nustem

Exploring Extreme Environments

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Final Report

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Science and Technology Facilities Council

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Executive Summary

Exploring Extreme Environments (E3) is a cross-curricular schools science and arts project funded by STFC's Nucleus Award. E3 brought together scientists, public engagement experts and artists to provide ongoing and sustained engagement with children in primary schools and their key influencers around STFC work in extreme environments over three years.

The project was evaluated within the framework of the STFC's Generic Learning Outcomes (GLOs) and found evidence of changes across all 5 of the GLO measures: that audiences have been inspired to do, feel, value, and understand things differently, and develop new skills.

Exploring Extreme Environments was shown to have impacts in all four of the four intervention aims:

- STFC research and facilities were showcased throughout the 3-year project. They inspired the development of resources and activities for children and family groups, and were used to spark inspiration for creative and performance pieces that in turn inspired new audiences with science. The STFC STEM Person of the Week tool, showcasing the work of STFC scientists was found to be of particular value. There were increases in participating teachers' knowledge of the STFC (+22%) and of science teaching resources (+14%).
- Participating primary school teacher's confidence to teaching science increased over the course of the intervention. From baseline (2019) to end point (2021), improvements were found across all four elements of 'confidence': enjoyment of science (+16%), science teaching self-efficacy (+16%), and perceived relevance of science (+6%), anxiety to science teaching (-3%). Confidence levels were found to be higher among teachers in the study sample than among the general teaching population.
- The evaluation found evidence to support a positive influence of the E3 project in some elements of science capital among children, although not all. The intervention showed an increase in children describing science as a 'positive experience', and a reduction in stereotypical descriptions of scientists. However, declines from baseline were found in the enjoyment of science, science self-efficacy and STEM aspiration categories.
- The public engagement capacity of participating research and academics at the university was developed. Academics highlighted the benefit of the E3 programme in building communication skills, in understanding audiences and in developing public engagement strategies. Academics expressed motivation to continue public engagements beyond the project and that the project has inspired future public engagement projects.

The cross-curricular collaborative nature of the E3 intervention was successful, building and developing existing relationships. Over the course of E3, academic research inspired new artistic outputs, creative collaborations and schools' engagement enabled researchers to view their work in new light and see the value to wider society, while good working relationships between collaborators have fostered ongoing partnerships and ways of working.

The E3 delivery period was during September 2018 - December 2021 and delivery was impacted by the Covid-19 pandemic which also presented presented challenges for the evaluation of E3The E3 project was adapted to a remote delivery model and evaluation modified appropriately. Despite the challenge caused by the pandemic, the majority of delivery and engagement targets were achieved.

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Introduction

Exploring Extreme Environments (E3) is a cross-curricular schools science and arts project funded by STFC's Nucleus Award. E3 brought together scientists, public engagement experts and artists to provide ongoing and sustained engagement with children and their key influencers around STFC work in extreme environments. It used the fascinating opportunities afforded through the STFC themes of Big Telescopes and Earth Observation to engage schools and wider communities with solar physics and earth observation of remote locations.

Over three years, children in eight primary schools, their teachers and families, met professionals from the arts and sciences to investigate how we understand extreme environments found across the Sun-Earth connection: from the intense heat of the Sun's corona to the sub-zero conditions of Antarctica. The project included story-time sessions for the youngest children, assemblies and extended workshops for KS1 and KS2 children, after-school family activities and regular teacher CPD, with the aim that STFC science and technology become embedded in the school ethos.

The project started in September 2018 and ran over 39 months until December 2021. This included a short extension (3 months) to enable completion of delivery following covid disruption.

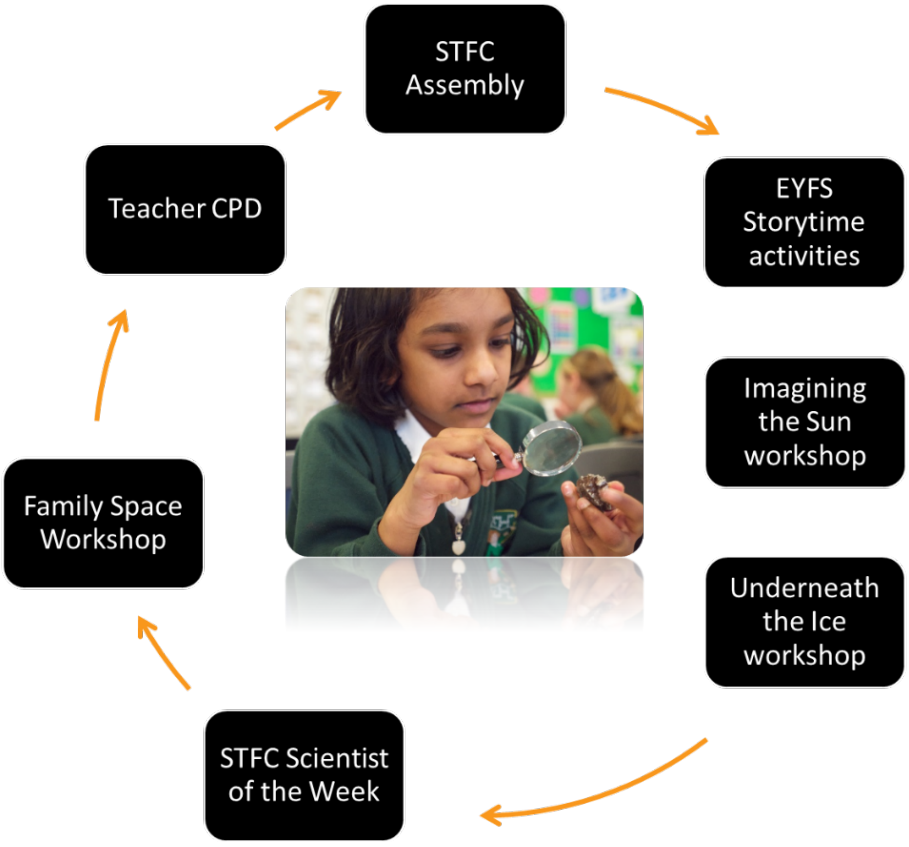
Exploring Extreme Environments had four aims:

1. SHOWCASE STFC research and facilities, including DKIST, Solar Orbiter, and ENVISAT, to children, families and teachers through repeated and sustained interactions with the project over a three-year period;
2. BUILD science capital in low science-capital families and communities in the North East;
3. INCREASE the confidence of primary school teachers to teach science and technology through regular exposure to STFC research themes and raising their awareness of careers within STFC funded projects;
4. DEVELOP the public engagement capacity of researchers and academics at Northumbria University.

The Intervention Overview

E3 used a model of multiple overlapping interventions which dovetail to provide a cohesive and coherent offer, but also offer a flexible range of opportunities for schools. Each school was offered a menu of activities and NUSTEM worked with the school science coordinators to determine the appropriate balance of activities and plan them into the school calendar. It was intended that during the project children would experience several activities which were mutually reinforcing. Simultaneously, teachers were exposed to a range of applications which highlighted the benefits of integrating STEM careers examples and language in everyday teaching practice.

Figure 1 shows the activities which were planned for the project, with each activity being repeated in each year of the project.



Activity	Audience
Continuing Professional Development	Teachers
'Imagining the Sun' Workshop	Children aged 7 – 9
'Underneath the Ice' Workshop	Children aged 9 – 11
Story-time activities	Children aged 2 – 5 and their parents/carers
Family Exploration workshop	Children aged 7 – 11 and their parents/carers
Whole school assembly	Children aged 5 – 11, teachers
Scientist of the Week project	Children aged 7 – 11, teachers
Poetry and Sound Performances	General audience

Figure 1: Overview of the activities planned for the E3 project.

Activities developed for E3

	Outputs	Description and Target numbers	Post-Covid adaptions	Engagements
Children and Families	Workshop 1: Imagining the Sun (Year 3 & 4 pupils)	○ Solar physics presentation ○ Art presentation	Remote workshop delivery	children: 1536 adults: 64
	Workshop 2: Underneath the Ice (Year 5 pupils)	○ Satellite / Antarctic presentation ○ Poetry presentation	Remote workshop delivery	children: 1200 adults: 60
	STEM Person of the Week	o 15 different scientists or technologists from or funded by STFC	Postcards were not able to be used in 19/20 so were used in 20/21 instead	Two sets of postcards shared in all 8 schools/
	Family activity	○ 3 different maker or science activities linked to STFC science	Family activities stopped due to Covid-19	children: 121 adults: 101
	Family Space Explorer activity	○ Story book activity "Are we Nearly There Yet"	Family activities stopped for Year 3 due to Covid-19	children: 205 adults: 192
	Robots reception activity	○ Story book activity "Robots, Robots everywhere'	No adaption required	children: 346 adults: 15
	Whole school assembly	○ Year 1 – STFC and the nature of science ○ Year 2 – Big Telescopes and imagining the Sun (DKIST)	Year 3 assembly not completed due to Covid-19. Remote assembly trialled.	children: 2733 adults: 79
	Online materials	○ Project overview ○ More information and activities to do at home	No adaption necessary	https://nustem.uk/activity/underneath-the-ice/
Teachers	Staff CPD Sessions	○ Year 1 – working scientifically, ○ Year 2 – light and the sun ○ Year 3 – the Earth in Space	The Year 3 CPD sessions were not delivered due to Covid-19	teachers: 164
Wider audiences	Poetry and sound performance	○ Poems ○ Sounds performance	The performance moved online at Wordsworth Grasmere.	65 members of the public

Audience Engagement

Eight schools joined the Exploring Extreme Environment project and all took part in a range of activities over the course of the project. The selected schools had higher than national and regional averages of pupils in receipt of free school meals which is consistent with the approach of STFC's Wonder Initiative to focus engagement on under-served communities in the most economically-deprived areas of the UK. Within these schools, E3 had 6362 engagements with children, 427 engagements with teachers and other school staff, and 478 engagements with parents and carers.

Programme Activities

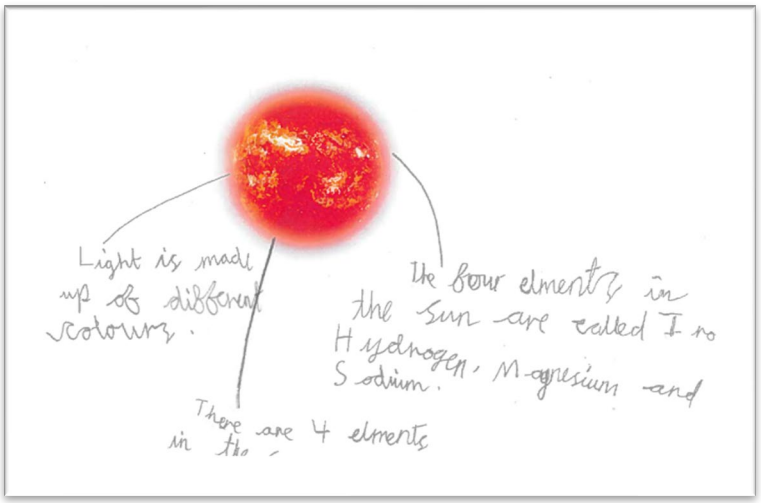
Teacher Continuing Professional Development

E3 offered CPD for participating teachers, aimed at providing scientific knowledge and understanding of the processes of science for teachers who may not have a strong background in STEM.

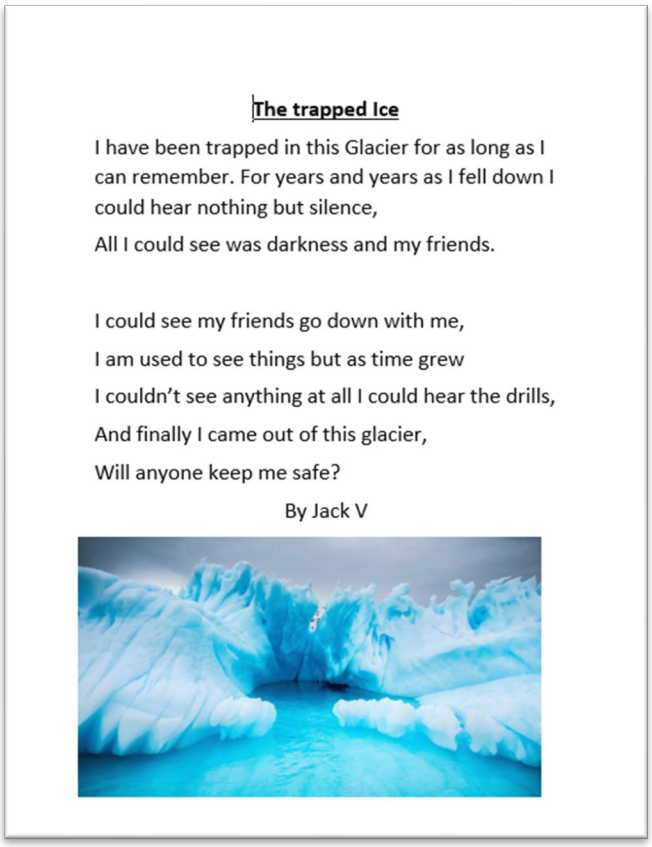
- Year 1: Working scientifically and STFC research (science as a developing body of knowledge).
- Year 2: Light, linking to big telescopes.
- Year 3: Forces, linking to Earth Observation.

Imagining the Sun Workshop:

This was a two-session cross-curricular art–science workshop, initially developed with artist Helen Schell, and continued with support from staff at the Discovery Museum, Newcastle upon Tyne. The first session included an introduction to solar physics and how we observe that extreme environment and the initial development of children's artwork. The second session focused on the development of the artwork, pop-up books, which were used to consolidate the children's understanding of the underlying physics.



Underneath the Ice Workshop:
A two-session cross-curricular literacy-science workshop developed with poet Katrina Porteous. The first session included an introduction to Earth Observation and Ice Core analysis in the Antarctic, and introduced the children to Katrina's poetry about the Antarctic. The second session focused on refining the poems children created in response to the science, reinforcing the importance of drafting written work to better express the scientific subject, and consolidating their understanding of earth observation.



The trapped Ice

I have been trapped in this Glacier for as long as I can remember. For years and years as I fell down I could hear nothing but silence,

All I could see was darkness and my friends.

I could see my friends go down with me,

I am used to see things but as time grew

I couldn't see anything at all I could hear the drills,

And finally I came out of this glacier,

Will anyone keep me safe?

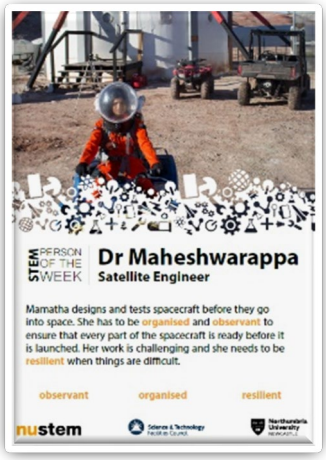
By Jack V

Whole School Assemblies
Whole school assemblies introduced the school to STFC scientists and technologies, highlighting different career paths, and the benefit of studying STEM for both children and society. The topics covered over the three years were:

- Year 1: Introducing Extreme Environments and the STFC,
- Year 2: Big Telescopes
- Year 3: Satellites and Earth Observation.

Story-time activity sessions
There were two story time activity sessions.
Space explorers: Pre-school and nursery children read a space-themed story book ('Are we nearly there yet?') and then explored robotic exploration of extreme environments in the Solar System using Duplo.
Robots: Pre-school and nursery children read a book about robots ('Robots, Robots, everywhere') and then use a simple game to 'program' a robot to move on the surface of Mars.

STEM Person of the Week: A five-week whole-school project which allowed teachers to showcase the character attributes, rather than achievements, of scientists. STFC scientists and engineers were used as the role models and inspiration within these postcards. Each week a new person, and their characteristics, were showcased via postcards and posters and praise children for using these characteristics in science, or other, lessons.



Family Exploration Workshops: These workshops extended classroom learning by inviting families to attend a workshop at the end of the school day. Children and their carers worked together build and refine blades for a wind turbine using the context of the Princess Elisabeth Research Station in Antarctica. This station is the first net zero Antarctic base.

Poetry and Sound performance

'Under the Ice' is a collaboration between a poet Katrina Porteous, composer Peter Zinovieff and researchers from Northumbria University's Cold and Palaeo-Environments team.
The performance piece explores cutting-edge research: the 'remote sensing' techniques used to investigate this secret landscape and to discern the movement of glaciers. Katrina's poetry responds particularly to research by Dr Kate Winter at Northumbria University, who was stationed at the Princess Elisabeth Research Station in December 2018 and 2019. Peter Zinovieff's sound composition for 'Under the Ice', heard in this performance in stereo reduction, was derived from real sounds from Antarctic glaciers.

Evaluation of the E3 project

A longitudinal mixed methods evaluation was used for the project evaluation. It focused primarily on assessing the impact of the project in achieving its intended aims.

The evaluation approach combined process data, feedback, focus groups and testimonials, with primary data from questionnaires and creative methods. A pre-intervention baseline was established with repeat measures taken over the course of the intervention (Year 2 – mid intervention and Year 3 – post intervention) to measure impacts. The table below outlines the evaluation tools used and which aims they were used to assess.

	Evaluation Instruments	Outcome Evaluated
Children	'*Science and you*' questionnaires with children using Pupil View Template for children in years 3 – 6. Informal 'science and you' focus groups with children in years 1 – 2.	*Build science capital in low science-capital families and communities in the Northeast* Collect pupils' attitudes and perspectives on science and scientists, their career aspirations as well as some information about what they like to do outside of school and their family background.
	'*STEM attitudes, perceptions and aspirations*' focus groups for children in years 3 – 6 for children in participating research schools. These incorporated interactive sorting activities.	*Build science capital in low science-capital families and communities in the Northeast* Explore pupils' knowledge, attitudes, perceptions and aspiration towards science in more depth.
Teachers	Quantitative 'Science Attitudes, Confidence and Knowledge' survey based on Dimensions of Attitudes Toward Science (DAS) instrument with teachers in participating schools.	*Increase the confidence of primary school teachers to teach science and technology* Measures teachers' professional view of science including enjoyment, self-efficacy, anxiety and perceived relevance of science.
	Qualitative informal focus group discussion for science coordinators in participating research schools.	*Increase the confidence of primary school teachers to teach science and technology* Collects thoughts on being part of the E3 project, E3 activities or programmes they have been involved in, and also how E3 has supported STEM curriculum and cross-curricular enrichment in the school.
Academics	Process data collecting numbers involved in project Testimony from participating academics	*Develop the public engagement capacity of researchers and academics at Northumbria University. Collects thoughts on being part of the E3 project,* and how involvement has supported future direction.

Four of the 8 participating schools were selected as research schools to take part in the evaluation activities with children, while teachers from all 8 schools participated in the teacher survey. Baseline measures were gathered at the beginning of the project, after year 1 for some elements, and in the final year of the project for all elements.

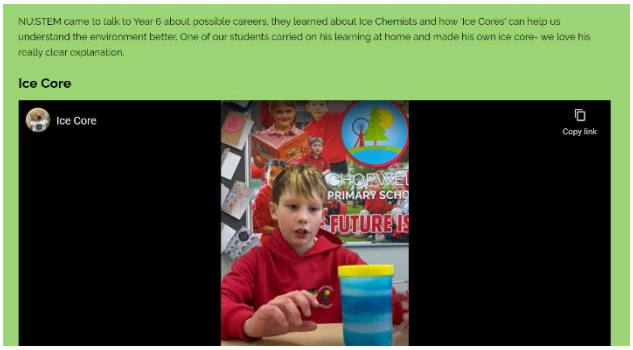
The project ran during the Covid-19 pandemic which affected both the project delivery and the final evaluation approaches available. The focus groups with teachers could not be continued at the final data collection stage as was originally intended.

Feedback on the E3 Programme

STFC interpret the value of programmes using their General Learning Outcomes toolkit. This assesses how activities enable participants to DO, FEEL, VALUE or UNDERSTAND something differently, and learn new SKILLS. We present feedback on the programme more generally within the context of this framework.

E3 inspired participants to DO something new:

- Our teacher workshop survey showed that following E3 workshops: children created follow-up artwork, learnt lots of facts, increased their interest in space and have spent time doing their own research and drawing space pictures.
- Our teacher workshop survey showed that teachers have used this project as inspiration, continuing elements such as scientists of the week in their classrooms and to developing similar activities and approaches in other subjects.
- Testimony from participating academics show and intention to share gained knowledge of engagement approaches and tools 'with a whole host of people as I move forward in my career'.
- An email from a head teacher reported a child carrying out similar activities at home in their own: https://youtu.be/OshS8Netw2s



E3 influenced the way people FEEL about science:

- Feedback from teachers highlight pride in being part of a science project, "*I am really proud as a subject leader that we have worked alongside NUSTEM over the course of this project. I feel like we have raised the profile of science and engineering in our school at a time when this was perhaps not the easiest to do.*"
- Feedback from teachers also highlight the pride children have shown in learning and developing work for this project, "*The children loved all the facts and figures/data and took pride in remembering from one week to the next. They enjoyed being able to use their creativity and imaginations*."
- Academics involved in the project have shown how involvement has allowed them to see the value of their work to wider society, "*I'm so pleased that NUSTEM introduced me to Katrina Porteous. Katrina took the time to sit down with me and really learn about my work, picking my brain for all the details and intricacies of my research, to fully understand what I do and why, in order to open up my science to a new audience. As a researcher, it allowed me to look at the work I do in a new light, reminding me why I love what I do, and why it is important to society*." Kate Winter
- Feedback on the Underneath the Ice performances show how general public have been able to emotively experience Antarctic research, *"Katrina your words are so evocative and beautiful for their description of landscape, observation and scientific process. A profound and affective contribution to creative Antartica."*

E3 changed the way people VALUE science:

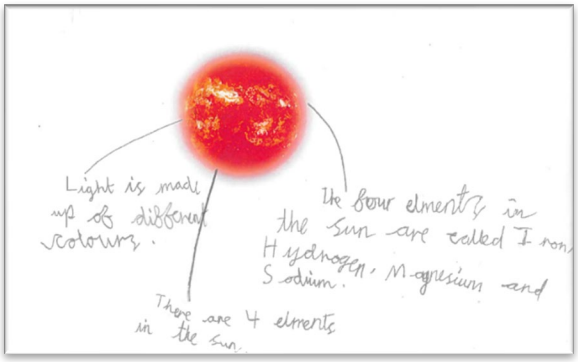
- Feedback from teachers showed the value of the Scientist of the Week resource and intention to continue using this in future science lessons, "*choosing a child from each class to be our 'scientist of the week'*."
- The survey of teachers showed their perceived relevance of science to have increased by 26% from baseline at the mid-point of the intervention.

E3 improved the SKILLS of participants:

- Academics report improved skills in designing outreach and engagement activities around their research: "*The opportunity afforded to work with experts in science communication and pedagogy has changed my approach to engagement. I now try to plan activities with a clear and tangible goal in mind, aiming to develop content and materials that will work towards this while anticipating the audiences abilities and needs*." Dr Richard Morton
- Academics also report improved communication skills, "*The E3 project has made me a much better listener and communicator. I am more confident that my outreach activities are important and impactful*." Dr Kate Winter

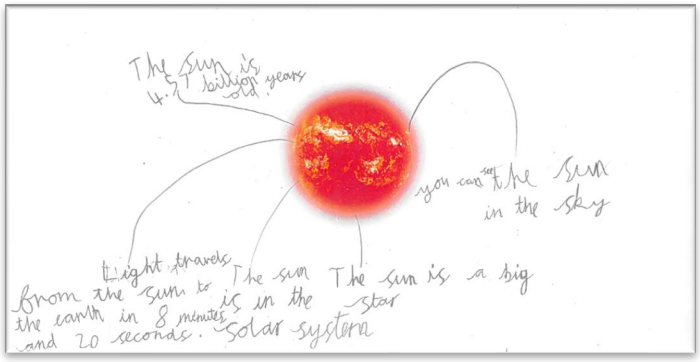
E3 increased participants' understanding:

- Our annual survey with primary school teachers in participating schools showed that their knowledge of STFC research and facilities among teachers increased by up to 23% during the E3 project.
- Evaluation of the imagining the sun workshop showed children's improved understanding of solar physics from before to after the workshops.



Before

Transcript:
Light is made up of different colours
There are 4 elments(sic) in the sum
The four elements in the sun are called Iron, Hydrogen, Magnesium and Sodium



After

Transcript:
The sun is 4.56 billion years old
Light travels from the sun to the earth in 8 minutes and 20 seconds
The sun in in the solar system
The sun is a big star
you can see the sun in the sky.

Impact Evaluation

This section reviews the E3 project against the 4 original intended aims.

1. SHOWCASE STFC research and facilities, including DKIST, Solar Orbiter, and ENVISAT, to children, families and teachers through repeated and sustained interactions with the project over a three-year period

Throughout the project, children, families and teachers had the opportunity to become familiar with STFC science and technology and develop confidence in and understanding of science and related careers.

Our annual survey with the primary school teachers showed that teachers' knowledge of STFC research and facilities increased by 23% over the course of the E3 project.

STEM Person of the Week

STEM Person of the Week showcased 10 diverse people working with STFC research and facilities in the form of postcards[1]. The STEM Person of the Week programme ran in all E3 primary schools.

This model for engagement has been found to have a strong effect on children's vocabulary when describing scientists, and when trialled previously impacts remained detectable a year after the intervention[2].

In Year 1 of the project the STFC staff featured were:
Scott Lawrie, Physicist; Tristan Canfer, Electronic Engineering Apprentice; Mariastefania de Vido, Laser Scientist; Sabrina Gartner, Instrument Scientist; and Mamatha Maheshwarappa, Satellite Engineer.

In Year 2 of the project the STFC staff featured were:
Christopher Toth, Facility Scientist; Emma Hancock, Software Engineering Apprentice; Alexandra Gibbs, Materials Scientist; Ninad Pattalwar, Accelerator Technician; Kate Winter, Polar Geologist

Approximately 2900 children took part in STEM person of the week over the three years of the project. The majority (93%) of children received 10 postcards each.

STFC Science within Family events

Families heard about STFC science, including DKIST, solar orbiter and ENVISAT during an evening stargazing event for an E3 partner school. Families were given the opportunity to explore telescopes themselves, using them to view the moon.

STFC Science within School Workshops and assemblies

Children and teachers were introduced to instruments used to study the sun including ground-based telescopes and satellites. Children were shown images and videos of the DKIST telescope and the Parker Solar Probe.

[1] All the STEM Person of the Week postcards from the E3 project are available at: http://nustem.uk/stem-person-of-the-week/ .
[2] 'Scientist of the week: evaluating effects of a teacher-led STEM intervention to reduce stereotypical views of scientists in young children' https://doi.org/10.1080/02635143.2021.1941840

2. BUILD science capital in low science-capital families and communities in the North East

The E3 project was designed to build building sustained partnerships with a network of schools over a 3-year period, and to work closely on activities both with children and their key influencers (teachers, families and communities). This model was theorised to support the development of science capital among children and their families.

To evaluate 'science capital' the concept was broken down into a number of different aspects within the data: attitudes to science (enjoyment of science and positive experience), science self-concept (self-efficacy in science), perceptions of scientists (target attributes and stereotype words), and STEM aspirations (STEM aspiration). Each of these becomes an individual measure that can be used to measure changes in aspects of children's science capital over the course of the E3 intervention.

Findings

The evaluation found evidence to support a positive influence of the E3 project in some elements of science capital among children, although not all. The number of children describing science as a positive experience increased by 14% from the start to the end of the project. We also saw a reduction in stereotypical perspectives of scientists by the end of the project: the number of 'intelligence' words as a total of all words used to describe scientists decreased (-1%), as did other types of stereotyped words such as *crazy*, *lab coat*, *white hair*, *glasses* etc. (-4%).

However, for some individual measures we see a decline in agreement from baseline to end-point: enjoyment of science (-5%), self-efficacy in science (-6%), STEM Aspiration (-3%). The median scores also remain static or showed a decline from baseline to end-point of the intervention for these measures.

Comparison of subscales by year

The table below considers aspects of science capital over the course of the project:

	Baseline % agreement	Baseline median	End-point % agreement	End-point median
Enjoyment of Science	68	4	63	4
Self-efficacy in Science	52	4	46	3
Positive Experience	53	n/a	67	n/a
STEM Aspiration	39	n/a	36	n/a
Intelligence Words	34	n/a	33	n/a
Stereotype Words	42	n/a	38	n/a

Evaluation Instruments

All data for the measures are drawn from within the 'Science and You' qualitative questionnaire (see Appendix 1) completed by children at the start and end of the E3 project. The 'Science and You' qualitative questionnaire was completed by 621 children in 2015 and 301 children in 2019. Children were in Years 1 - 6 in participating research schools. Focus groups were held with children (Years, 1,2,3, 4, 5 and 6) in the first year of the project, with the aim of further interpreting the explore pupils' knowledge, attitudes, perceptions and aspiration towards science in more depth. The focus groups with children in Years 1 and 2 however revealed that children's understanding of science was still limited and that further exploration of measures within this group was likely to be unreliable. It was intended that focus groups with children in Year 3, 4, 5 & 6 be completed at the end-point of the

intervention, however this was not possible due to restrictions brought about by the Covid-19 pandemic.

Measurement of 'Enjoyment of science' is drawn from the 'How much do you like science?' question and self-efficacy in science is drawn from the 'How good are you at science?' question. Positive experience is drawn from the qualitative categorisation of pupils' responses within the Pupil View Template and includes the following coding categories: interested, amazing, excited, happy, good at, like it, love it, good lesson, feel clever. STEM aspiration is drawn from the qualitative coding of pupils' aspirations in the 'what would you like to be when you grow up?' question into whether or not a pupil reported a STEM aspiration. Aspirations were coded using the Office for National Statistics Standard Occupational Codes (SOC2). Target attributes and stereotype word measures are drawn from the qualitative coding of the 'What six words would you use to describe a scientist?' question.

3. INCREASE the confidence of primary school teachers to teach science and technology through regular exposure to STFC research themes and raising their awareness of careers within STFC funded projects

The E3 project aimed to improve primary school teachers' confidence to teach science and technology through regular exposure to STFC research and themes, and to raise their awareness of careers within STFC funded projects. Teachers were offered three continuing professional development sessions and were further engaged with science of extreme environments during their classroom sessions and STEM person of the Week activities.

This impact was evaluated using a survey of teachers in participating schools each year, as well as through a comparison with the wider teaching population. The Dimensions of Attitudes Toward Science (DAS) survey considered 4 elements related to teachers' confidence: enjoyment of science, science teaching self-efficacy, anxiety of science teaching, and perceived relevance of science. The survey additionally explored teachers' knowledge of STFC science, science careers and science teaching resources.

Summary

We found increases in all elements within the survey from start (2019) to end point (2021). Teachers reported increased levels of:

- knowledge of science careers (+23%),
- knowledge of the STFC (+22%),
- enjoyment of science (+16%),
- science teaching self-efficacy (+16%),
- knowledge of science teaching resources (+14%), and
- perceived relevance of science (+6%).

Teachers also reported a reduction in anxiety towards science teaching (-3%). We found that teachers in our sample in 2020 reported higher levels of confidence in teaching science than teachers in the 2020 general population (data obtained via the Teacher Tapp primary panel). This indicates an overall success in this project aim.

Notably, higher levels of agreement were seen within the midpoint survey for some elements: knowledge of STFC careers (+31%), enjoyment of science (+30%), perceived relevance of science

(+26%), knowledge of science teaching resources (+25%) when compared to the baseline. This indicates impacts generated by the project that were not always sustained to the end-point of the intervention. It is likely that difficulties posed by the Covid-19 pandemic to engagement was the cause of the decline from this higher mid-point to the end point.

Comparison of Subscales by Year

The table below considers primary school teacher's confidence over the course of the intervention with reference to the various elements within the survey.

	Baseline **% agreement**	Baseline **median***	Mid-point **% agreement**	Mid-point **median**	End-point **% agreement**	End-point **median**
Perceived Relevance of Science	74.5%	4.40	100%	4.40	80%	4.60
Enjoyment of Teaching Science	43.6%	3.75	73.7%	4.00	60%	4.00
Anxiety of Teaching Science	62.5%*	4.00	57.9%*	4.00	60%*	4.00
Science Teaching Self-efficacy	43.6%	3.50	52.6%	4.00	60%	4.00
Knowledge of Science Teaching Resources	59.7%	4.00	84.2%	4.00	73.3%	4.00
Knowledge of STFC	3.8%	2.00	26.3%	3.00	26.7%	3.00
Knowledge of Science Careers	63.4%	4.00	94.7%	4.00	86.7%	4.00

* *Questions have been recoded for analysis and so median score is in line with other subscales, but disagreement is looked at instead of agreement in the statements order is reversed here to reflect teachers' responses.*

Comparator Group via Teacher Tapp[3]

To mitigate against the lower response rate from the baseline survey to the mid-point survey, we employed a comparator group from the wider teacher population in the UK. Analysis of teachers in our sample with teachers more generally in 2020, shows that teachers in our sample felt more confident in science than teachers in the 2020 general population (via Teacher Tapp - a teacher survey tool). Four items from our teacher survey were sent out via the Teacher Tapp app to gain responses from the wider primary teacher population.

	2020 Survey % agreement	2020 Teacher Tapp % agreement
Teaching science makes me anxious	68.4*	55*
I feel stressed when I have to teach science	73.7*	58*
I am able to handle students' questions about science well	73.7	67
I have sufficient command of science content to support students with their investigations in the classroom effectively.	68.4	72

** disagreement is looked at instead of agreement in the statements. The order is reversed here to reflect teachers' responses.*

[3] Teacher Tapp is a UK based EdTech app, which sends teacher users three quick multiple-choice questions about their day or their opinions on teaching each working day https://teachertapp.co.uk/

In comparison to data from the Teacher Tapp sample, teachers in our sample reported less anxiety about teaching science than teachers in the Teacher Tapp sample ('teaching science makes me anxious' -13%, 'I feel stressed when I have to teach science' -16%). In comparison with data from Teacher Tapp sample, teachers in project schools feel more able to handle students' questions about science well (+17% 2020). However, teachers in our sample report that they have slightly less of a command over science content to support student investigations effectively (-4% 2020) in comparison with from the Teacher Tapp sample.

Evaluation Instruments

The survey used was an adapted version of the Dimensions of Attitudes Toward Science (DAS) Instrument (van Aalderen-Smeets & Molen, 2013). Survey 1 (baseline) was issued Feb - May 2019, survey 2 (mid-point) April – May 2020 and survey 3 (end-point) June - July 2021. Survey 1 received 52 responses, survey 2 in 2020 received 19 responses, and survey 3 received 15 responses. The lower response rates to survey 2 and survey 3 are likely caused by the complications associated with COVID-19 and lockdown, and the inability to send out paper copies as worked successfully for Survey 1, and then the challenges of re-engaging with E3 project post lockdown when schools reopened in a new format.

Results from our survey in 2020 were compared with data from the Teacher Tapp app in 2020. The sample is weighted to ensure the panel represents the teaching population in the UK.

We had originally proposed to run a number of qualitative informal focus groups with science coordinators in participating research schools to aid in the interpretation of data, however engagement with these was low in year 1. Focus groups were removed from the evaluation methodology following the Covid-19 outbreak to reduce administrative burden on teachers. Mitigations for this include the comparison with Teacher Tapp data, and post-project open survey with science coordinators, and participating teachers. Response rates to these were again low (3 teachers), and no teachers mentioned confidence levels specifically.

Feedback for teachers highlights both the challenges of delivering an intervention during the Covid-19 pandemic, but also the value of continuing efforts to do so.

"I am really proud as a subject leader that we have worked alongside NUSTEM over the course of the project. I feel like we have raised the profile of science and engineering in our school at a time when this was perhaps not the easiest to do. All of the lessons in school have been heavily disrupted through Covid – right in the middle of the sample of work – but despite this the children who took part were certainly encouraged to think scientifically and hopefully inspired to do this outside of the taught lessons too."

Richard Dutton, Albany Village

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4. DEVELOP the public engagement capacity of researchers and academics at Northumbria University.

The public engagement capacity of participating researchers and academics at the university has been strengthened. Academics highlighted the benefit of the E3 programme in building their communication skills, in understanding audiences, and in developing public engagement strategies. Academics expressed motivation to continue public engagements beyond the project and that the project inspired future public engagement projects.

Testimony

Testimony for the development of public engagement capacity is presented for two of the researchers in the programme:

> *"My experience of working on E3 was very positive, and I believe has improved my skills in Public Engagement. Working with NUSTEM, and also attending the training sessions, has broadened my perspective of Public Engagement and also challenged me to think more critically during the planning and delivery of activities. The opportunity afforded to work with experts in science communication and pedagogy has changed my approach to engagement. I now try to plan activities with a clear and tangible goal in mind, aiming to develop content and materials that will work towards this while anticipating the audiences abilities and needs. The experience gained during E3 played a key role in the development of an outreach plan when applying for my UKRI Future Leaders Fellowship, and is continuing to influence the design of the workshops and events we are planning to deliver."*
>
> *Dr Richard Morton, Solar physicist*

> *"It is often difficult to communicate complex research ideas and methods to younger audiences, but NUSTEM expertly helped me to break down the work I do into bite-sized, accessible and interesting chunks. Their outreach approach - to be guided by the questions and interests of students is inspirational. It has shown me how others view my work, and how I can help to share high-end research with students who naturally have an interest in the planet and the world around them and almost always want to make a positive impact on the environment. We have a lot of fun during the school workshops and I am able to take the lesson format and teaching materials with me when I do my own outreach.*
>
> *The E3 project has made me a much better listener and communicator. I am even more excited about the direction my research is headed and I am more confident that my outreach activities are important and impactful. I will share this knowledge with a whole host of people as I move forward in my career. I look forward to working with NUSTEM, and a variety of artists and outreach groups in the future."*
>
> *Dr Kate Winter, Glaciologist*

The Power of Collaboration

E3 was a cross-curricular project bringing together scientists, public engagement experts and artists together with a new network of schools to provide ongoing and sustained engagement with children and their key influencers.

Dr Kate Winter highlights the value of the collaboration on the interpretation of her own research:

> *"I'm so pleased that NUSTEM introduced me to Katrina Porteous. Katrina took the time to sit down with me and really learn about my work, picking my brain for all the details and intricacies of my research, to fully understand what I do and why, in order to open up my science to a new audience. As a researcher, it allowed me to look at the work I do in a new light, reminding me why I love what I do, and why it is important to society. It was such a privilege to listen to Katrina's wonderful poems, alongside Peter Zinovieff's musical accompaniment. Both are such accomplished artists, and I have learnt a lot about their work on our journey together. I have Katrina's signed poems printed outside my office so that students, staff and visiting researchers can read them as they pass. They are quite a talking point!"*

Academic Staff from Northumbria University

Staff from the Extreme Environments Multidisciplinary research community at Northumbria University have inspired and supported the development of this project.

Dr Richard Morton and Professor James McLaughlin from the Solar Physics research group brought expertise in probing the extreme solar environment through remote observations and mathematical models. Richard and James provided academic input into the solar physics workshop and coordinated the recruitment and involvement of other research staff. Richard also delivered some of the school workshops.

Professor John Woodward and Dr Kate Winter from the Cold and Palaeo-environment group provided expertise in polar science and the use of Earth Observation to investigate extreme and remote locations. Kate and John worked closely with Katrina Porteous to support the development of her poetry. John has previously led a number of on art-science collaborations.

Artists

This project builds on existing partnerships between Katrina Porteous, Peter Zinovieff, Helen Schell, Carol Davenport, John Woodward, James McLaughlin, Richard Morton and NUSTEM developed as part of the 'Imagining the Sun' project previously funded by STFC (ST/N005562/1).

Helen Schell

Helen is a visual artist who specialises in art and STEAM projects about space exploration and science. Her work includes 'SOLAR' a large scale artwork representing the layers of the sun which was commissioned as part of the previous STFC project (ST/N005562/1). Helen was involved in the development, resource creation, and initial delivery of the lower KS2 art-science workshop 'Imagining the Sun'.

Katrina Porteous

Katrina is a poet who has a strong interest in poetry and science as different, but complementary, ways of knowing the world, and nature. Her previous science-themed poetry works include Edge,

Field and Sun. Katrina was involved in the development of the upper KS2 literacy-science workshop 'Underneath the ice' and the creation of a new portfolio of poetry focussed on polar science.

Dr Peter Zinovieff (1933 – 2021)
Peter was an engineer and composer who was instrumental in the development of electronic music from the late 1960s onwards. In recent years he was primarily a composer of electronic music and explored the possibilities of surround sound speakers to produce immersive and sometimes disturbing soundscapes.

As part of Exploring Extreme Environments, Peter and Katrina collaborated to create *Under the Ice*, a poetry-sound performance inspired by the polar regions, and the use of science and technology to explore extreme environments under and above the ice. Peter incorporated sounds from Antarctic glaciers in the soundscape he composed to accompany Katrina's poetry.
Sadly, Peter became unwell during 2021 and sadly died on 23rd June 2021. We feel privileged to have been able to work with Peter over the past few years, and are grateful to have had his input to our work.

Primary School Partners
Eight new partnerships were formed with primary schools in five local authorities in the North East of England for the E3 project.

They were:
Gateshead: Chopwell Primary School
Newcastle-Upon-Tyne: Cheviot Primary School, Walkergate Community School
North Tyneside: Fordley Primary School
Northumberland: Morpeth Road Primary Academy
Sunderland: Albany Village Primary School, Usworth Colliery Primary School, Castletown Primary School

The project team would like to thank the staff, children and families at these partner schools. Without their enthusiastic support and involvement, the project would not have been possible.

NUSTEM at Northumbria E3 Project Team
NUSTEM Director: Dr Carol Davenport
NUSTEM Outreach Specialist (Primary and Early Years): Joe Shimwell
NUSTEM Primary Outreach Officer: Melanie Horan
NUSTEM Outreach Assistants: Ivan del Rey Cousins, Sonia Singh Chahal, Bethany Willis.
NUSTEM Evaluation and Social Research: Annie Padwick

Further Information

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Appendix 1 Science and You survey

nustem : Science and You

We would like to find out about you and your views about science.

When we ask you questions there are no right or wrong answers.

It is your own views that matter.

Your Views on Science

1. What words would you use to describe a scientist? *Write up to six words in the spaces below.*

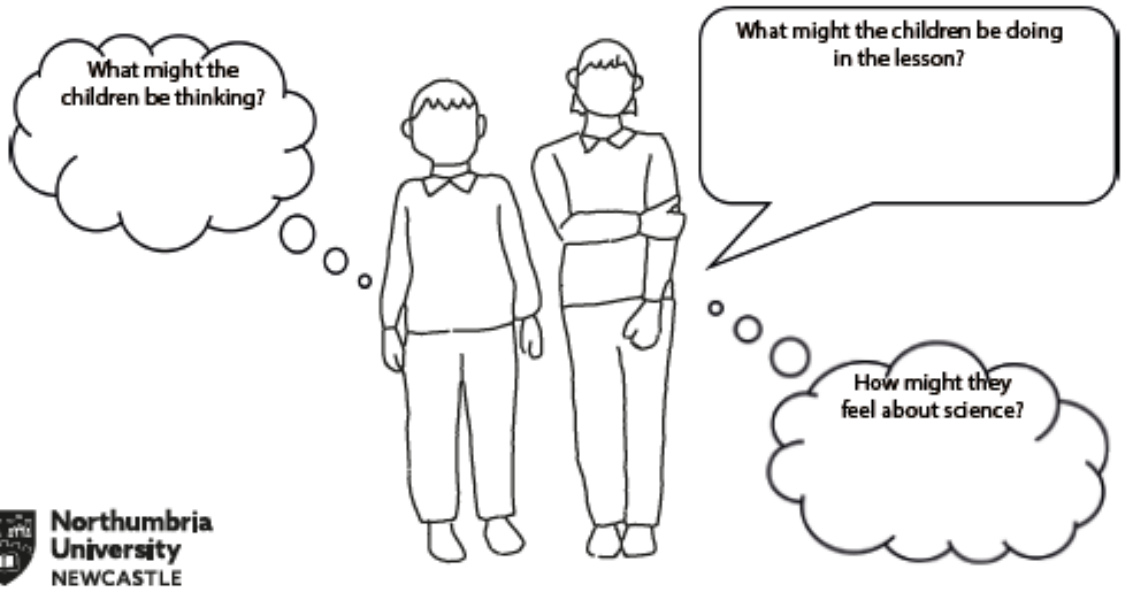
2. How good are you at science? *Circle one of the faces.*

Not very good — Very good

3. How much do you like science? *Circle one of the faces.*

Not at all — Very much

4. These children are in a science lesson at school. *Write in the bubbles below.*



Northumbria University NEWCASTLE

nustem : Questionnaire

Jobs and the Future

7. What would you like to be when you grow up? *Please write up to three answers below.*

_____ Why? _____

_____ Why? _____

_____ Why? _____

8. What do your parent(s) / the people who look after you do for work? *Please fill in the table below.*

Who? What relation? *(e.g. Mum)* *(e.g. Grandad)*	**Job** *(e.g. train driver)* *(e.g. doesn't have a job)*

About You

9. What is your name?

First name: _____ Last name: _____

10. What is your birthday?

Date : *(e.g 9th)* _____ Month: *(e.g April)* _____

11. Are you a boy or a girl? *Please tick one box only.*

boy ☐ girl ☐

12. How old are you? *Please tick one box only.*

6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐

13. *Turn over the page and look at your answers for Question 1.*
Circle any of the words that you would use to describe yourself.

Science and Technology Facilities Council