



# Children Challenging Industry

**EVALUATION OF THE  
IMPACT OF THE CHILDREN  
CHALLENGING INDUSTRY  
PROGRAMME 2018 TO 2020**

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# Children Challenging Industry



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## EXECUTIVE SUMMARY

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### Background

The Centre for Industry Education Collaboration (CIEC) at the University of York has been delivering the Children Challenging Industry (CCI) programme for 25 years. The programme is aimed at children and teachers in primary schools, as well as science-based manufacturing companies, with children learning about science through real-life practical problem-solving activities. The project involves children in completing a series of hands-on activities in the classroom, and a visit to industry, or from an industry ambassador (and occasionally both).

### Previous reports

The impact and effectiveness of CCI has been measured through pupil and teacher questionnaires since the project's inception in 1996. Initially, a number of semi-structured interviews with teachers and focus groups of children formed the development of the questionnaires, although these have been adapted over the years, including special focus areas in recent iterations of the questionnaires. The most recent report prior to this was published in August 2018, covering data up to 2017, with a further brief impact infographic published to cover the 2018-2019 academic year. The current report spans two academic years, from 2018 to 2020. During this period, the CCI project has involved 1,764 pupils from 56 schools in North East (NE) and East of England (EE) regions and 710 teachers received a total of 928 hours of professional development. Eleven companies facilitated 51 industrial site visits, and 24 ambassadors visited schools.







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## Methodology

Quantitative and qualitative data were gathered through online questionnaires from teachers and children before the start of their CCI project, and again after the project was completed. Data were subjected to statistical analysis where appropriate, comparing data from different groups and time points. Qualitative data were explored thematically.

## Sample

Key findings from 940 pupils (representing 53%) who completed ‘matched’ pre- and post-CCI questionnaires are reported here: 49.3% girls and 50.7% boys. This represents just over half of all pupils involved in the programme across the two years. 72% of data were derived from North East children and 28% from the East of England. Year Six children made up 58.0 % of the sample, Year Five children 38.2%, and Year Four children the remaining 3.8%.

## Findings

### *Children*

Analysis of pre- and post-project questionnaire data indicates that children’s attitudes towards science and industry were improved through participation in the project. The pupils from both regions showed a statistically significant improvement in their attitude to science over the course of the project. The ‘attitudes to industry’ individual items almost invariably raised a positive response and improvement, though the probe does not provide a consistent scale. These findings are corroborated by overwhelmingly positive comments made by children in answer to open-ended questions. Children reported enjoying the hands-on nature of in-class activities and learning about science and industry in a real-life context during their visit to the industry. There was also a positive response amongst children to visits from apprentices, with some reporting feeling inspired to continue learning science with a view to becoming an engineer or a scientist in the future. When asked what they liked least, a high proportion of children said “nothing” or did not give a response. Where negatives were expressed, they tended to be environmental (e.g., too much walking and standing, cold weather, uncomfortable protective clothing and boots); having to write; or related to specific activities, in particular those which children have found either “too easy” or “hard” and “confusing”. However, these were minority criticisms. The group work approach received generally positive feedback, with pupils enjoying working alongside friends, with a few children complaining that others had not listened to them or could not agree on a way to approach the experiment at hand.



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## *Teachers*

The qualitative and quantitative data from the teachers show how well received the CCI programme was. It helped teachers understand the benefits and importance of industry; a message they felt better able to relay to future pupils as a result. The teachers particularly valued the variety of activities included in the programme and the opportunity it provided to connect practical work to the context of a real-world STEM industry.

## **Conclusions**

According to the quantitative and qualitative data analysed in this report, the CCI programme achieved its educational and organisational objectives and was a rewarding learning experience for all parties involved. The programme increased children's knowledge of and excitement about STEM industries, with most knowing more about and holding more favourable views towards science and industry upon its completion. Differences between girls and boys, between the two regions and year groups were subtle and not necessarily consistently related to one factor or aspect of the project. The role of the visiting ambassadors and industry professionals welcoming children to the site visit were crucial to the success of the programme, as illustrated by the questionnaire responses from both children and teachers. The qualitative responses suggest that it might be possible to make small improvements to some of the industry visits, which would make them an even better experience for the pupils, but company level reporting is more appropriate to enable this to happen.





## 1. CHILDREN CHALLENGING INDUSTRY PROGRAMME

### 1.1 Background

Children Challenging Industry (CCI) is a flagship programme of the Centre for Industry Education Collaboration (CIEC) based at the University of York. The programme has run since 1996 and connects pupils and teachers with local science-based manufacturing companies in various English regions. During 2018-20, the programme was active in the North East and East of England. It is one of the few national science initiatives focused on broadening student aspirations in relation to STEM at the primary-school level (Tabaqchali et al., 2018), with the vast majority of others aimed at secondary, college, or undergraduate level students (Mann & Oldknow, 2012). In this sense, as noted by Archer et al. (2013), the current focus of most activities and interventions aimed at connecting education and industry - at secondary school - “is likely to be too little, too late” (p.4).

Previous evaluations of the CCI programme have shown it plays an important role in increasing children’s interest in science, improving their attitudes toward industry, and developing their awareness of a wide range of potential STEM careers at an early stage; aspirations which can then be further nurtured throughout primary and secondary education. The programme consists of several elements designed to place curriculum science in a real-world context, aimed at ultimately developing pupils’ scientific literacy, and attracting pupils to study STEM subjects and take up careers in industry. All pupils complete a series of practical problem-solving activities in the classroom with a CIEC advisory teacher. The vast majority of children also visit the sites of local industrial partners or, in a few cases, receive a visit from a trained science ambassador. Ambassadors are scientists, engineers and apprentices within the science and manufacturing sector. Professional development for teachers (CPD) and training for industrial partners, as well as ongoing support, is a fundamental component of the programme; with all elements being delivered by CIEC’s team of advisory teachers.

The impact of CCI has been measured through pupil and teacher questionnaires since its inception. Previous evaluation reports and other publications can be accessed online at [www.york.ac.uk/ciec/research/](http://www.york.ac.uk/ciec/research/). The questions, which were adapted and added as the programme has evolved over the years, now examine children’s experiences during the programme, their attitudes towards industry and science, and since 2018 – the development of their science capital. Teachers’ questionnaires explore their perceptions about science and the industry and opinions about the strengths and weaknesses of the programme.



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This report presents a combined analysis of data collected on the CCI programme from September 2018 to July 2020. During that time, 1,764 pupils from 56 schools in North East (NE) and East of England (EE) regions took part (Table 1) [1]. 710 teachers received a total of 928 hours of professional development. Eleven companies facilitated 51 industrial site visits, and 24 ambassadors visited schools. Key findings from 940 pupils (representing 53%) who completed both pre- and post-CCI questionnaires allowing us to measure change are reported here.

SCHOOL YEAR	REGION	
	NORTH EAST	EAST OF ENGLAND
2018 - 2019	525 (from 18 schools)	393 (from 11 schools)
2019 - 2020	557 (from 18 schools)	289 (from 10 schools)
<b>TOTAL:</b>	1,082 (61%)	682 (39%)

Table 1. CCI programme participants by region 2018-2020

## 1.2 Aims of the CCI programme

The CCI programme aims to:

- provide classroom-based training for teachers in aspects of the National Curriculum for science;
- increase children's enjoyment of science;
- improve primary school children's perception of the science-based manufacturing industries and their relationship with science;
- improve teachers' knowledge and confidence of teaching science;
- improve teachers' perception of the science-based manufacturing industries and their relationship with science. (Porter et al., 2011, p.4).

[1] Several schools (15 in the NE and four in EE) had to cancel or postpone their participation in 2019-2020 due to COVID-19 pandemic-related school closures in the summer term.





## 1.3 Programme design

The programme consists of the following elements:

- a range of written and web-based materials which enable pupils to investigate science in a real-life context;
- one to five hours of professional development made up of four hours of classroom-based CPD for participating class science teachers (in which the children carry out practical enquiry-based science activities) and one hour of whole staff CPD;
- a 4-hour training session for industrial partners;
- liaison between CIEC advisory teachers and industrial partners to ensure a successful site visit that is well-matched with the scientific concepts involved in the classroom investigation;
- a half-day site visit by each participating class or, on occasion, a visit to the school by an industrial ambassador.

## 2. AIMS OF THE EVALUATION

The primary objectives of the following evaluation are to assess the impact of the CCI programme on:

- pupils' and teachers' attitudes to science
- pupils' and teachers' attitudes to industry
- development of pupils' science capital.

A secondary objective is to collect formative feedback on the programme for the developers, delivery team, and industry partners, to provide recommendations for future years.

## 3. METHODOLOGY

Children and teachers from participating schools were asked to complete a questionnaire before and after the project (for details of the questionnaire see Appendices A-H). Although the questionnaires changed slightly between the two years, for example, to aid pupils' ability to distinguish between subtly different questions, data remains considerably comparable. Where comparisons cannot be made for some questionnaire items, or where new items were added for the 2019-2020 school year, this is described below.



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Only those schools completing both pre- and post-questionnaires were included in the analysis. The combined two-year response rate for children's questionnaires was 53%, with a higher response rate in the North East (63%) than in the East of England (38%). Although it has improved year-on-year, the response rate for post-questionnaires in 2019-2020 school year was affected by school closures caused by Covid-19 in Spring 2020, as reflected in the final numbers.

## 3.1 Data collection – pupils

Children in all participating schools were asked to complete an online (Qualtrics) questionnaire before and after the programme. The pre-project questionnaire was designed to gauge children's attitudes towards science and industry, find out what science-related activities they already engage in, and determine whom they speak to about science outside school. Basic demographic questions were included to allow for comparisons across gender and age. The programme included lessons investigating selected science topics and activities related to the industry/industry representative the children later visited/were visited by. The topic was introduced by a CIEC advisory teacher who led two out of the three classroom sessions and provided guidance, lesson plans, and all necessary equipment to the class teacher leading the third (usually middle) session.

The majority of children (just over 98%) visited the site of an industry partner, and/or a specially trained industry employee (industry ambassador) visited the school during one of the CCI sessions:

- 52% of children visited an industry site,
- 41% of children benefited from both a visit to an industry site and a visit from an industry ambassador,
- 5% of children had a visit from an ambassador,
- a very small number of children (1%) benefited only from the lessons with a CIEC advisory teacher.

Upon completion of all elements of the programme, children completed an online questionnaire with questions similar to those asked before their participation. Additional questions about what children had enjoyed most and least about the project, as well as what they had shared with friends and family about CCI activities, were included. Both the pre- and post- project questionnaires can be found in Appendices A-D. Additional school-level data, including information shared by CIEC advisory teachers about which practical topic(s) children were working on during the programme, were added to the dataset.

Due to pupil absences either during the industrial site visit, or when questionnaires were completed in-class, the programme was not completed by all participants at each school. Such cases were removed before analysis where pre- or post-data was missing.





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## 3.2 Data analysis – pupils

### 3.2.1 Quantitative data

Quantitative data were prepared for use with SPSS. Three-point and five-point Likert scale items measuring direction and strength of opinion were checked and coded 1-3 or 1-5 as relevant. Statements representing negative concepts (e.g., ‘We do too much science in school’ and ‘Industry is dangerous’) were reverse coded before statistical analysis was performed. Changes in responses to these items were represented with a range of -2 to +2 for three-point items, and -4 to +4 for five-point items, where a positive change indicates an improvement in attitude or opinion. T-tests were performed to assess the statistical significance of changes in the responses to individual questionnaire items. New items for 2019-20 are denoted with a caret (^) for clarity.

Independent-sample t-tests (or one-way between-group ANOVAs) were performed to explore differences in the findings by participant characteristics and by region. All differences were tested for statistical significance and only those that were statistically significant at the 5% Confidence Level are included in the commentary of the report. All statistically significant findings are summarised in the supporting graphs and tables. Not all percentages in the report sum to 100% due to rounding.

Questionnaire items that probed children’s attitudes to science and industry were assessed for their suitability to form part of an overall attitudes score using Cronbach’s alpha statistic. As established in previous evaluations, the ‘attitudes to science scale’ can be used to calculate an overall score reflecting children’s attitudes to science, whereas children’s attitudes to industry cannot be judged on an overall scale (see Turkenburg-van Diepen & Hanley, 2017). In 2019-20 several new items were added (including some items used in previous years but not in the 2018-19 school year). These items are denoted with a caret (^) for clarity. Because of these changes, the internal consistency of the ‘attitude to science’ and ‘attitude to industry’ scales were calculated using data from 2019-20 only, with following attitude scale analysis completed with the same dataset. Where Cronbach’s alpha was  $\geq .7$  for both the pre- and post-project data, the scales demonstrated an acceptable level of internal consistency and the coded data were taken together to form a score. For instance, for the ‘attitudes to science’ score, each pupil was given a score between 12 (disagreeing with every positive statement and agreeing with every negative statement) and 72 (agreeing with every positive statement and disagreeing with every negative statement). Paired sample t-tests were performed using the pre- and post-project questionnaire data to investigate the difference in attitudes to science before and after the programme. T-tests were also performed to investigate differences between groups by gender, year group and geographical region.



From 2018-19 a new set of questions was used to gather information on children's science capital [2]: In the pre-project questionnaire only, six items in 2018-19 and seven items in 2019-20 related to science media consumption and participation in out-of-school science learning contexts, and nine items related to specific science projects. A further three items in 2018-19 and four items in 2019-20 were added to investigate the extent to which children are encouraged by their parents to continue with science when they have the choice to do so. In both pre- and post-project questionnaires, additional items were included to gauge whether children talk about science outside of lessons (with their class teacher or classmates) or outside school with key people in their lives (e.g., friends, siblings, parents, grandparents). The frequencies are presented below.

### 3.2.2 Qualitative data

Descriptive codes were applied to the free text answers of the children and developed into a coding framework. Analytical judgements were then made to organise codes into themes based on repeating patterns.

## 3.3 Data collection – teachers

Prior to taking part in the CCI programme, teachers were asked to complete a pre-project questionnaire, with questions about their previous engagement with professional development opportunities related to science and industry and their school's prior links with industry. Teachers were asked to rank their main objectives for taking part in the CCI programme from a list of four and were given the option to add their own objective. They were also asked how far they agreed with an array of statements designed to gauge their attitudes towards industry and the jobs it offers (five-point scale from 'Strongly disagree' to 'Strongly agree'). A new set of questions for 2018-2020 were included to investigate teacher's prior knowledge about science capital, to gauge their views on the relevance of science capital to their teaching, and to seek their opinion about how many children in their class engage in out-of-school science learning activities. In 2019-20 an additional item was added which asked teachers to estimate how many children in their class 'have the potential for a career in STEM', 'have expressed an interest in a future in STEM' and 'have a family member who has a career in which STEM plays an important role'. Finally, a set of questions relating to teachers' own science capital were added. Both 2018-19 and 2019-20 questionnaires can be found in Appendices E-H.

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[2] 'Science capital refers to science-related qualifications, understanding, knowledge (about science and "how it works"), interests and social contacts (e.g. knowing someone who works in a science-related job)' (ASPIRES, 2013). As noted recently by Moote et al. (2020), science capital is strongly related to engineering and physical sciences future study aspirations.



The post-project questionnaires began by asking teachers to rate the programme on a scale from ‘very poor’ to ‘excellent’. Teachers were also given a list of 11 statements and asked to indicate which they considered true regarding the strengths of the classroom training and were given the option to add their own. Next, teachers were asked to rate different elements of the CCI programme and indicate which elements most increased their knowledge and confidence in teaching STEM subjects. A question gauging teachers’ attitudes towards industry, matching that from the pre-project questionnaire, was also included. Several open-ended questions were included in both pre- and post-project questionnaires to provide additional detail to the closed question responses.

### 3.4 Data analysis – teachers

Quantitative data were prepared for use with SPSS. As the teacher questionnaires were completed anonymously, the responses to pre- and post-project questionnaires were not paired. Instead, they were considered separately with descriptive statistics used to describe the features of the data.

Although relatively few teachers gave responses to the open-ended questions, the responses were coded inductively with a few common themes identified and presented below with selected illustrative quotations included.

## 4. FINDINGS

### 4.1 Pupil’s data

#### 4.1.1 Sample

Pre- and post-project questionnaires were returned from 42 schools in the North East and the East of England. Instances in which pupils were unable to complete both the pre- and post-project questionnaires were removed before analysis. Sample sizes differ between individual questions as not all pupils answered all the questions on the questionnaires. Valid percentages are reported for each question.

The dataset comprised a total of 940 children, 49.3% girls and 50.7% boys (Table 2 overleaf). This represents just over half of all pupils involved in the programme across the two years. The gender balance of almost 50/50 was the same across both regions.

72% of data were derived from North East children and 28% from the East of England. Year Six children made up 58.0 % of the sample, Year Five children 38.2%, and Year Four children the remaining 3.8% (Table 3 overleaf).



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<b>GENDER</b>	<b>SCHOOL YEAR</b>		<b>TOTAL:</b>
	2018 - 2019	2019 - 2020	
GIRL	196	267	463
BOY	235	241	476

Table 2. CCI programme evaluation 2018-2020 (sample) pupil characteristics: gender (n=939)

2018 - 2019			2019 - 2020		
	BY REGION:				TOTAL BY SCHOOL YEAR:
SCHOOL YEAR	NE	EE	NE	EE	
Year 4	35	1	0	0	36
Year 5	84	63	212	0	359
Year 6	161	88	185	111	545
TOTAL BY REGION:	280	152	397	111	940

Table 3. CCI programme evaluation 2018-2020 (sample) pupil characteristics: school year and region (n=940)

Each class followed a practical topic relevant to the schools' company partner. The different topics and the percentage of pupils doing each is shown in Table 4 (overleaf). These topics are freely available as downloadable teaching materials on the CIEC website, at [www.ciec.org.uk/primary.html#resources](http://www.ciec.org.uk/primary.html#resources).



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TOPIC	NO. OF CHILDREN	PERCENTAGE
Runny Liquids / Cough Syrup	209	22.2%
Kitchen Concoctions / A Pinch of Salt	275	29.3%
Water for Industry	122	13.0%
Generating Electricity	307	32.7%
Plastic Playtime	27	2.9%
Rough Guide to Gas / Science of Healthy Skin / Water for Industry	75	8%

Table 4. Range of CCI topics (n=940)

## 4.1.2 Results

### *QUANTITATIVE DATA – RESPONSES TO INDIVIDUAL QUESTIONNAIRE ITEMS*

The percentage of pupils responding on a three-point Likert scale (Agree / I don't know / Disagree) or five-point scale (Agree a lot to Disagree a lot) for pre- and post- individual questionnaire items is discussed below and represented in Figures 1-9. A caret (^) indicates questionnaire items introduced in 2019-20. For the positive questionnaire items, an increase in the fraction of pupils answering 'Agree a little' or 'Agree a lot' indicates an improvement in attitude whilst the opposite is true for negative questionnaire items. Within the two-year sample, statistically significant differences in mean attitude changes between genders, region and year groups were observed for some of the 'attitudes to science' and 'attitudes to industry' questionnaire items. These are highlighted in Appendix Tables A3 and A4.

As in previous years, children's attitudes towards science and industry improved over the course of the project. Following completion of the CCI programme, children responded more positively to all questions examining attitudes to science (for full details of the statistics for the whole sample see Appendix Table A1). In particular, there were statistically significant increases in the number of children answering positively (choosing 'agree a little' or 'agree a lot') to the statements:



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- 'I like science' (Pre- 85%, n=939; Post- 86.5%, n=936);
- 'I'd like to be a scientist' (Pre n=928; Post n=936) (Figure 1). The proportion of children responding positively to this statement was considerably higher than in previous years, e.g., 28% in 2016-17 (Tabaqchali et al., 2018):



Figure 1. Proportion of children responding positively to statement *'I'd like to be a scientist'*

More children have also responded positively to statements about out of school activities related to science, in particular those more hands-on:

- 'I would like to go to a science centre, science museum or zoo' (Pre- 51.4%, n=928; Post- 83.6%, n=926);
- 'I would like to go to a museum that is not about science at all' (Pre- 50.1%, n=918; Post- 54%, n=926);
- 'I like watching science programmes on TV or online' ^ (Pre- 51.6%, n=504; Post- 55%, n=507);
- 'I like doing science experiments at home' ^ (Pre- 62.8%, n=506; Post- 68.9%, n=504);
- 'Science clubs are a good idea' ^ (Pre- 58%, n=501; Post- 76.6%, n=500);

A negative change has been noted for one statement - 'I like reading science stories' ^, with a smaller proportion of children agreeing with this statement after the programme (Pre- 47.6%, n=505; Post- 27.4%, n=503).

Other positive increases were also noted for the remaining statements, although those were not statistically significant:

- 'Science is my favourite subject' (Pre- 47.6%, n=926; Post- 48.3%, n=929);
- 'I'd like to be an engineer' (Pre n=928; Post n=926) (Figure 2):



Figure 2. Proportion of children responding positively to statement *'I'd like to be an engineer'*





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Based on these results, it is clear that participation in the CCI programme improved children's attitude to science learning, with a larger proportion disagreeing with the negatively phrased statements (although the results are not statistically significant):

- 'We do too much science in school'^ (Pre- 79.4%, n=500; Post- 82.7%, n=498);
- 'We do too much writing in science'^ (Pre- 56.2%, n=502; Post- 61.9%, n=504);
- 'We have to do too much work in science'^ (Pre- 68%, n=503; Post- 70.5%, n=501).

After the programme, more children also disagree that 'science is too difficult'^ (Figure 3):

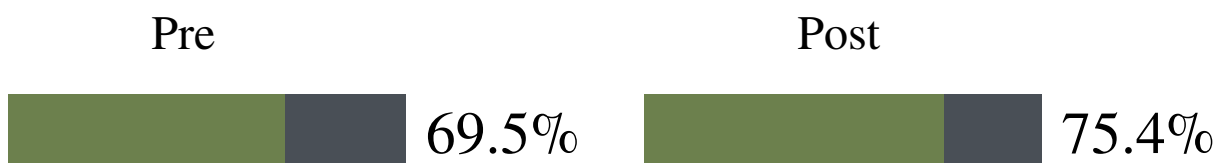


Figure 3. Proportion of children who **disagree** with the statement '*Science is too difficult*'

For the majority of questionnaire items related to industry, a statistically significant improvement in attitude was observed (indicated by an asterisk \* below; further details of the statistics for the whole sample can be found in Appendix Table A2). Many of these items related to topics and experiences encountered during children's sessions with industry ambassadors, or during their visit to a local industry site. In particular, children responded more positively to statements about the value of industry for our everyday lives after the project:

- 91.5% of children (n=506) agreed 'a little' or 'a lot', that 'industry is useful'^ after the programme, compared to 78.7% beforehand\*;
- after the programme, 73.2% of children have agreed that 'our lives would be worse without industry'^, a 19.4% improvement compared to pre-programme stage (53.8%)\*;
- 90.6% of children agreed that 'industry makes things we need'^, compared to 79.7% beforehand.\*

Data from some of the positively worded items (Fig. 4) paired with negatively worded items (Fig. 5) suggests that, through participation in the CCI programme, children learnt about pollution caused by industry in a more informed way, beginning to understand that the negative aspects associated with industry in terms of safety and pollution, when controlled, are not as adverse as they first seem (all results were statistically significant).



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Pre

Post

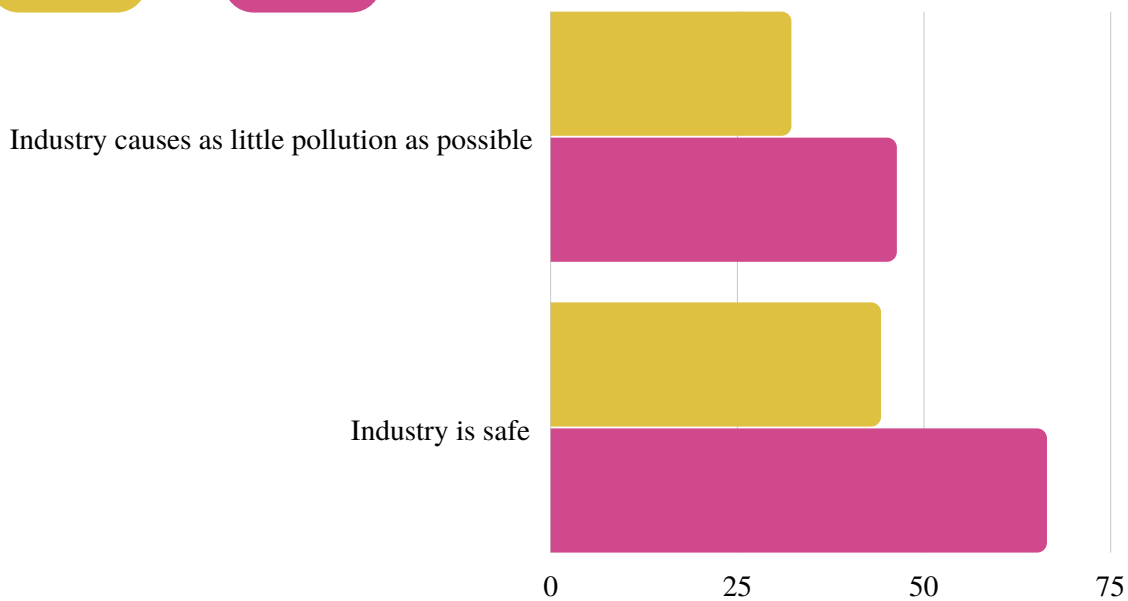


Figure 4. Proportion of children who **agree** with the positively worded items

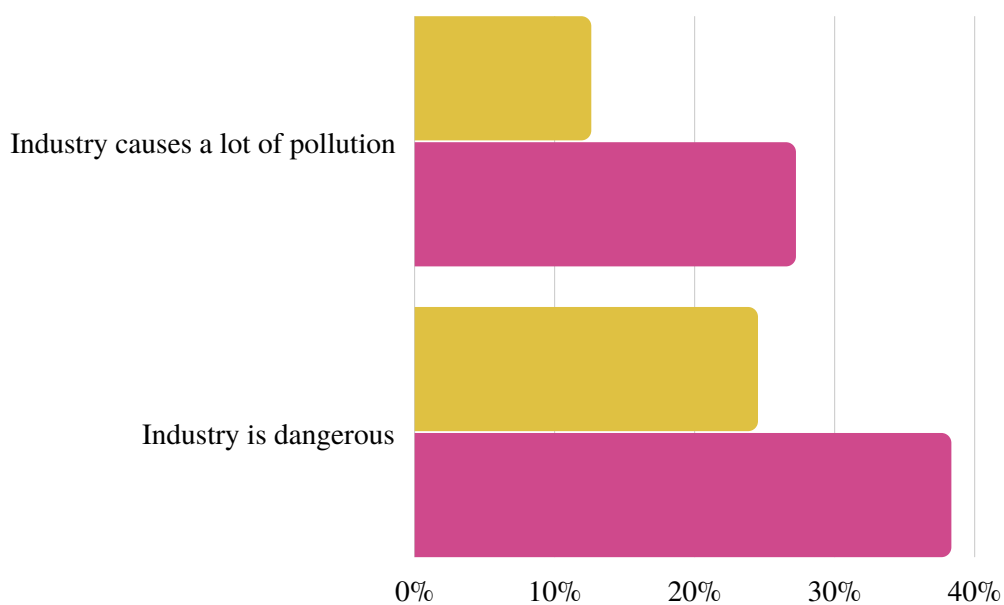


Figure 5. Proportion of children who **disagree** with the negatively worded items



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While a proportion of children agreeing that they ‘learn about industry from TV or online’ has increased after the programme (81.4% compared with 70.7% beforehand<sup>^\*</sup>), a substantially higher proportion of children have said that they ‘learn about industry from their teachers’ after the programme (72% compared with 51.6% beforehand<sup>^\*</sup>).

Increased knowledge about transferability of science, that is children’s understanding that science ‘opens doors’ to many careers has also been noted:

- Children were more aware that both scientists and engineers work in industry and indeed have important jobs in industry after the programme (Figures 6-8),
- children are also more aware of the presence of young people and women in industry - 47.2% of children have agreed that young people work in industry after the programme, compared to 41.9% beforehand<sup>^\*</sup>; 94% have said that there are women scientists and engineers in the post-programme questionnaire, compared with 87.3% in the pre-questionnaire<sup>^\*</sup>.

These changed attitudes towards industry relate closely to the school topics and encounters with young male and female apprentices, and a diverse range of people on site visits.

## Many scientists work in industry\*

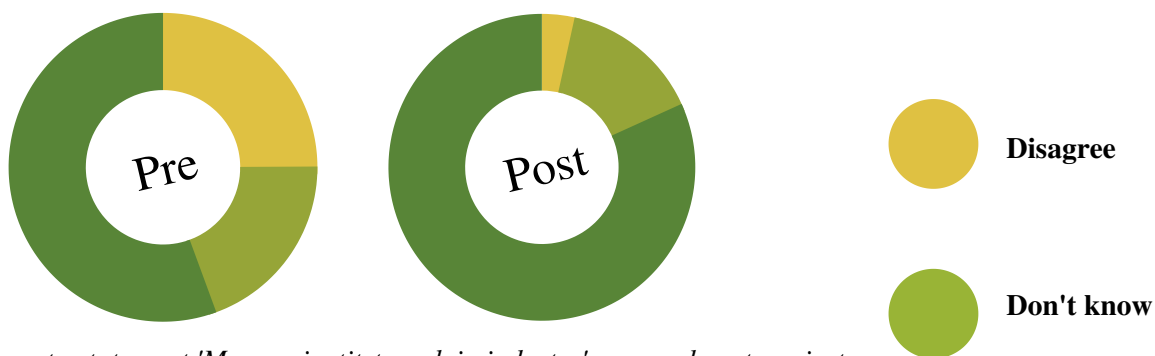


Figure 6. Responses to statement 'Many scientistst work in industry' pre- and post-project.

## Many engineers work in industry\*

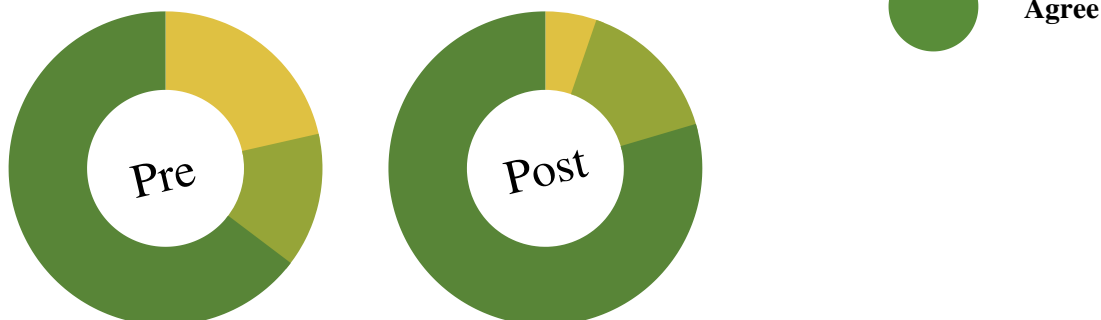


Figure 7. Responses to statement 'Many engineers work in industry' pre- and post-project.



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## Scientists and engineers have important jobs in industry\*

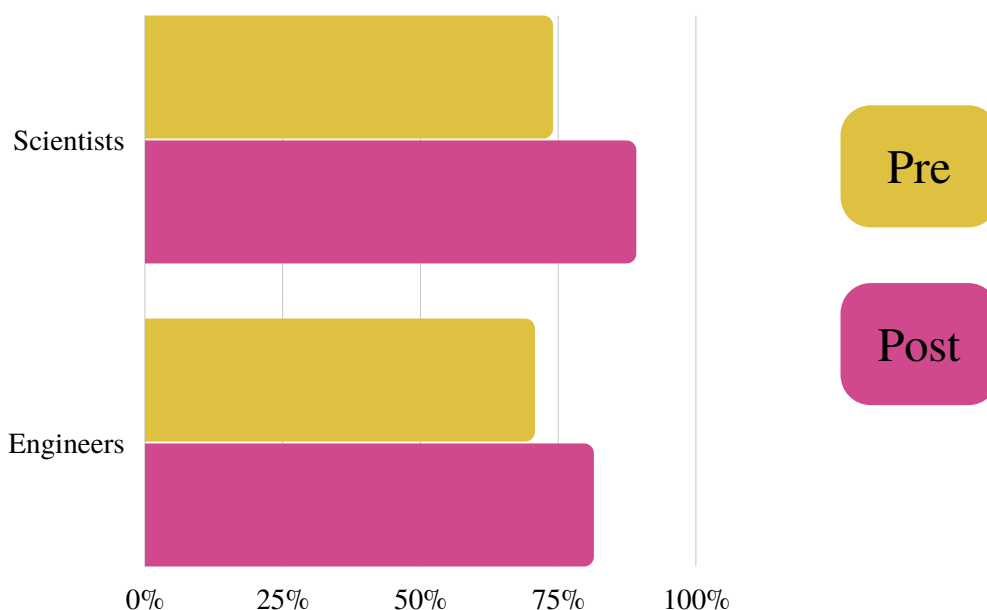


Figure 8. Proportion of children who **agree** with the statements pre- and post-programme.

Children responded more positively to statements about their career aspirations in the STEM industries, with the number of positive responses in relation to a statement 'I could work in industry in the future' increasing from 24.3% pre-project to 43.3% after the project (Figure 9).



Figure 9. Responses to statement 'I could work in industry in the future' pre- and post-project.



## *QUANTITATIVE DATA – ‘ATTITUDES TO SCIENCE’ SCALE*

A reliability analysis carried out using Cronbach's alpha on the 14 items assessing children's attitudes to science, gave a score of over .7 for the pre-project responses (whole sample). The post-project score, however, was below .7. This was replicated when the sample was split by gender, year group (years five and six), and in the North East when sample was split by region, although in the East of England the score was above the acceptable level for both pre- and post-project responses. A closer examination of the questionnaire item-total statistics indicated that alpha would increase to .78 for both pre- and post-project analysis if two items: 'I'd like to go to a museum that is not about science at all' and 'I like reading science stories' were removed. The first item does indeed relate to non-science activity, while 'science stories' may be a term too ambiguous for children. Alpha has also been increased to an acceptable level (between .72 and .82) for data split by year group, gender, or region (Table 5 overleaf). Consequently, these two items were dropped for the subsequent analyses which are based on children's responses to the remaining 12 items:

- I like science
- I'd like to be a scientist
- I'd like to be an engineer
- Science is my favourite subject
- I would like to go to a science centre, science museum or zoo
- I like watching science programmes on TV or online
- I like doing science experiments at home
- School science clubs are a good idea
- Science is too difficult
- We do too much writing in science
- We do too much science in school
- We have to do too much work in science

The whole sample of children had statistically significant improvement in the 'attitudes to science' score. This was also true for both girls and boys separately, in the North East region, and for Year 5 children. Further details on the statistics, samples and mean scores can be found in Table 6 below.





# Children Challenging Industry



SAMPLE	PROJECT PHASE	NO. OF RESPONSES	CRONBACH'S ALPHA
Whole data set (2019-2020)	Pre	453	.78
	Post	453	.78
North East	Pre	362	.74
	Post	354	.77
East of England	Pre	98	.79
	Post	99	.82
Girls	Pre	243	.75
	Post	239	.75
Boys	Pre	217	.77
	Post	214	.81
Year 5	Pre	193	.72
	Post	185	.73
Year 6	Pre	267	.78
	Post	268	.81

*Table 5. Cronbach's alpha statistic testing reliability of an 'Attitudes to science' scale.)*





# Children Challenging Industry



SAMPLE	PROJECT PHASE	M	SD	SCORE RANGE	PAIRED T-TEST
Whole data set (2019-2020)* (n=508)	Pre	42.95	8.39	16 to 60	Improvement $t(507)=3.71$ , $p<.001$ , $d=0.17$
	Post	41.75	8.79	15 to 60	
North East* (n=397)	Pre	42.20	8.35	16 to 60	Improvement $t(396)=3.37$ , $p=.001$ , $d=0.17$
	Post	43.43	8.72	16 to 59	
East of England (n=111)	Pre	40.15	8.41	16 to 60	Improvement $t(110)=1.56$ , $p=.121$ , $d=0.13$
	Post	41.24	8.84	15 to 60	
Girls* (n=267)	Pre	42.12	7.93	20 to 59	Improvement $t(266)=2.79$ , $p=.006$ , $d=0.17$
	Post	43.23	7.98	15 to 59	
Boys* (n=241)	Pre	41.35	8.88	16 to 60	Improvement $t(240)=2.48$ , $p=.014$ , $d=0.16$
	Post	42.62	9.61	15 to 60	
Year 5* (n=212)	Pre	41.24	8.18	16 to 60	Improvement $t(211)=3.84$ , $p<.001$ , $d=0.26$
	Post	43.09	8.54	15 to 60	
Year 6 (n=296)	Pre	42.13	8.54	16 to 60	Improvement $t(295)=1.68$ , $p=.095$ , $d=0.08$
	Post	42.84	8.97	15 to 60	

Table 6. Mean scores on the Attitudes to Science scale, with standard deviation and score ranges, for pre- and post-project phases.

M - mean score, SD - standard deviation

\*indicates categories where the difference between pre- and post-project data is statistically significant



# Children Challenging Industry



## *QUANTITATIVE DATA – ATTITUDES TO INDUSTRY SCALE*

The 'Attitudes to industry' scale contained 16 items on the ways in which industry benefits our lives, the potential negatives associated with industry, types of people who work in industry including young people, scientists, engineers and women and the importance of their roles, and how children learn about industry. Analysis of both pre- and post-responses gave a Cronbach's alpha of less than .7, indicating low reliability, below an acceptable level for analysis. Upon further inspection, it was found that removal of every item, in turn, would not increase the Cronbach's alpha score above .7, and therefore reliability could not be improved in this way. This means that the individual items cannot be grouped together to form an overall 'Attitudes to industry' score before or after the project.

## *QUALITATIVE DATA – CCI PROJECT IMPACT ON ATTITUDES TO SCIENCE AND INDUSTRY*

In both questionnaires, an open-ended question was asked encouraging pupils to say anything they wanted to about science – as a subject and a reflection on their journey as part of the programme. It was intended as a means of further analysis of pupils' pre- and post-programme attitudes to science. 489 comments were made in the pre-project questionnaire, and 517 comments in the post-project questionnaire. 540 additional comments were made in response to four questions, asking what children enjoyed most and least about the CCI programme after its completion, and why. These comments were analysed qualitatively.

The findings reflect the patterns in the quantitative data - many children (372, 40%) reported enjoying science even before the programme, both at school and at home:

***"I like doing experiments in science, they are really enjoyable, and you can do them as a family"***

(Girl, Year 6, NE – pre-programme)

***"Science is really fascinating, and I love science lessons!"***

(Boy, Year 6, NE – pre-programme)



# Children Challenging Industry



This was the case even if children occasionally find it hard (58, 6%):

***"Science is cool but sometimes it can be hard (...)"***

(Girl, Year 6, EE – pre-programme)

***"It's a really good topic (...) a little difficult but it helps us in everyday life."***

(Boy, Year 5, NE – pre-programme)

Children's attitudes towards science and science learning at school, as well as attitudes towards industry, have visibly further improved over the course of the CCI programme:

***"I find it almost magical and logic. I cannot wait to go to secondary."***

(Girl, Year 6, NE – post-programme)

***"I think science is interesting and fun as it makes me intrigued to know more."***

(Girl, Year 6, EE – post-programme)

***"I enjoyed everything because I love science, it was all amazing."***

(Girl, Year 5, NE – post-programme)

It was clear from some of the statements that, at least for a few children, the subject has become more enjoyable after participating in the project. For example, a pupil who in the pre-questionnaire said *"Science is not my favourite subject of all."* after the programme said:

***"Science is a really interesting subject to learn and I think I would quite like to be a scientist or an engineer when I am older."***

(Girl, Year 6, NE)



# Children Challenging Industry



Another pupil who before the programme said *"Science is confusing to me but after the topic is explained I usually understand it. So hopefully I might enjoy science even more after this experience"*, after the programme declared that she too would like to work in STEM:

***"I also liked seeing the scientists and all the other people as they inspired me to get into the STEM industry."***

(Girl, Year 6, EE)

The majority of children reflected on the practical aspects of the programme, the science experiments (47.6%) and visit to industry partner (33%), as being the most enjoyable:

***"The visit was amazing, and I enjoyed all of the lessons. I cannot say what I enjoyed the most as I do not know (...) it was all interesting."***

(Girl, Year 6, NE)

***"I enjoyed the challenges where we could get 'hands on.'"***

(Boy, Year 6, NE)

***"I enjoyed the trip to [the company] the most as we got to see what it was actually like at a real industry site rather than being told about it. I learned a lot from the visit and went home able to tell my parents everything about [the company]."***

(Girl, Year 6, NE)





# Children Challenging Industry



Several children recalled specific experiments (37%), things they have learnt, or things they have seen during their visit (17.2%):

**"I enjoyed going to the industry and seeing all off the machines, robots and learning what [the company] do."**

(Girl, Year 6, EE)

**"I enjoyed creating hydrogel because the progress was good, and I LOVED putting my hands in the bowl!"**

(Boy, Year 5, NE)

A small number of children (37), in particular girls, reflected on the problem-solving and teamwork foci of the activities:

***"I enjoyed last week task we did when they give us a problem and we had to fix [it]."***

(Girl, Year 6, NE)

***"I enjoyed it because it was challenging and required lots of thinking. We had to learn to listen to everybody's ideas."***

(Girl, Year 6, NE)

***"[the CCI lessons] were more practical than the ones that we sort of had to just listen to, basically I really enjoyed it because we could help out and see how things worked by us doing an experiment."***

(Girl, Year 6, EE)

***"I enjoy[ed] how we worked together, and we listened to each other."***

(Girl, Year 6, NE)



# Children Challenging Industry



When responding to the question about what they enjoyed least, the majority of children (38%) said that there was nothing at all that they did not enjoy (with a further 18% leaving the answer blank). Of those who did write about dislikes, the most common response was about the parts of the programme were the less hands-on parts (10.3%), including scientific writing and learning about the history of the industrial site or safety brief:

***"Sitting in the room for like an hour while they told us safety issues etc."***

(Boy, Year 5, NE)

***"I least enjoyed when we were talking about the scientist and when we were not doing anything it was still fun though."***

(Boy, Year 6, EE)

180 (19%) children commented on one of the experiments or activities, but no particular activity stood out. 37 children (3.9%) have found some of the activities 'hard' or 'confusing':

***"(...) it was a little bit tricky. And people weren't saying what we think was good and bad we needed to talk more about our idea."***

(Girl, Year 5, NE)

Others (61 children, 7%) mentioned aspects which were beyond the organisers' control, e.g., cold weather, noise or smells or having to walk a lot to get to different parts of the site during their industry visit. A small number (19, 2%), complained about the 'too big' and 'uncomfortable' safety equipment.

While, as noted above, several children enjoyed working in groups, there were some indications that in some cases there had been problems with group dynamics, with children not listening to each other, acting 'dangerously' around the equipment and arguing, which had not been sorted out at the time:





# Children Challenging Industry



***"Because my group kept on arguing on what radio to do. Although we did settle on one our measurements were so accurate that there wasn't enough to test on."***

(Girl, Year 6, EE)

16% of children mentioned specifically learning science in a real-life context and meeting science professionals:

***"[I enjoyed] the part where we made little blue beads during the session. It was fun that we were actually in a real laboratory."***

(Girl, Year 5, NE)

***"I enjoyed seeing an actual lab and meeting real scientists."***

(Girl, Year 6, NE)

***"I enjoyed the sessions we had with the visiting scientist / industry ambassador, especially the one where we were testing the viscosity of different substances."***

(Girl, Year 4, EE)

***"(...) it's better than being told as you can see it in person and learn more from people who actually work there and are there every day as their job."***

(Girl, Year 6, NE)





# Children Challenging Industry



A small number of children (17, 2%) have further commented on learning specifically about the role of scientist and engineers in industry, and the impact of their work on everyday life:

**"I most enjoyed getting to learn what all the different scientists' roles were and how they all impact on our lives today."**

(Girl, Year 6, EE)

**"What I enjoy the most is that industry care for who work there, for people who lives nearby and for the planet."**

(Boy, Year 6, NE)

**"The thing I enjoyed least was leaving. Because [the company] is such a prestigious workplace, and it is made up of so many hard working, inspiring people who help make each day fantastic and full of science."**

(Girl, Year 6, EE)

Some children said that, although they enjoyed the project, they would not consider a career in science or industry:

***"I like doing experiments with people, but I wouldn't like to be a scientist."***

(Girl, Year 5, NE)

***"I like science but it's not what I'd like to do when I'm older."***

(Boy, Year 5, EE)

A few children (11), however, were very enthusiastic about what they have experienced during the CCI programme and went as far as to attribute their altered career aspirations to the activities completed during their classroom sessions and during industry site visits. While most comments mentioned science, some referred to the industrial context and engineering career options:



# Children Challenging Industry



***"I enjoyed going to the [company] and seeing engineers working there and I thought I would love to do that when I'm older."***

(Boy, Year 5, NE)

***"It made me realise how much more important science is to our lives and it also gave me second thoughts that maybe I should be a scientist one day."***

(Girl, Year 6, EE)

***"I (...) liked seeing the scientists and all the other people as they inspired me to get into the STEM industry."***

(Girl, Year 6, EE)

Looking at the findings from quantitative and qualitative data together, taking part in the CCI programme had been a positive experience for the vast majority of children, with only six children reporting that they have not enjoyed anything about the programme. Children have learned through practical activities, met scientists and engineers, and visited industry sites which has improved their attitudes to both science and industry and their understanding of STEM careers. In particular, children's understanding of the presence of young people and women within the industry has increased. One pupil has noted for example:

***"Girls and Boys both can be whatever they want if it's an engineer [or] a scientist."***

(Girl, Year 5, EE)





## *QUANTITATIVE AND QUALITATIVE DATA - SCIENCE CAPITAL*

In the 2018-19 and 2019-20 academic years, a new set of questions was introduced in both pre- and post-project questionnaires, designed to gather information on the impact of the CCI programme in increasing levels of science capital in children.

Science capital is a measure of engagement or relationship with science, which gives us an insight into why and how some people engage with STEM, while others do not.

Science capital can be broken down into four elements or pillars:

1. What you know refers to your science knowledge and understanding,
2. How you think refers to your views about science,
3. Who you know refers to people who are interested and talk about science with you and motivate you in science, and
4. What you do refers to the science-related things you do in your spare time.

(the above terminology was agreed in discussion with Professor Louise Archer, Institution of Education, whose research on science capital has led this field in recent years).

As the ‘what you know’ and ‘how you think’ elements were discussed in the previous parts of this report, here the ‘who you know’ and ‘what you do’ elements of science capital are discussed.

In the pre-questionnaire only, seven items related to science media consumption and participation in out-of-school science learning contexts, and nine items related to specific science projects were included. The findings are presented in Tables 7-8. A further three items in 2018-19 and four items in 2019-20 were included that were designed to gauge the extent to which children are encouraged by their parents to continue with science. In both pre- and post-project questionnaires, additional items were included to gauge whether children talk about science outside of lessons (with their class teacher or classmates) and out of school with key people in their lives (e.g., friends, siblings, parents, grandparents) (Table 9 and Figures 10-14). Open-ended questions were asked to find out what children share about science learning. Qualitative data were also collected to understand who the role models in children’s lives are, inspiring them to pursue science interests.



# Children Challenging Industry



## WHAT YOU DO

A small number of children (1.1%) reported to not engage in any of the science activities outside of school. Others have said they engage in at least some of them, at least some of the time (Table 7).

How often do you do the following	Never (%)	At least once a year (%)	At least once a term (%)	At least once a month (%)	At least once a week (%)	Total positive (at least sometimes) (%)
Go to a museum that is not about science (n=933)	19.8	38.9*	23.7	10.6	7.0	80.2
Do science activities (e.g., science kits, nature walks, experiments) (n=921)	11.4	10.6	21.0	28.2	28.8*	88.6
Read a book or magazine about science (n=924)	30.2*	11.3	14.4	22.1	22.1	69.8
Visit websites about science (e.g., YouTube, Steve Spangler, Billy Nye, Slow Mo Guys) (n=930)	27.4	9.7	10.2	18.9	33.8*	72.6
Visit a science centre, science museum or zoo (n=922)	16.8	36.1*	20.5	13.1	13.4	83.2
Watch a TV programme about science or nature (n=923)	14.1	10.5	12.5	28.4	32.6*	85.9

Table 7. Frequency of engagement in science activities outside school.

\*highest percentage of answers for each activity



# Children Challenging Industry



Independent samples *t*-test (or Mann-Whitney U test where data was not normally distributed) was used to compare the differences between personal characteristics and regions. In terms of gender, differences were observed for most of the specified activities. However, statistical significance was observed for only two items:

- more girls were engaging in 'science activities' than boys - 92.3% compared to 85.2%; (Girls M=3.64, SD=1.247; Boys M=3.42, SD=1.363;  $t(914.887)=2.51$ ,  $p=.012$ ,  $d=0.17$ );
- while more boys than girls were visiting websites about science - 75.4% compared to 69.7% (Boys Mean Rank=489.52,  $n=471$ ; Girl Mean Rank=439.78,  $n=458$ ;  $U=96310.00$ ,  $z=-2.925$  (corrected for ties),  $p=.003$ , two-tailed,  $r=0.1$ ).

In terms of regional differences, pupils in the NE were visiting websites about science significantly more often than those in the EE (NE Mean Rank=478.94;  $n=670$ ; EE Mean Rank=430.85,  $n=60$ ;  $U=78092.00$ ,  $z=-2.538$  (corrected for ties),  $p=.011$ , two-tailed,  $r=0.1$ ). Pupils in the EE were engaging more often in all other activities, however, these differences were not statistically significant.

There were no statistically significant differences observed between year groups (Appendix Table A5).

In response to a question 'Are you a member of a science club?' ( $n=918$ ), a very small number of children responded positively (2.6%), with 43.1% responding no, and more than half – 54.2% choosing a 'I'm not sure my school has a science club' option. No significant regional, gender or year group differences were observed here.

The majority of children (61.5%) have not conducted (or were not sure whether they have) any of the activities listed in the questionnaire (Table 8 overleaf). The largest percentages of children have conducted three (7.0%), four (9.4%) or five (9.0%) of the activities.

An independent samples *t*-test, one way between-group ANOVAs (or Mann-Whitney U test where data was not normally distributed) was used to compare the differences between personal characteristics and regions. Some differences were observed in parental attitudes (or rather children's perceptions of these). Boys have reported that their parents/carers think science is interesting more often than girls (68.2% compared to 64.5% choosing 'agree a little' or 'agree a lot'). More boys said that their parents/carers think it is important for them to learn science than girls did (75.3% compared to 73.1%). Boys have also said that their parents/carers would be happy if they become scientists more often than girls did (62.8% compared to 57.8%). These observed differences were not statistically significant. However, boys were statistically significantly more often (66.0% compared to 52.5%), saying that their parents/carer would be happy if they become engineers than girls (Boys Mean Rank=269.67,  $n=238$ ; Girls Mean Rank=230.00,  $n=259$ ;  $U=25901.00$ ,  $z=-3.208$  (corrected for ties),  $p=.001$ , two-tailed,  $r=0.14$ ).





# Children Challenging Industry



Have you ever done any of the following?	No %	Don't know %	Yes %
Made slime (n=929)	53.6	13.8	32.6
Tried the coke and mentos experiment (n=927)	31.1	3.1	65.8
Made rainbow milk (n=922)	78.4	4.2	17.4
Done the bottle flip (n=927)	5.9	2.5	91.6
Made a fruit battery (n=911)	80.0	6.9	13.1
Bounced a raw egg, after putting it in vinegar (n=923)	71.0	4.7	24.4
Made a 'lava lamp' (n=924)	55.0	5.7	39.3
Made a bubble snake (n=919)	76.6	7.7	15.7
Made 'gloop' from cornflour and water (n=917)	54.1	6.5	39.4

Table 8. Specific popular science projects.



# Children Challenging Industry



No statistically significant regional variances were observed, with very similar answers in both NE and EE. The highest observable difference was in the proportion of pupils saying that their parents/carers would be happy if they become engineers (65.7% in EE agreeing at least a little, compared to 57.1% in NE region).

Although these differences are not statistically significant, children in Year 4 agreed that their parents/carers think science is interesting (77.8% compared to 63.7% Y5, and 67.5% Y6). They also said that their parents/carers think it is important to learn science more often than older children (83.3% compared to 72.9% Y5, and 74.5% Y6).

Statistical significance was observed for the remaining two items, between year 5 and 6 children:

- Year 6 children said more than year 5 children, that their parents/carers would be happy for them to become scientists - 62.6% compared to 56.1% (Year 6 M=3.88, SD=1.186; Year 5 M=3.60, SD=1.317;  $t(697.718)=-3.200$ ,  $p=.001$ ,  $d=0.35$ ).
- Year 6 children said that their parents/carers would be happy for them to become engineers more often than Year 5 children - 63.7% compared to 52.4% (Year 6 M=3.86, SD=1.191; Year 5 M=3.53, SD=1.354;  $t(410.165)=-2.799$ ,  $p=.005$ ,  $d=0.23$ ).

## *Sharing experiences of learning with others*

In the pre-programme questionnaire, children were asked how often they talk about the science they've learnt at school, and who they talk to. The findings are presented in Figure 10. In the post-programme questionnaire, they were asked the same questions in relation to sharing experiences of the advisory-teacher-led science sessions, visit from an industry ambassador, and visit to industry. The findings are presented in Figures 12-14. Children were also asked open ended questions, to gauge what is it that they share with others about their science learning, and what responses they receive. These findings are also presented below.

During the pre-project stage, the majority of children (84.1%) reported speaking to someone about science at least some of the time, with some 50.9% sharing their experiences of science learning at school on a weekly basis.

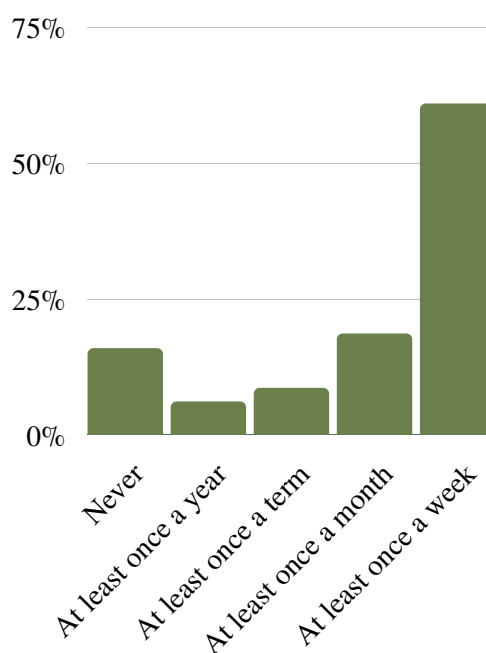


Figure 10. Frequency of engagement in discussions about science with family. (n=924)



# Children Challenging Industry



Again, an independent samples *t*-test, one way between-group ANOVAs (or Mann-Whitney U test where data was not normally distributed) was used to compare the differences between personal characteristics and regions.

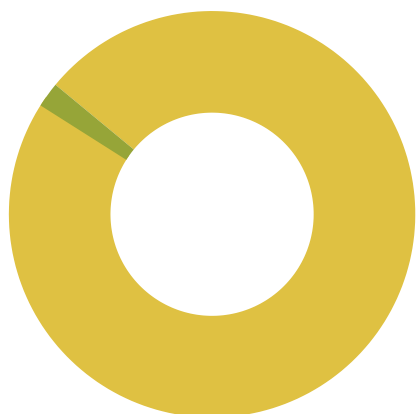
Boys reported to ‘never’ talk about what they’ve learned with a family member more often than girls (17.9% compared to 13.6%). On the other hand, girls more frequently said that they talk to someone in their family about science at least once a week (55.8% compared to 46.2.%). The overall difference between girls and boys was statistically significant (Girls Mean Rank=488.07, *n*=455; Boys Mean Rank=230.00, *n*=259; *U*=94607.00, *z*=-3.165 (corrected for ties), *p*=.002, two-tailed, *r*=0.1).

Most children reported talking to their mother/stepmother/female carer (89.6% of those who reported talking to someone, *n*=777) and father/stepfather/male carer (73.2%). A slightly higher number of girls reported speaking to mother/stepmother/female carer (92.62% compared 86.5%), while more boys reported speaking about science to their father/stepfather/male carer (74.0% compared to 72.5%).

There was a statistically significant regional difference, with children in the NE talking about science more often than those in the EE (NE Mean Rank=473.38, *n*=667; EE Mean Rank=434.26, *n*=257; *U*=78452.50, *z*=-2.156 (corrected for ties), *p*=.031, two-tailed, *r*=0.1).

The youngest children reported talking to their family members most (only 11.1% saying they ‘never’ talk about science with family, compared to 14.9% Y5 and 16.9% Y6), but the difference is not statistically significant. More year 4 children speak to their mother/stepmother/female carer (93.8%, compared to 89.7% of Y5 and 89.4% of Y6) and to their grandparents (56.3% compared to 47.4% of Y5 and 43.3% of Y6 children), while more year 5 children speak to their father/stepfather/male carer (73.8% compared to 65.6% of Y4, and 73.4% of Y6 children). See Table 9 overleaf for an overview.

The programme has been successful in so far as only 21 of the 940 pupils (2.2%) reported that they did not speak to anyone about the activities they completed during the CCI programme:



Of those 21, only nine pupils are the same who have previously reported to ‘never’ speak about science with family or friends. Eighty-three of the pupils who would not normally share their learning experiences have reported to have told someone about their CCI experience.

Figure 11. Proportion of pupils who did not speak to anyone about any of the CCI programme (*n*=940).



# Children Challenging Industry



	Mum/ stepmum/ female carer	Dad/ stepdad/ male carer	Brother/ sister/ cousin	Grandparents	Aunt/ Uncle	Other**
Total children talking about their science learning at school (n=777)	696 (89.6%)	569 (73.2%)	254 (32.7%)	353 (45.4%)	191 (24.6%)	113 (14.5%)
Girls (n=393)	364 (92.4%)	285 (72.5%)	140 (35.6%)	170 (43.3%)	96 (24.4%)	57 (14.5%)
Boys (n =384)	332 (86.5%)	284 (74.0%)	114 (29.7%)	183 (47.7%)	95 (24.7%)	56 (14.6%)
Year 4 (n =33)	30 (90.0%)	21 (63.6%)	4 (12.1%)	18 (54.5%)	9 (27.3%)	4 (12.1%)
Year 5 (n =302)	271 (89.7%)	223 (73.8%)	106 (35.1%)	143 (47.4%)	77 (25.5%)	49 (16.2%)
Year 6 (n =443)	396 (89.4%)	325 (73.4%)	144 (32.5%)	192 (43.3%)	105 (23.7%)	60 (13.5%)

Table 9. Count and percentage of children talking about science learning with key people in their lives (pre-project). \*\* Included in other were friends, teacher, tutor, childminder, pets and unidentified 'other'.

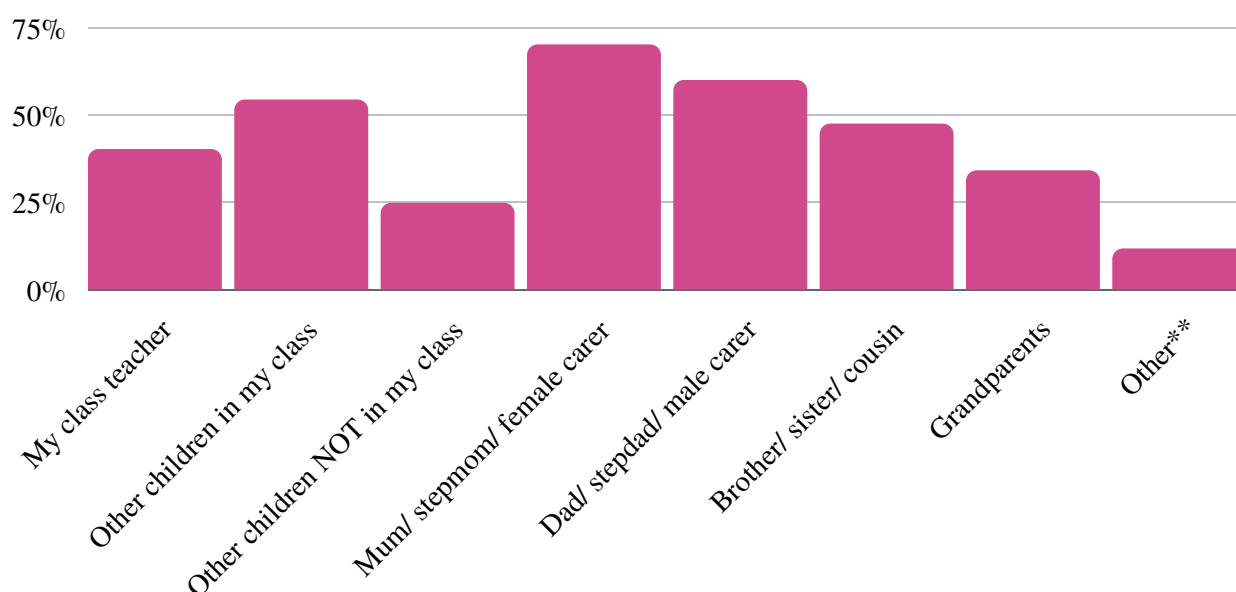


Figure 12. Percentage of children talking about science lessons with the **advisory CCI teacher** with key people in their lives (n=940). \*\*Included in other were friends, teacher, tutor, childminder, pets and unidentified 'other'.



# Children Challenging Industry



88% of pupils (n=940) reported speaking to somebody after their advisory-teacher-led lesson(s). A common theme in the qualitative responses was that the children enjoyed the ‘fun’ and ‘interesting’ session with the advisory teacher, and they wished they could do it again.

***"I told them these were amazing experiments and I had learned a lot."***

(Boy, Year 5, NE)

***"They were fun [way] to learn about things we haven't learnt about before."***

(Girl, Year 5, NE)

Many children reported talking about specific science activities and what they have learnt in the lesson:

***"I told them how fun it was and what I learnt from the lessons. I told them the results on the different experiments that we did and also how we learned about different types of jobs."***

(Girl, Year 6, EE)

***"I really liked it and that it was really fun. I also told them about the main focus of the experiment."***

(Girl, Year 6, NE)

Several children said that they have recommended these activities to their friends and siblings, and that they believed all schools should participate in similar programmes:

***"[I said] that it was really fun and if I could do it again I would. I also told my little brother if he ever got to do the lessons I did he would love it too, and he would hopefully have as much of an enjoyable experience as I did."***

(Girl, Year 6, NE)

***"[I said] that it was very interesting, and I would recommend it to other schools."***

(Boy, Year 6, NE)



# Children Challenging Industry



Some children have said that it had inspired them to learn more and pursue science in the future:

***"I said that it was very fun and hopefully I would carry on science (...)."***

(Girl, Year 6, NE)

***"(...) it inspired me more to become an engineer."***

(Boy, Year 5, NE)

***"That we had lots of fun and I may want to be a scientist when I am older."***

(Girl, Year 5, EE)

Children reported that their family members, class teachers, friends and other people they have spoken to about the class were generally excited for them, often asking probing questions to learn more about the specific experiments conducted in class and offering more information about science.

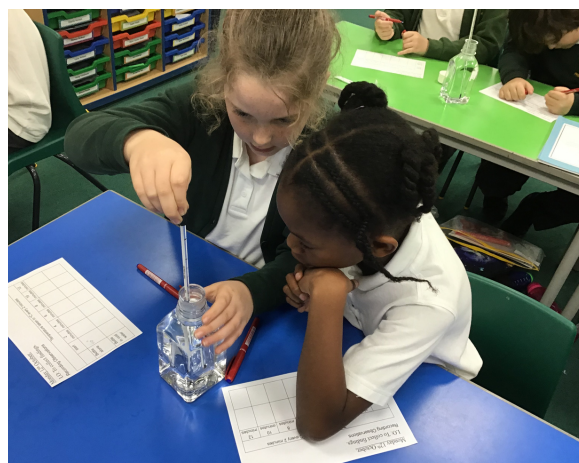
***"My parents said they were glad that I liked my experience and my brother said he would like to do the same lessons and trips I have."***

(Girl, Year 6, NE)

***"They had said that they were proud of me because of all the stuff I learned."***

(Boy, Year 5, NE)

Some parents have suggested repeating the experiments at home, while others expressed hope that children will be able to participate in more CCI or similar activities soon.







# Children Challenging Industry

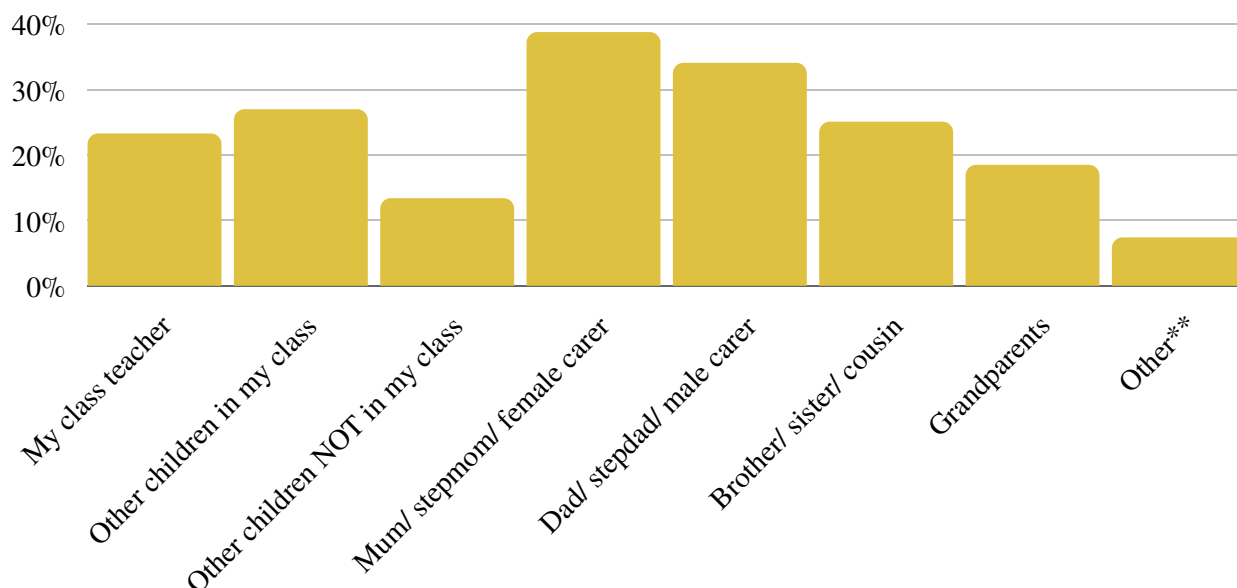


Figure 13. percentage of children talking about a visit from **industry ambassador** with key people in their lives. \*\*Included in other were friends, teacher, tutor, childminder, pets and unidentified 'other'.

79.5% of pupils (n=483) reported speaking to somebody after their visit from the industry ambassador. Similarly, after the advisory teacher sessions and visit from the industry ambassador, children shared with their family and friends how much they have enjoyed the session, and what they have learnt:

***"[I said to them] That I got to meet someone that worked in science and it was really fun."***

(Boy, Year 6, NE)

***"[I said] That it was inspiring and fun."***

(Girl, Year 6 EE)

***"[I said] That it really helped my learning to see a real worker!"***

(Boy, Year 6, NE)



# Children Challenging Industry



Many children complimented the ambassador, and reflected on their industry careers:

***"I said she was very clever, kind and helpful."***

(Girl, Year 6, NE)

***"That she was very enthusiastic to teach us."***

(Boy, Year 6, NE)

***"I told them that they have lots of different jobs in the industry."***

(Girl, Year 5, EE)

***"How amazing their jobs were (...)."***

(Girl, Year 5, EE)

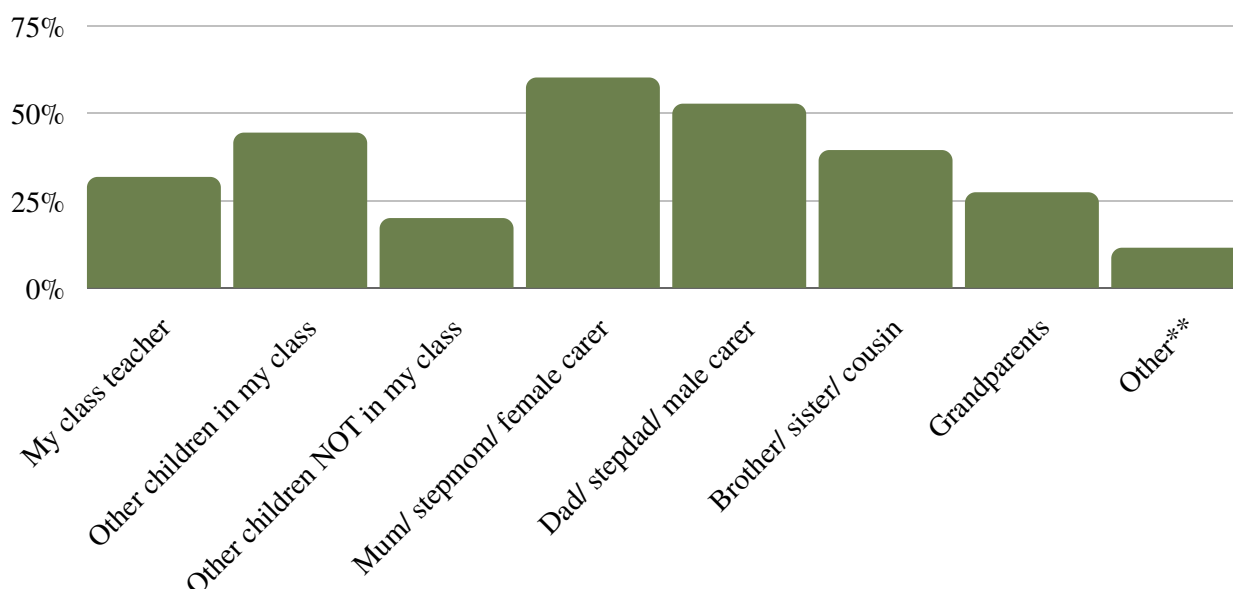


Figure 14. Percentage of children talking about a **visit to industry site** with key people in their lives.

\*\* Included in other were friends, teacher, tutor, childminder, pets and unidentified 'other'.

A majority (88%) of pupils (n=878) reported speaking to somebody after their visit to industry site. Many reported to have told others that they would like to go back and learn more:



# Children Challenging Industry



***"I told them that I had a brilliant time and learnt a lot about the industry, especially when seeing it in the flesh."***

(Girl, Year 6, NE)

***"There were some exciting experiments, and I had a lot of fun."***

(Boy, Year 6, NE)

***"That it was really cool visiting a place that scientists work in nearly every day."***

(Girl, Year 6, NE)

Several children shared specific activities they have enjoyed, and their observations about the industry and people working in it:

***"[I've told them] How busy but well organised everything was and how efficient people were."***

(Girl, Year 6, NE)

***"[I've said that] It was fun, and they [scientists and engineers working in industry] know a lot of stuff. And they are very clever!"***

(Boy, Year 6, SE)

The industry site visits have made a particular impression on some children who have told their close ones:

***"It was fascinating." (Boy, Year 6, EE) and 'It was the best and I'm working there when I am 16."***

(Boy, Year 4, NE)

***"That science is really fun, and I really enjoyed seeing all these amazing people who are creating the future today."***

(Boy, Year 6, EE)



# Children Challenging Industry



Children have said that the responses they have received were very positive:

***"They said that it sounded like a once in a lifetime experience."***

(Girl, Year 6, NE)

***"That they [were] very happy for me and that the[y are] happy for me to go into the industry."***

(Girl, Year 5, EE)

***"My parents were pleased to hear that I had fun, and my friends and I could mostly all agree that it was super good fun!"***

(Girl, Year 5, EE)

Several parents and other family members have reportedly reflected on their own science learning experiences and science careers, and have discussed with children the value of learning science at school:

***"They said that I should carry on science in the future (...)"***

(Girl, Year 6, NE)

***"They would like me to get involved in more science activities around school."***

(Girl, Year 5, NE)

They also encouraged children to consider science and engineering for future career:

***"They said that they were happy I was into STEM subjects and that industry is a very good job."***

(Girl, Year 6, NE)

***"That science is a good career and something I should aim for as it is a very good paying job, and that it sounds really fun and interesting."***

(Girl, Year 6, EE)

***"That maybe I could be like that one day!"***

(Boy, Year 6, NE)



# Children Challenging Industry



Further qualitative data were collected in the pre-programme questionnaire, to understand who the role models in children's lives are, inspiring them to pursue science interest. Children mentioned most often:

1) Their parents, grandparents, siblings and other family members (153 children)

***"My dad has made me very interested in science because he shows me lots of science stuff like flowers space underworld /ocean it's amazing the way how life works it inspires me to be a scientist when I grow up."***

(Girl, Year 5, EE)

***"My mum say that science is in football, so I started to like science a lot more."***

(Boy, Year 6, EE)

2) Science teachers (88 children)

***"She has showed me that science isn't just about written work."***

(Girl, Year 6, NE)

***"She taught us that it is fun to do science and enjoy working with the people around us."***

(Boy, Year 6, NE)

3) Famous scientists, including e.g., Maria Curie Sklodowska, Sir David Attenborough, Sir Stephen Hawking, Isaac Newton, Albert Einstein, Thomas Edison, Charles Darwin, Professor Brian Cox (83 children)

***"Because even though he [Stephen Hawking] had a disability he kept his dream of being a scientist."***

(Girl, Year 6, NE)

***"Because he [Albert Einstein] failed his maths GCSE but he was a maths genius."***

(Boy, Year 4, NE)



# Children Challenging Industry



Few children have also cited YouTube and television programmes, and their friends.

In the post-programme questionnaire, several children further referred to the visits they have received from the industry ambassadors, and the site visits as inspiring:

*"You have inspired me to be a technician when I grow up (...)."*

(Girl, Year 5, SE)

*"I (...) liked seeing the scientists and all the other people as they inspired me to get into the STEM industry."*

(Girl, Year 6, SE)

Of the three types of activities, children reported speaking least about their visits from an ambassador, although it is possible that some children have confused the role of advisory teacher and industry ambassadors. Most children reported speaking to their mother/stepmother/female carer and father/stepfather/male carer. A smaller number of children (in comparison to the pre-programme questionnaire) reported speaking to their grandparents, but more children reported speaking about their experiences with science to their siblings and cousins.

Overall, many children engaged in some science-related activities at home and reported discussions about their science learning with family members and friends prior to participating in the CCI programme. The 'exciting', 'fun' and 'hands on' activities linked to real-life careers and applications undertaken during the programme, however, appear to have further raised children's interest in science learning, and aspirations to pursue science and industry professions. Children shared their experiences more often during/after the programme, engaging with those close to them in conversations about the role of science and industry and related career opportunities. This is an important finding considering the pivotal role of parents in helping children form educational aspirations (Archer et al., 2012) and think about career choices (Otto, 2000; Kniveton, 2004), including in STEM (Lloyd et al., 2018), as children are much more likely to talk about this to family than teachers.

Looking at all the findings from qualitative and quantitative data together, we can say that children participating in the CCI programme have generally had a positive experience, learning a lot about the careers within the industry, and showing considerably improved attitudes both towards science (including science learning), and industry, and showing greater interest in pursuing STEM careers. The hands-on nature of the activities, involvement of science and industry professionals and the industry visit appear central to the success of the programme. This aligns with findings cited in other literature, suggesting that out-of-school trips have positive motivational effects (De Witt & Storksdieck, 2008; Wünschmann et al., 2016).





## 4.2 Teachers' data

### 4.2.1 Sample

Teachers involved in observing the CCI classroom sessions were asked to complete pre- and post-programme questionnaires. Thirty-one teachers (from 26 schools) completed the pre-questionnaire, and 17 teachers (from 17 schools) completed the post-project questionnaire. As teacher questionnaires are anonymous, it is not possible to pair pre- and post-programme questionnaires. Instead, they were considered separately with descriptive statistics used to describe the features of the data. Not all teachers answered all the questions in the pre- and post-programme questionnaires leading to variable sample sizes per question.

### 4.2.2 Results

#### Motivations for Participation

In the pre-programme questionnaire, seven of the 31 teachers reported that their school has links with external organisations, but only three teachers specified that their school has a policy on such external links which include industry. Six teachers reported that they have used teaching resources produced or sponsored by industry or industry organisations before (including three teachers citing use of CIEC resources), and eight teachers have organised visits to industry in the past.



The average amount of science CPD undertaken by teachers (n=21) in the past three years was 3.3 days, with six teachers having done none, and six teachers having completed one day in three years. From these findings, it seems that the CCI programme is playing a crucial role in affording teachers the opportunity to receive science CPD. Indeed, although the majority of teachers chose opportunities for children to learn about science and industry as 'the main attractions of taking part in the CCI programme', nine teachers (43%) have selected professional development as a second (of four) and 17 (81%) as a third most important objective for the classroom session. Several teachers have also mentioned the science CPD as an important objective of the CCI programme as a whole in their qualitative comments:



# Children Challenging Industry



*“CPD for me! Having contact with specialist science teachers who can inspire learning and interest in science that we don't have the capacity to do.”*

*“Opportunity to observe teaching. Raising the profile of industries with the children. Hopefully inspiring children especially girls.”*

*“CPD for staff, new ideas in the classroom, engagement of children in science in the real world.”*

*“To upskill myself as a teacher and as a science coordinator.”*

*“Reinforces what we teach through science enquiry by another person. The activities are challenging and exciting working with other pupils from different tutor groups. The site visit then links everything they've been working on which really inspires the pupils in the world of science.”*

*“Developing a positive attitude and appreciation toward science and engineering, and to develop an awareness of possibilities in STEM careers. To also further my own knowledge and skills in teaching science in the classroom.”*

*“Observing others teach is a wonderful learning opportunity for us teachers. I am very, very keen for the children to connect what they learn in class with the 'real world' and the relevance it has. Science with a purpose. Also, keen to forge links so that maybe other opportunities will evolve to enhance our curriculum.”*



# Children Challenging Industry



Ten teachers reported having been previously involved in the CCI programme, and all have reported that their previous involvement has inspired them to do further lessons or activities that were influenced by their experience of CCI:

***“We ran a science residential weekend which covered 2 of the projects and a school science fair for parents to attend.”***

***“I changed the way I carried out Science investigations and tried to incorporate more opportunities to link the Primary Science curriculum that I taught to 'real-life' Scientists and Science experiments.”***

***“I looked carefully at the way we conducted investigations to make them more purposeful and focused and to allow Y6 children to develop their enquiry skills more effectively; I also made more effort to look at how our science topics link to real-life jobs in Science and Industry and ensure that I point this out to the children.”***

***“We have been running this programme at school for 6 years. We have benefited from the investigations, resources and site visits. It actually impacted on decisions some pupils made at GCSE and A level.”***

After the programme, all teachers (n=15) have said that their expectations of the programme were met, illustrating how well-received the programme was by all teachers.



# Children Challenging Industry



## Attitude to Industry

In both pre- and post-project questionnaires, teachers were asked to respond with their level of agreement with an array of statements designed to gauge their attitudes towards industry and jobs it offers (5-point Likert scale, 'Strongly disagree' to 'Strongly agree'). Although no direct pre-post programme comparison of teachers' attitudes towards industry cannot be made as teachers' responses could not be matched, overall, the responses were more positive after the participation in the CCI programme.

Before the programme 28% of participating teachers (n=29) have 'Partially disagreed' and further 21% were undecided, whether 'Industry causes as little pollution as possible'; after the programme, no teachers disagreed, and only 13% remained undecided (n=16), indicating an improvement in attitude. There was also an increase in the fraction of teachers answering 'Partially agree or 'Strongly agree' in relation to the following statements:

- 'Industry improves our quality of life' - 90% pre-programme to 94% afterwards,
- 'Industry creates wealth and boosts our economy' – 86% to 88%,
- 'Industry provides many career opportunities' – 62% to 100%.

There was also an increase in the proportion of teachers answering 'Partially disagree' or 'Strongly disagree' in relation to the following negatively phrased statements (and thus, indicating improved attitudes):

- 'I feel negative about industry' – 79% to 87%,
- 'Industry has a negative impact on the environment' – 28% to 50%,
- 'A job in industry would be tedious' – 55% to 63%.

A negative change in the fraction of teachers answering 'Strongly' or 'Partially agree' has been noted in relation to only one statement - 'Industry offers interesting and rewarding jobs' – decreasing from 96% - to 88%. However, as noted above, as teachers answers could not be paired and as pre- and post-project sample sizes differed, it cannot be conclusively claimed that the lower proportion indicates worsening of attitudes.

## *Science Capital & Science Teaching*

In the pre-project questionnaire, teachers were asked about their knowledge and understanding of the term 'science capital'. Only three teachers had heard the term before. Nine said they were unfamiliar with it and a further 17 were unsure what it meant. After being provided with the definition of science capital in the next question, all teachers (n=29) responded saying they considered it to be 'quite' (11) or 'very' (18) relevant to their teaching. Some teachers elaborated on their responses:



# Children Challenging Industry



*“The opportunities for future jobs in Science in our area are great and it is important to ensure all children have the potential to access these careers if they choose.”*

*“I think a lot of children can be disengaged from science, as they don't see how it can be used / applied in real world scenarios. I think it's important to be able to show them how they can relate to it.”*

*“Moving forward, I think that Science-related opportunities are going to really boost career opportunities for the children in our school. Many parents work in the Science industry and we would like to promote positive links and attitudes to Science.”*

After the programme, teachers were asked to reflect on how their knowledge and understanding of science capital had changed. Several teachers responded that their understanding of the term had improved and that they now recognised its relevance to science teaching:

*“It has definitely broadened my understanding of the potential for Science-related jobs in our local area.”*

*“I feel I am more aware of it and feel I should encourage my own and the children in my class to get more involved [in science activities].”*



# Children Challenging Industry



Before participating in the CCI programme (62.1%, n=29) teachers rated feeling comfortable with teaching and learning about STEM at more than 50 (on a scale of 1 to 100, 1 meaning not at all comfortable, and 100 meaning fully comfortable). Confidence levels regarding teaching STEM were not related to the level of science qualification held by teachers (GCSE to postgraduate degree). One teacher, for example, said:

***“I don't feel that I have a wide enough understanding about Science beyond the parameters of the National Curriculum, therefore if the children ask a question that is not part of my planned lesson, I am worried about being able to answer them correctly / in as much detail as they would like at Year 6.”***

A slightly smaller proportion (57.1%, n=28) rated feeling comfortable teaching about the role of STEM in everyday life and only 39.1% rated feeling comfortable teaching about STEM-related careers at more than 50 on the 1-100 scale.

In response to questionnaire items asking teachers what they found most difficult about teaching STEM, “staying up to date with subject knowledge” and “making science lessons exciting and relatable” were the responses cited most often. Other specific examples mentioned by teachers included:

***“Teaching and resourcing of technology and engineering activities.”***

***“Scientific terminology at upper key stage two, as I always shy away from pushing the children for specific terms, thinking they might not be able to apply them properly. For example, words relating to the circulatory system, DNA and evolution.”***

***“Science in everyday life to inspire children to seek work in the areas. Specific job roles that are classed as STEM.”***





# Children Challenging Industry



Several teachers noted that in-class discussions about careers are not part of the curriculum and that, when they occurred, if they took place at all, it was on an adhoc rather than a planned basis. While some teachers reported inviting parents and local companies to speak about STEM careers at school, others reported struggling with knowing how to integrate discussions about STEM careers into their classroom teaching:

***“[I] integrate them into my topic plans where appropriate, but I don't feel I know about a wide-enough range of STEM-related careers to do this more confidently.”***

The proportion of teachers that reported feeling comfortable about teaching STEM-related careers did not change following participation in the CCI programme. However, a higher proportion of teachers (71.4%, n=14) rated feeling comfortable teaching about the role STEM plays in everyday life at over 50 (on a 1-100 scale). Several teachers commented on particular aspects of their science teaching they felt had been improved through participation in the programme:

***“Following this programme, I am far more confident in teaching the Electricity unit of work as I had not taught it previously.”***

***“I would be more confident to plan practical activities that are child led, as the children were so engaged by them and really enjoyed the learning.”***

***“My approach to investigative Science has changed completely. The lesson I delivered really showed me how opportunities could be given for more discussion about results and opportunities to re-test. Something that I have found difficult to include in the past.”***



# Children Challenging Industry



Teachers were also asked to estimate how many children in their class engage in out of school science learning activities. These findings are summarised in the table (10) below. Teachers' estimations were generally in-line with pupils' responses, although more children reported speaking about their science learning at school than teachers thought.

How many of the children in your class...	0-25%	26-50%	51-75%	76-100%
Have the potential for a career in STEM (n=28)	21.4 %	42.9%	28.6%	7.1%
Have expressed an interest in a future in STEM (n=26)	61.5%	19.2%	11.5%	7.7%
Have a family member who has a career in which STEM plays an important role (n=21)	66.7%	19.0%	9.5%	4.8%

Table 11. Teachers' perceptions about pupils' STEM potential, aspirations, and science capital.

Finally, a set of questions relating to teacher's own science capital were asked in 2019/20. A few teachers reported engaging in STEM-related activities in their own time, often with their children:

***“I have a son who is 7 and is particularly interested in Science; because of this, I engage / have engaged in more STEM related activities in the last few years than I would have done otherwise. These might be reading non-fiction books based on STEM topics, watching programmes on TV, YouTube videos, working on STEM activities / toys, visiting museums / working STEM-related places.”***

When reflecting on those who influence their views about STEM, teachers cited their partners, parents or other family members with STEM careers, or their young children who had shown an interest in science learning, or now grown-up children working in STEM.



# Children Challenging Industry



## *Programme Evaluation*

Following completion of the project, teachers (n=17) rated the CCI programme very highly overall, either as ‘excellent’ (82.4%) or ‘good’ (17.6%). They also rated individual aspects of the programme very highly, as either ‘very good’ or ‘fairly’ good, as represented below:

- Site visit (n=16): ‘Very good’ 93.8% // ‘Fairly good’ 6.2%
- Ambassador visit (n=8): ‘Very good’ 100%
- Classroom session from advisory teacher (n=17): ‘Very good’ 94.1% // ‘Fairly good’ 5.9%
- Classroom session led by the teacher (n=14): ‘Very good’ 78.6% // ‘Fairly good’ 21.4%
- Whole staff CPD(n=8): ‘Very good’ 100%

Teachers were given a list of eleven statements and asked to indicate which they considered true regarding the strengths of the classroom-based training. They were also given the option to highlight anything they felt had been a particular strength of the programme not included in this list. Teachers identified the following facets of the programme as its main strengths: expert knowledge of science and practical science activities (88.2%), children’s investigative skills (82.4%), equipment provision and expert knowledge of industry (70.6%), career aspirations (64.8%) and group work (58.8%).

Next, teachers were asked to indicate how the programme had affected their own knowledge and teaching practice (Table 12). They were asked to rate how effective they perceived the classroom sessions to be in providing a link with the industry and the role played by the site visit in reinforcing these sessions (Table 13). Responses were given on a five-point Likert scale (Strongly disagree to Strongly agree).

How much do you agree with the following statements...	Strongly disagree %	Partially disagree %	Neither agree nor disagree %	Partially agree %	Strongly agree %
My knowledge of industry has improved	-	6.7	-	26.7	66.7
My confidence to teach science has improved	-	13.3	20.0	33.3	33.3
I will use the written resources again	-	6.7	13.3	26.7	53.3
I would now be confident to arrange visits to or from industry	-	-	6.7	33.3	60.0

*Table 12. Impact of the CCI programme on teachers’ knowledge and practice.*



# Children Challenging Industry



How much do you agree with the following statements...	Partially agree %	Strongly agree %
The classroom sessions offered an effective link with industry	20.0	80.0
The site visit reinforced the classroom session	26.7	73.3
The side visit is a valuable part of the programme	13.3	86.7

Table 13. Teacher's perceptions about the effectiveness of classroom sessions and site visits.

Teachers said that both they and their pupils enjoyed the programme and found it useful:

***"The pupils were incredibly engaged and thought the tasks were exciting."***

***"It really helped us to see how the 'working scientifically' strand of the curriculum can be used to drive lessons."***

***"The children continue to talk about their experiences. It was honestly like nothing else that [they] have taken part in. Very well thought out and put together from the initial letter from the industry to hook the children, the science experiments and the trip to the industry. Amazing!"***

***"The children got a lot [out] of the science experiments they were involved in and it being a real-life problem they had to solve was really exciting and made the link to industry and the real world."***



# Children Challenging Industry



*“Pupils really enjoyed the activities and having a visitor in the class. We got to complete experiments that we would not normally complete. Pupils really enjoyed the visit to the site - they loved seeing the different investigations/displays set up for them.”*

*“Children were enthused and excited by the project. It gave them the opportunity to think about careers that they may not have considered.”*

*“We had two excellent sessions in class and the children gained so much from the knowledge and enthusiasm of the advisory teacher.”*

*“Children benefit greatly from having 'real life' experiences and being taught by a Science specialist from industry. It appeals so much more than being taught by their teacher. Superb CPD for teachers who are not especially confident in chemistry and for schools with limited resources.”*

*“Both the children and I have learned so much from the CCI programme. As well as learning about Industry, it really has opened my eyes about creative ways I can teach investigative Science. During and since the project, I have found so many links between the themes we discussed in the CCI programme and other areas of the curriculum and it really has helped make these links more relevant to the children. Thank you so much for involving us.”*



# Children Challenging Industry



Teachers also reported that following their involvement in the CCI programme they had been inspired to do more STEM lessons and activities in their teaching:

***“It's inspired me to make greater efforts to connect their science learning with real-life science.”***

***“We were in the Ofsted framework and being heavily monitored at the time of the visit I was careful to record all sessions in the children's books - this is not recommended by CCI but was invaluable evidence.”***

***“I loved the enthusiasm of the advisory teacher and I have since used some of the terms and techniques that she modelled in sessions in class.”***

***“Due to H[ealth] & S[afety] I am wary of using chemicals and open flame in class but [advisory teacher] modelled a very safe example and all children were actively engaged and working in a safe and sensible manner. I will consider these more 'risky' hands-on activities in future.”***

***“I plan to find more opportunities to include practical Science in my Science teaching.”***

Overall, teachers rated the CCI programme highly, with both the quantitative and qualitative data indicating how well it was received. Both children and teachers enjoyed the industry visits and the variety of hands-on classroom activities included in the programme. In sum, the teacher-focused aims of the CCI programme were met.





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## Appendix - Details of Statistical Analysis

STATEMENT	Improvement of whole sample (paired t-test)
I like science (n=935) *	(t(934)=2.18, p=.030, d=0.07)
I'd like to be a scientist (n=918) *	(t(917)=4.25, p<.001, d=0.14)
Science is my favourite subject (n=915)	(t(914)=-0.528, p=.598, d=0.02)
I'd like to be an engineer (n=914)	(t(913)=1.70, p=.09, d=0.06)
I'd like to go to a science centre, science museum or zoo (n=915) *	(t(914)=16.20, p<.001, d=0.54)
I'd like to go to a museum that is not about science at all (n=900) *	(t(899)=2.57, p=.01, d=0.09)
I like doing science experiments at home^ (n=502) *	(t(502)=2.00, p=.046, d=0.09)
School science clubs are a good idea^ (n=494)	(t(493)=0.433, p=.665, d=0.02)
I like reading science stories^ (n=500) *	(t(493)=0.433, p=.665, d=0.02)
Science is too difficult^ (n=496) *	(t(499)=-2.09, p=.037, d=0.09)
We do too much writing in science^ (n=498) *	(t(495)=2.48, p=.014, d=0.11)
We do too much science in school^ (n=491)	(t(497)=2.41, p=.016, d=0.11)
We have to do too much work in science^ (n=496)	(t(490)=0.943, p=.346, d=0.04)
We have to do too much work in science^ (n=496)	(t(495)=1.62, p=.106, d=0.07)

Appendix Table A1



# Children Challenging Industry



STATEMENT	Improvement of whole sample (paired t-test)
Industry is useful <sup>^</sup> (n=505)*	(t(504)=7.76, p<.001, d=0.35)
Our lives would be worse without industry <sup>^</sup> (n=489)*	(t(488)=6.84, p<.001, d=0.31)
Industry makes things we need <sup>^</sup> (n=493)*	(t(492)=6.710, p<.001, d=0.30)
Industry causes as little pollution as possible <sup>^</sup> (n=501)*	(t(500)=6.42, p<.001, d=0.29)
Industry is safe (n=921)*	(t(920)=9.40, p<.001, d=0.39)
I could work in industry in the future (n=924)	(t(923)=9.76, p<.001, d=0.32)
Many scientists work in industry (n=929)*	(t(928)=15.95, p<.001, d=0.52)
Many engineers work in industry (n=923)*	(t(922)=10.46, p<.001, d=0.34)
Young people work in industry (n=917)*	(t(916)=5.95, p<.001, d=0.20)
Scientists have important jobs in industry (n= 920)*	(t(919)=10.03, p<.001, d=0.33)
There are women scientists and engineers (n=920)*	(t(919)=6.35, p<.001, d=0.21)
Engineers have important jobs in industry (n= 924)*	(t(923)=9.58, p<.001, d=0.08)
I learn about industry from TV or online (n=492)*	t(491)=3.22, p=.001, d=0.14)
I learn about industry from my teachers (n=500)*	(t(499)=6.96, p<.001, d=0.31)
Industry causes a lot of pollution (n=920)*	(t(919)=9.53, p<.001, d=0.31)
Industry is dangerous <sup>^</sup> (n=495)*	(t(494)=3.68, p<.001, d=0.17)

*Appendix Table A2*



# Children Challenging Industry



STATEMENT	Significant Gender Differences	Significant Region Differences
I'd like to go to a science centre, science museum or zoo	-	East of England region more positive change: $t(913)=2.67$ , $p=.007$ , $d=0.20$
Industry is useful	-	East of England region more positive change: $t(503)=-2.95$ , $p=.003$ , $d=0.33$
Our lives would be worse without industry	-	East of England region more positive change: $t(487)=-2.25$ , $p=.025$ , $d=0.26$
Industry makes things we need	-	East of England region more positive change: $t(491)=-2.37$ , $p=.018$ , $d=0.26$
Industry is safe	-	East of England region more positive change: $t(919)=-2.20$ , $p=.028$ , $d=0.17$
Many scientists work in industry	-	East of England region more positive change: $U=27671.0$ , $z=-2.80$ (corrected for ties), $p=.005$ , $r=0.11$
Many engineers work in industry	-	East of England region more positive change: $U=28148.50$ , $z=-2.43$ (corrected for ties), $p=.015$ , $r=0.09$
Young people work in industry	Girls attitudes have improved more: $t(687)=2.36$ , $p=.19$ , $d=0.18$	East of England region more positive change: $t(688)=-2.19$ , $p=.029$ , $d=0.23$
Scientists have important jobs in industry	-	East of England region more positive change: $t(688)=-2.19$ , $p=.029$ , $d=0.36$
There are women scientists and engineer	-	East of England region more positive change: $t(132.832)=-2.994$ , $p=.029$ , $d=0.33$
Engineers have important jobs in industry	-	East of England region more positive change: $U=26093.50$ , $z=-3.54$ (corrected for ties), $p<.001$ , $r=0.13$
Industry is dangerous	-	-

*Appendix Table A3 Significant differences in pre-post changes for attitudes to science and attitudes to industry items between genders and regions*



# Children Challenging Industry



STATEMENT	Significant Year Group Differences																								
I'd like to go to a science centre, science museum or zoo	<p>Year 4 children's attitudes improved more than those of children in higher year groups</p> <p>Welch's <math>F(2,100.99)=21.08</math>, <math>p&lt;.001</math>, est. <math>\eta^2=.40</math></p> <p>Year 4 - Mean 2.72; Year 5 - Mean 0.97; Year 6 - Mean 1.04</p> <table><tr><td></td><td colspan="3">Mean Differences (<math>\bar{X}_i - \bar{X}_j</math>) (Effect Sizes are indicated in parentheses)</td></tr><tr><td>Year</td><td>4</td><td>5</td><td>6</td></tr><tr><td>4</td><td>--</td><td></td><td></td></tr><tr><td>5</td><td>-1.77* (0.98)</td><td>--</td><td></td></tr><tr><td>6</td><td>-1.68* (0.94)</td><td>-0.07</td><td>--</td></tr><tr><td colspan="4">*<math>p&lt;.001</math></td></tr></table>		Mean Differences ( $\bar{X}_i - \bar{X}_j$ ) (Effect Sizes are indicated in parentheses)			Year	4	5	6	4	--			5	-1.77* (0.98)	--		6	-1.68* (0.94)	-0.07	--	* $p<.001$			
	Mean Differences ( $\bar{X}_i - \bar{X}_j$ ) (Effect Sizes are indicated in parentheses)																								
Year	4	5	6																						
4	--																								
5	-1.77* (0.98)	--																							
6	-1.68* (0.94)	-0.07	--																						
* $p<.001$																									
Industry is safe	<p>Year 6 children's attitudes improved more than those of children in year 5 <math>F(2,918)=4.94</math>, <math>p=.007</math>, <math>\eta^2=.01</math></p> <p>Year 5 (M=0.30, SD=1.57), Year 6 (M=0.63, SD=1.56), <math>d=0.06</math></p>																								
Many scientists work in industry	<p>Year 4 children's attitudes have slightly worsened, while attitudes of children in higher year groups have improved</p> <p>Welch's <math>F(2,112.58)=18.80</math>, <math>p&lt;.001</math>, est. <math>\eta^2=.37</math></p> <p>Year 4 - Mean -0.03; Year 5 - Mean 0.42; Year 6 - Mean 0.57</p> <table><tr><td></td><td colspan="3">Mean Differences (<math>\bar{X}_i - \bar{X}_j</math>) (Effect Sizes are indicated in parentheses)</td></tr><tr><td>Year</td><td>4</td><td>5</td><td>6</td></tr><tr><td>4</td><td>--</td><td></td><td></td></tr><tr><td>5</td><td>-0.446* (0.49)</td><td>--</td><td></td></tr><tr><td>6</td><td>-0.601* (0.72)</td><td>-0.155</td><td>--</td></tr><tr><td colspan="4">*<math>p&lt;.001</math></td></tr></table>		Mean Differences ( $\bar{X}_i - \bar{X}_j$ ) (Effect Sizes are indicated in parentheses)			Year	4	5	6	4	--			5	-0.446* (0.49)	--		6	-0.601* (0.72)	-0.155	--	* $p<.001$			
	Mean Differences ( $\bar{X}_i - \bar{X}_j$ ) (Effect Sizes are indicated in parentheses)																								
Year	4	5	6																						
4	--																								
5	-0.446* (0.49)	--																							
6	-0.601* (0.72)	-0.155	--																						
* $p<.001$																									

Appendix Table A4 Significant differences in pre-post changes for attitudes to science and attitudes to industry items between year groups (1/2)



# Children Challenging Industry



STATEMENT	Significant Year Group Differences																								
Many engineers work in industry	<p>Year 4 children’s attitudes have stayed the same, while attitudes of children in higher year groups have improved (the difference was statistically sig. for year 6 children)</p> <p>Welch’s <math>F(2,92.16)=3.38</math>, <math>p=.038</math>, <math>est. \eta^2=.07</math></p> <p>Year 4 - Mean 0.00; Year 5 - Mean 0.30; Year 6 - Mean 0.37</p> <table><tr><td></td><td colspan="3">Mean Differences <math>(\bar{X}_i - \bar{X}_j)</math> (Effect Sizes are indicated in parentheses)</td></tr><tr><td>Year</td><td>4</td><td>5</td><td>6</td></tr><tr><td>4</td><td>--</td><td></td><td></td></tr><tr><td>5</td><td>-0.296</td><td>--</td><td></td></tr><tr><td>6</td><td>-0.374* (0.43)</td><td>-0.07</td><td>--</td></tr><tr><td colspan="4">*<math>p&lt;.001</math></td></tr></table>		Mean Differences $(\bar{X}_i - \bar{X}_j)$ (Effect Sizes are indicated in parentheses)			Year	4	5	6	4	--			5	-0.296	--		6	-0.374* (0.43)	-0.07	--	* $p<.001$			
	Mean Differences $(\bar{X}_i - \bar{X}_j)$ (Effect Sizes are indicated in parentheses)																								
Year	4	5	6																						
4	--																								
5	-0.296	--																							
6	-0.374* (0.43)	-0.07	--																						
* $p<.001$																									
Industry is dangerous	<p>Year 6 children’s attitudes improved more than those of children in year 5 (no children from year 4 in the sample)</p> <p><math>t(493)=-2.22</math>, <math>p=.027</math>, <math>d=0.2</math></p>																								

*Appendix Table A4 Significant differences in pre-post changes for attitudes to science and attitudes to industry items between year groups (2/2)*

Cohen (1988) suggested that  $r=.1$  could be considered small,  $r=.3$  could be considered medium, and  $r=.5$  could be considered large;  $d=.20$  could be considered small,  $d=.50$  is medium, and  $d=0.80$  is large;  $\eta^2=.01$  could be considered small,  $\eta^2=.059$  could be considered medium, and  $\eta^2=.138$  could be considered large.





# Children Challenging Industry



	Total positive (engaging at least sometimes)				
	Year 4 (%)		Year 5 (%)		Year 6 (%)
Go to a museum that is not about science	69.4	<	78.7	<	81.9
Do science activities (e.g., science kits, nature walks, experiments)	100.0	>	86.5	<	89.2
Read a book or magazine about science	74.3	>	69.4	<	69.8
Visit websites about science (e.g., YouTube, Steve Spangler, Billy Nye, Slow Mo Guys)	83.3	>	69.5	<	73.9
Visit a science centre, science museum or zoo	75.0	<	81.8	<	84.6
Watch a TV programme about science or nature	91.7	>	85.2	<	86.0

*Appendix Table A5 Engagement in science activities outside school by year group*



# Children Challenging Industry





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