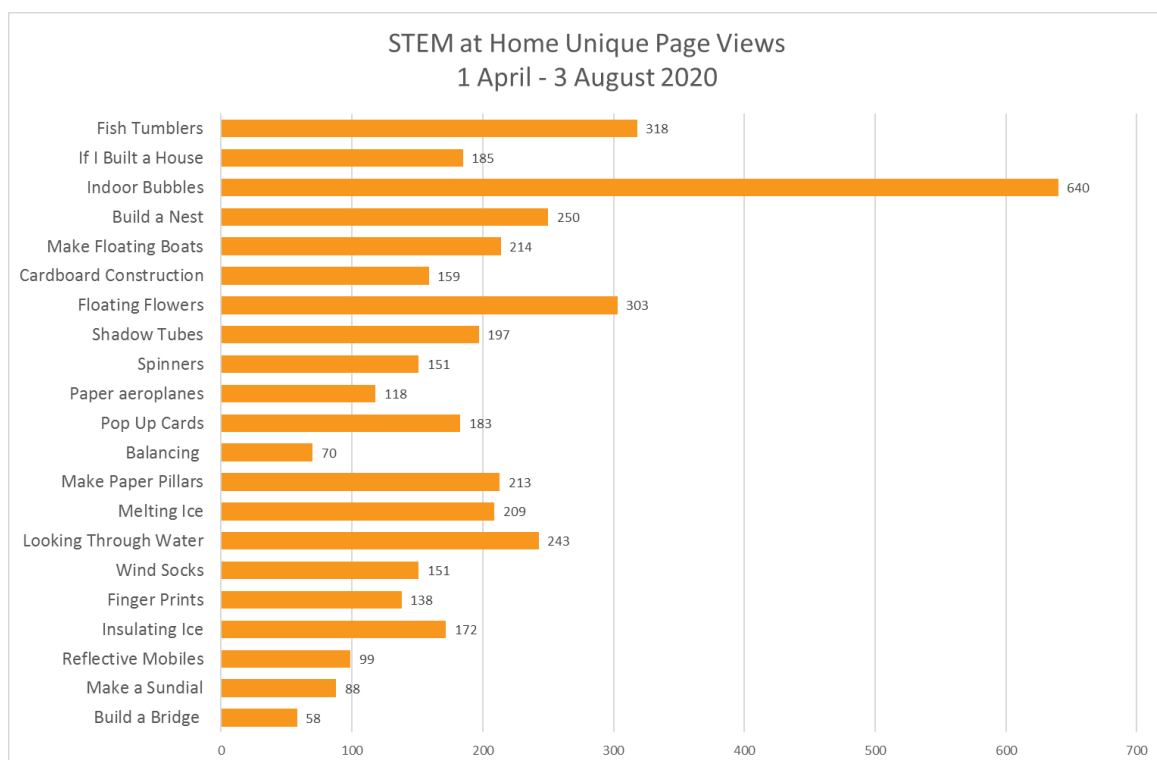
	Interactions	2014 – 2015	2015 – 2016	2016 – 2017	2017 – 2018	2018 – 2019	2019 – 2020	Total to date
Children and young people	Pre-school and Primary	4877	9322	10573	6033	12542	8019	51366
	Secondary school	6497	10754	5883	4501	4438	3266	35339
	Community events	3054	2145	1018	803	570	526	8116
Key Influencers	Teachers	447	1410	873	951	1220	875	5776
	Parents and Families	818	2055	1480	1409	1116	1049	7927
	Wider community	1277	891	706	550	464	356	4244
	Totals	16970	26577	20533	14247	20350	14091	112768

2019/20 Interactions by main funding stream	Children/Young people	Teachers	Families
Original 15 primary schools (Supported by Reece Foundation)	3055	165	331
Widening Participation 10 Primary schools	2879	103	134
Exploring Extreme Environments: 8 Primary Schools	1852	96	323
Ogden Outreach Officer: 10 Secondary Schools	1271	152	N/A

Additionally, support is provided to primary teachers and science coordinators to allow them to embed the NUSTEM approach into their own teaching – amplifying the impact that we have in the school.

Appendix 3 Principles of STEM at Home

1. **Activities shouldn't require extra resources** – it would be irresponsible to encourage parents to go out to the shops to pick up STEM education supplies.
2. **No food-based activities** – activities shouldn't contribute to any shortages in the food supply chain, nor should they distract from essential food shopping.
3. **Resource requirements should be flexible** – activities should be doable with a variety of different resources and with minimal preparation, so they are open to as many families as possible. A family not owning item x, can still do it with items y or z.
4. **Instructions need to be clear and written in simple language** – reading ability, and pedagogical understanding, of parents will vary greatly. Activity descriptions should be brief, friendly and clear.
5. **Span age ranges and abilities** – many parents will have multiple children of different ages and abilities. Accordingly, activities should be open-ended.
6. **Printable, ad-free and accessible on mobile devices** – we assume the primary way of accessing activities will be through a phone screen... but we should also check pages print well.
7. **Quick to start, early success with minimal information, and stretch-enabled** – quick start, low threshold high ceiling activities that provide success and fun quickly to capture and reward attention. Families should be enjoying themselves as early as possible. Extension is important, but not to the detriment of that 'first hit'.
8. **Indoors** – activities shouldn't assume access to outdoor space, and we shouldn't encourage families to venture out except as supported by government guidance.
9. **Safe** – activities should be low risk, with any hazards clearly described. Possible accidents requiring medical attention are particularly undesirable when hospital capacity is already stretched.
10. **Encourage social interaction** – where possible, aim to connect people, within families or beyond, through social media platforms like online galleries.



Appendix 4 The 16 STEM attributes

The attributes used in the Secondary Career postcards, the Primary Careers Tool, and the STEM Person of the Week cards were developed using previous studies of characteristics used by people who work in STEM. This includes work by the Science Council, the Royal Academy of Engineering, the Institute of Physics and the WISE campaign.

The definitions are written to be accessible for children and young people aged between 6 and 15 (with support for the younger children).

Collaborative: Collaborative people work together with others.

Committed: If you show commitment, you stick with an activity and try your hardest to make it happen.

Communicator: Communicators are good at sharing information and ideas with other people.

Creative: Creative people make new things and have original ideas.

Curious: If you are curious, you want to learn new things.

Hard-working: Hard-working people put all of their effort into finishing activities and projects.

Imaginative: If you are imaginative you can think of new and interesting ideas.

Logical: Logical people can solve problems by thinking through them in a sensible order. They understand how one action can lead to another.

Observant: If you are observant you are quick to see things, you are able to spot fine details, and you are good at paying attention.

Open-minded: Open-minded people are willing to listen to new ideas and respect other people's views and opinions.

Organised: Organised people are good at planning to make sure that they finish things.

Passionate: Passionate people have strong feelings about things that interest them.

Patient: If you are patient, you are able to stay calm when faced with problems.

Resilient: Resilient people can quickly recover from difficult or challenging situations.

Self-motivated: Self-motivated people like to do things for themselves without being told how to do them.

Tenacious: If you are tenacious, you are able to stick with something difficult until it is finished.

Appendix 5 Geography: Past, Present and Future: Summary Impact

Children's knowledge and interest in environmental science topics and careers was measured before the project, and again after they had taken part in the assembly, three workshops and a poster-creation activity. The following changes were observed after the project compared to the baseline measures.

Increased Knowledge

Children's understanding of environmental science topics improved, particularly among girls:

- Children's reported knowledge of climate change increased by 9% (girls +27%, boys -4%).
- Children's reported knowledge of environmental science increased by 14% (girls +8%, boys +17%).
- Girls reported knowledge of 'using science to predict the future' increased by 16% in comparison to 2% among boys.
- Girls reported knowledge of 'using science to understand the past' increased by 33%, in comparison to a 5% drop amongst boys.

Increased knowledge of environmental science related careers

Children demonstrated understanding of the nature of all three environmental science careers, and could name relevant attributes and characteristics of environmental scientists.

- 67% of children reported to know different jobs in environmental science, an increase of 45% from baseline. This was a statistically significant difference ($p=0.006$). There was a 49% increase of girls reporting positive responses from pre to post survey, and an increase of 41% among boys.

Improved acceptability of environmental science careers

Children's responses moved from largely negative and neutral pre-intervention, to more neutral and positive post intervention.

- There was a 14% increase in girls who could consider a science job post-intervention ('I would like a science job when I grow up'). This compares with a 3% decline among boys.

Increased environmentally friendly intentions

Children reported an increased desire to learn about climate change and to act in an environmentally friendly way following the intervention. Examples include:

"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."

"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."

Enjoyment

Children enjoyed all three the workshops, but the intervention was not shown to improve interest in science more broadly.

Appendix 6 NUSTEM Publications in 2019/20

Padwick, A. et al. (2020) *Tackling the digital and engineering skills shortage: Understanding young people and their career aspirations*. Frontiers in Education FIE Conference 2020. IEEE. Accepted for publication.

Archer, M., DeWitt, J., Davenport, C., Keenan, O., Coghill, L., Christodoulou, A., Durbin, S., Campbell, H., Hou, L., (2020) *'Going beyond the one-off: How can STEM engagement programmes with young people have real lasting impact?'*. Submitted for publication.

Emembolu, I., Padwick A., Shimwell, J., Sanderson, J., Davenport, C., Strachan, R. (2020) *'Using Action Research to design and evaluate sustained and inclusive engagement to improve children's knowledge and perception of STEM careers'*, International Journal of Science Education, DOI: 10.1080/09500693.2020.1729442.

Davenport, C. et al., (2020) *'A Theory of Change for improving Children's perceptions, aspirations and uptake of STEM careers'*, Research in Science Education, DOI:10.1007/s11165-019-09909-6.

Emembolu, I., Strachan, R., Davenport, C., Dele-Ajayi, O., Shimwell, J. (2019) *'Encouraging diversity in computer science among young people: using a games design intervention based on an integrated pedagogical framework'*, Frontiers in Education Conference 2019, DOI: [10.1109/FIE43999.2019.9028436](https://doi.org/10.1109/FIE43999.2019.9028436).