Children Challenging Industry

Evaluation Report 2022-23

By Ana Benavides Lahnstein & Joy Parvin

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Table of Contents

I. Report summary

Centre for Industry Education Collaboration (CIEC)

Children Challenging Industry (CCI)

Summary of Evaluation Report 2022-23

The Centre for Industry Education Collaboration (CIEC) aims to promote excellence in primary science teaching and learning, increase children's and teachers' awareness of STEM careers and industries, and raise children's science capital.

Since 1996, the CCI programme has:

- **Connected over 1000** inspiring scientists and engineers (CCI ambassadors) with teachers and children.
- **Empowered** 15,600+ teachers with science professional development.
- **Engaged** 62,000+ primary school children and raised their enthusiasm for STEM careers.

Participation in 2022-23

67 CPD sessions for 1,184 teachers

32 site visits

60% of the programme was delivered in-person and 40% followed a combination of remote and in-person delivery

67 classes with 1,912 children

49% of children went to one of the 32 company site visits and 51% had a CCI ambassador visiting their class (in person or remotely)

The 2022-23 CCI team of advisory teachers

Melanie Boyeson

Clare Docking

Mackayla Millar

Nicky Waller

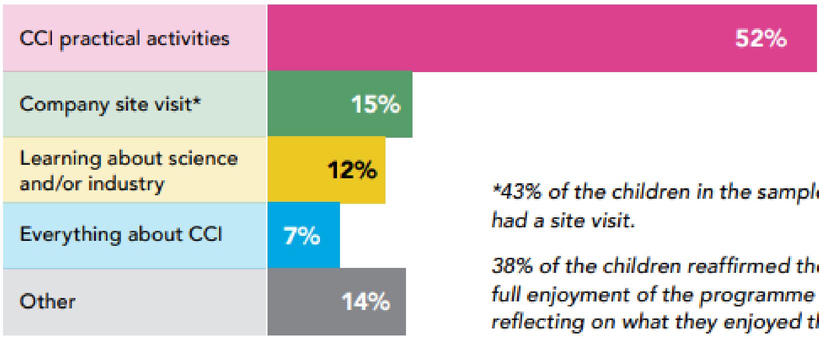
2022-23 Impact Evaluation Sample

- 1,327 children from 60 classes
- 48% of the children were girls and 52% were boys
- 59% of the children were in Year 5, and 41% were in Year 6.

[Enjoyed] all the experiments we did. Because I got to experience a day in the life of a scientist and the experiments were really cool. (Boy, Year 5)

Children described the CCI practical activities and the site visits as their top CCI experiences

What children enjoyed the most about CCI in 2023-23 *(n=1050)*

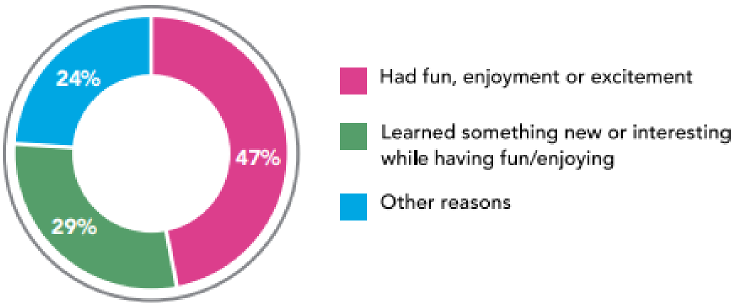


**43% of the children in the sample had a site visit.*

38% of the children reaffirmed their full enjoyment of the programme when reflecting on what they enjoyed the least!

Children enjoyed the CCI practical activities best because they had fun learning something new or interesting

Why children enjoyed the CCI practical activities



it is fun as we get to test/fix different companies problems and discover our own results... (Girl, Year 5)

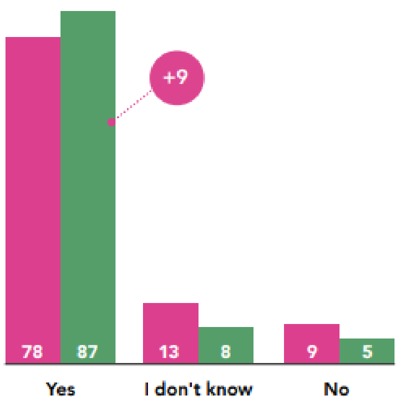
[CCI activities] showed us how fascinating industry is, and how many opportunities there are. (Boy, Year 5)

I enjoyed doing the pop rockets most! Because it was really fun and I got to work in a team and do my own experiments like a real scientist! (Girl, Year 6)

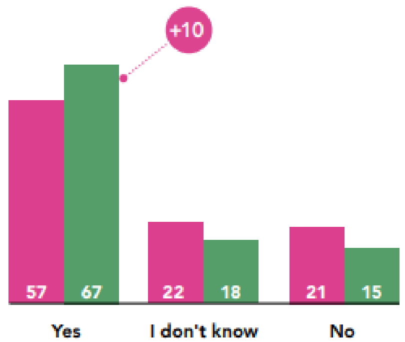
CCI ignites children's curiosity about industry and encourages them to learn with teachers

% Before CCI   % After CCI

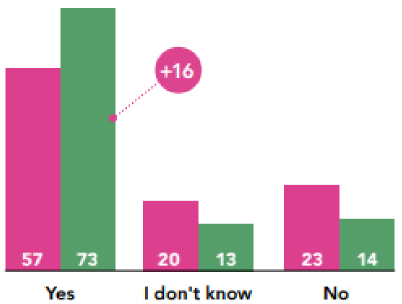
Industry makes things we need



Our lives would be worse without industry



I learn about industry from my teachers



I liked going to [company]. I enjoyed it because I got to see scientists and what they create. (Girl, Year 5)

Children enjoyed the company site visits

It felt like we worked there.
(Girl, Year 6)

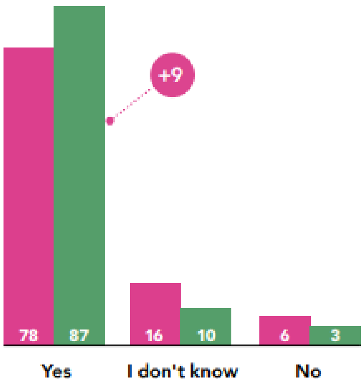
Wearing safety clothing. It made me feel like a real scientist.
(Boy, Year 6)

The trip was amazing. We got to experience industry first hand.
(Boy, Year 5)

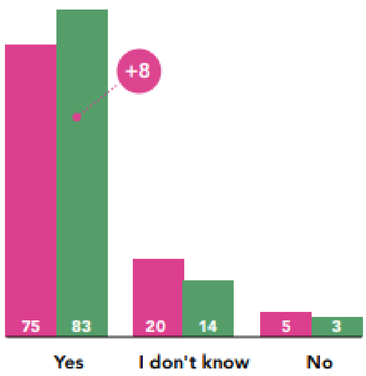
CCI raises awareness of the roles of scientists and engineers in industry

% Before CCI   % After CCI

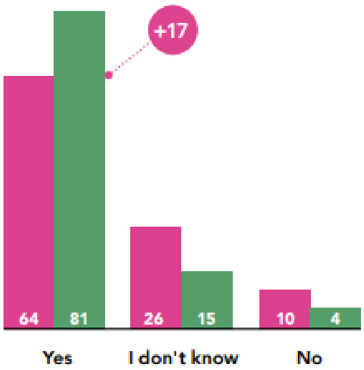
Scientist have important job in industry



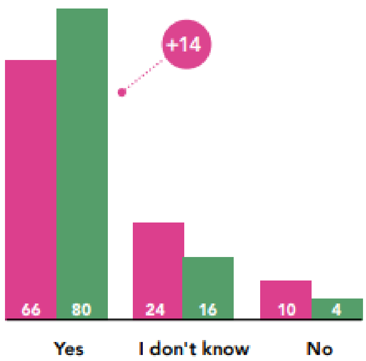
Engineers have important job in industry



Many scientists work in industry



Many engineers work in industry



The trip was amazing. We got to experience industry first hand. (Boy, Year 5)

I would like to be an engineer or a chemist.' (Boy, Year 6)

i would like to manufacture environmentaly healthy packaging. (Girl, Year 6)

CCI closes the gap

Children who saw parents as not interested in science saw a significant rise (11%) in wanting industry jobs after CCI.

We need to continue motivating children into seeing themselves as potential STEM professionals in the future.

Focus on teachers

CCI builds teacher expertise[1]! From reactions to the programme to classroom impact, teachers gain lasting skills.

What do we know about the participating teachers?

Professional experience

- Avg. 12 years in the classroom
- Avg. 2.5 days spent doing Science CPD (last 3 years

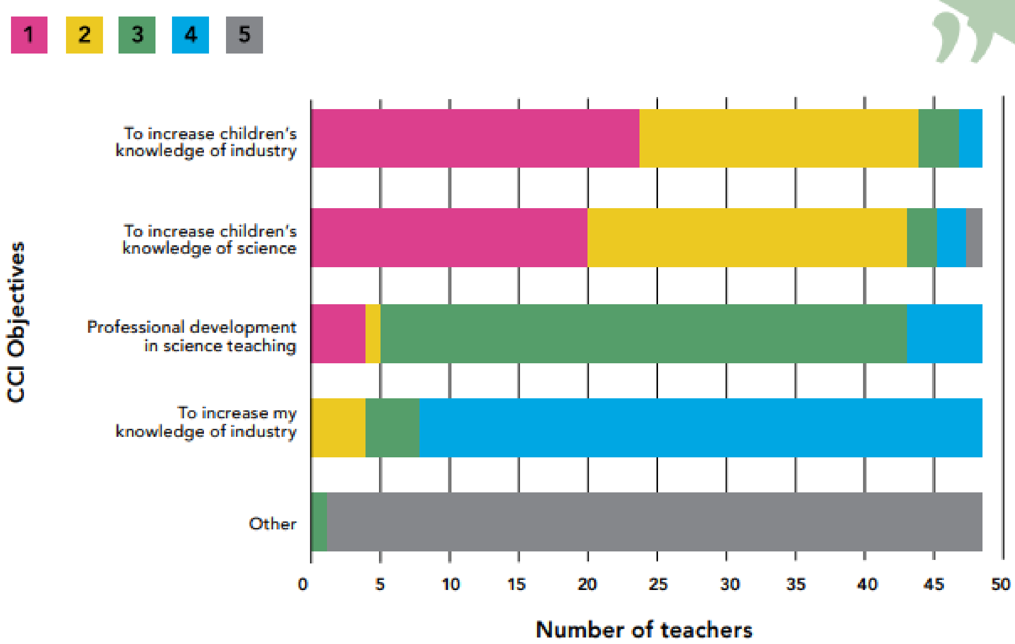
Prior CCI participation

- 17 teachers had previously participated
- 12 of 23 who recognised the 'science capital concept had previously participated in CCI Science Capital CPD

**Pre-questionnaire data, n=49-50*

What are the main objectives of the CCI classroom sessions *(n=48)*

Ranking 1-5 with 5 being the most important objective.



the job that id like to do in industry is making cars and engines. (Boy, Year 5)

[I would like to be] Chemistry scientist who tests the experiments to see if the medicine or drug is in order to sell.' (Girl, Year 6)

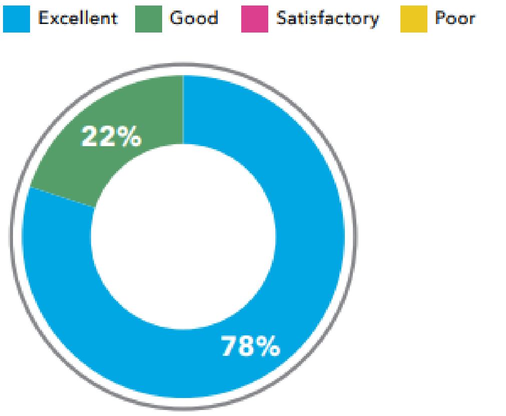
I would like to be a scientist and make things to make the polution of industrys as little as possible. (Boy, Year 6)

I would like to make cars and mobile if I were to work in industry. If I was in industry I would really love to be an engineer or a scientist. (Girl, Year 5)

[1] Guskey, T. R. (2016). Gauge impact with 5 levels of data. Journal of Staff Development, 37(1), 32–37.

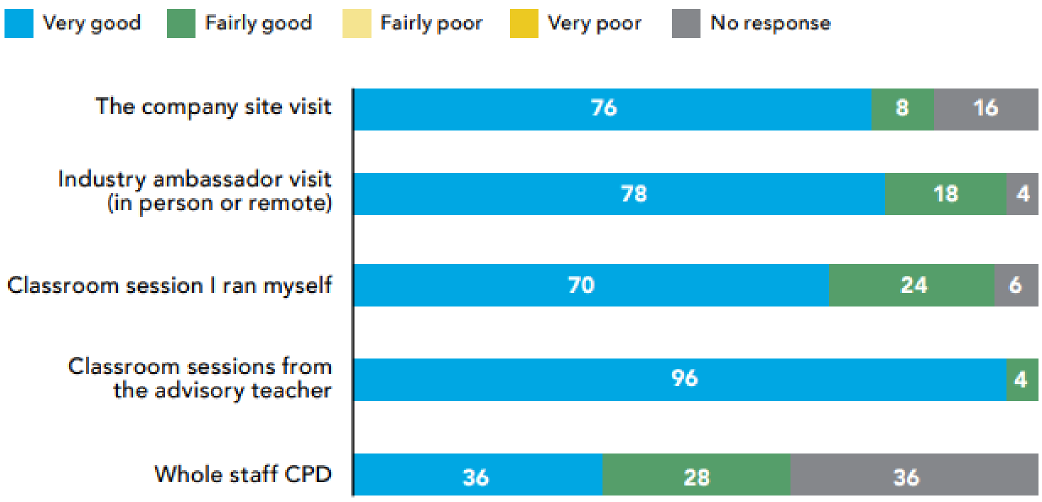
Teacher's reactions to CCI

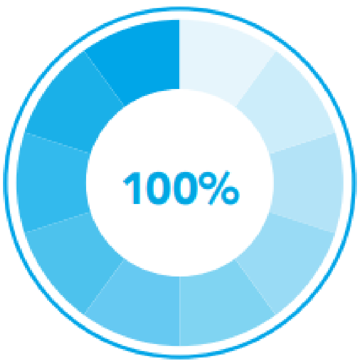
Teachers' rating of the CCI programme *(n=50)*



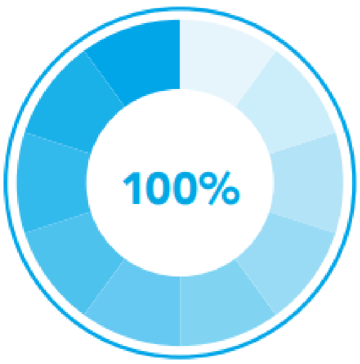
'An amazing programme from start to finish! The sessions were engaging and practical; giving each pupil a vital role in their experiment. They were able to find solutions to real life industry problems whilst having fun and developing key working scientifically skills from the National Curriculum.'

Teachers' rating of individual elements of the programme *(n=50)*





agreed their expectations of CCI were met



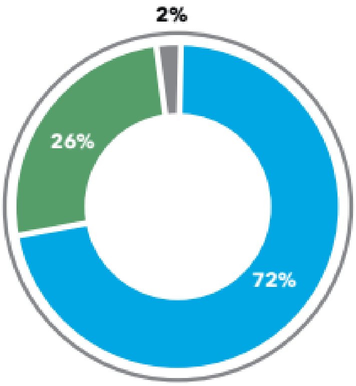
of the teachers (n=50) gave an overwhelmingly positive rating to CCI

I am incredibly happy with the whole service that we received from the CCI programme… I feel that the whole programme was beneficial for so many reasons and really showed the children that a career in STEM or industry is achievable

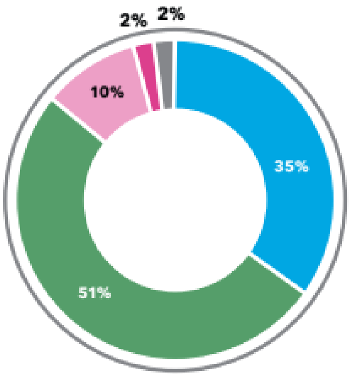
CCI boosts confidence

Strongly agree | Partly agree | Neither agree or disagree | Partly disagree | Disagree

My knowledge of industry has improved *(n=49)*



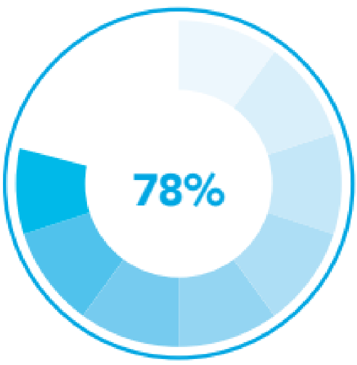
My confidence to teach science has improved *(n=49)*



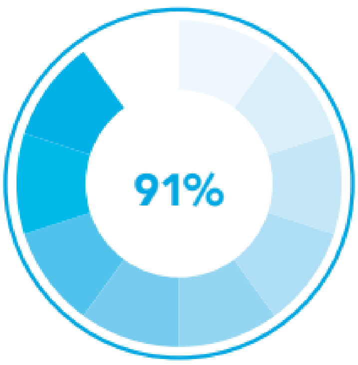
'I have more confidence to take on 'messy' experiments after seeing how much enjoyment the class got from the opportunity to get 'stuck in'.'

'I would now welcome any further opportunities to be involved with other industrial companies as I feel the children hugely benefited from the opportunity to visit the site itself.'

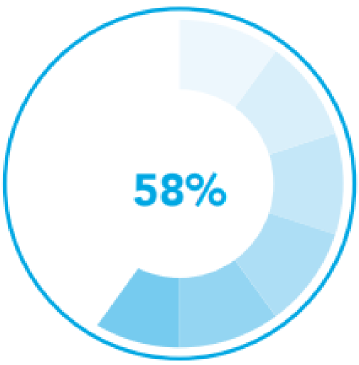
''The programme has made me feel more confident about delivering practical science lessons and the questions that I could ask/use alongside this.'



Believed the programme would benefit other classes in their school.



Shared their CCI experiences with colleagues.



Felt inspired to make changes in their practice.

Results summary

CCI successfully met its primary educational and professional development goals, providing a valuable learning experience for the participating children and teachers. Children enjoyed the CCI practical activities most, a consistent trend observed across the three regions and in previous annual evaluations. However, the reintroduction of company site visits sparked a renewed enthusiasm for learning about science in industry, igniting excitement in exploring the inner workings of science-based companies. Teachers universally recognised CCI's multiple strengths, with company site visits emerging as a pivotal factor. Finally, teachers raised their awareness of the benefits and importance of industry, bolstering their confidence in science teaching in the context of STEM careers.

1. Introduction

Since 1996, the Centre for Industry Education Collaboration (CIEC) at the University of York has run the Children Challenging Industry (CCI)[1] programme, fostering collaborations between local science companies and schools to nurture children's attitudes towards science, industry and STEM career aspirations. After 28 years running, 62,000 children from 2115 schools have participated in the programme.

In 2021-22, CCI was taken to schools through either live-and-remote or blended delivery formats (Bórquez Sánchez, 2022), replacing the usual in-person school visits and company site visits with virtual interactions (Lambrechts, 2021; Tabaqchali et al., 2018). In 2021-22, only three of 52 classes had site visits to science companies (Benavides Lahnstein and Parvin, 2023). The following academic year, the programme made robust progress in overcoming most of the challenges imposed by the Covid-19 pandemic. In 2022-23, CCI reached 60% in-person delivery, including 32 site visits. The remaining 40% was split between blended (39%) and remote (1%) delivery styles, primarily concentrated in the North East of England region.

The 2022-23 CCI programme was led by four CCI advisory teachers who engaged 1,912 primary school children and 67 classes from the North East, Humber, and East of England regions. The CCI advisory teachers also provided training and ongoing support for 67 classroom teachers and 119 CCI ambassadors from 16 industry partners. To foster *science capital*[2] expertise in schools, the advisory teachers offered each participating school continuous professional development (CPD), facilitating whole-school or 1-2-1 CPD for science subject leaders and engaging 1,184 teaching staff members. Comparing results of the 2021-22 CCI evaluation, the present report discusses the impact of the CCI programme in 2022-23 on children's and teachers' attitudes towards science and industry, and it gathers their impressions and experiences of the programme.

[1] More information about the CCI programme is found here: https://www.york.ac.uk/ciec/cci/

[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)' (Archer et al., 2013). As noted recently by Moote et al. (2020), science capital is strongly related to engineering and physical sciences and related future study aspirations.

2. Methodology

2.1. Evaluation design

The annual evaluation of the CCI programme employs a repeated measures design through a pair of online questionnaires (Cohen et. al., 2018), administering the questionnaires before and after the programme. Every year, additional questionnaire data collection is carried out with the CCI ambassadors, but the examination of these data sets is not included in this report. Overall, the CCI advisory teachers facilitate the questionnaire data collection by sharing the weblinks to the online questionnaires and encouraging their completion by both target groups. The following sections detail the content of the 2022-23 children's and teachers' questionnaires.

2.1.1. The 2022-23 CCI children's questionnaires

The children's pre-questionnaire (C1) and post-questionnaire (C2) consist of 23 and 24 questions, respectively. Together, these questionnaires gather basic demographic information and gauge attitudes towards science (11 Likert items) and industry (15 Likert items), with mirrored content across the questionnaires. Both questionnaires include free-text sections encouraging children to share their thoughts on science, careers in industry, and their experiences in the CCI programme. The post-questionnaire encourages children to reflect on what they enjoyed the most and least about participating in CCI and report if they talked about CCI with others. The 2022-23 version of the questionnaires saw some changes, including the removal of two individual items from the science and attitude scales and the introduction of a new scale (12 Likert items) to assess children's ideas about working scientifically.

2.1.2. The 2022-23 CCI teacher questionnaires

The teacher pre-questionnaire (T1) comprises 28 questions, and the post-questionnaire (T2) consists of 25 questions, not including sub-questions. T1 gathers information that is useful for creating summaries of teacher professional profiles. Both questionnaires capture teachers' attitudes towards industry and science teaching experiences linked with STEM careers learning. They are also invited to self-assess their confidence in teaching about STEM careers and STEM in daily life. The questionnaires also allow the comparison of their initial expectations of CCI and their post-participation evaluation of the programme. The post-questionnaire also prompts teachers to estimate the impact and transferability of the programme activities within their school.

2.2. Samples

During the 2022-23 academic year, a total of 1,912 children participated in the CCI programme spanning the North East, East of England, and Humber regions. This section outlines the samples, distinguishing between children and teachers who completed both questionnaires, forming the paired samples, and those who completed only one, resulting in unpaired or unmatched samples.

2.2.1. Unmatched questionnaire responses

Children questionnaires, unmatched sample: The unmatched children's sample includes questionnaire responses with completion rates of over 40%, with the exclusion of any duplicate entries. Across the three regions, 1,717 children from 67 classes completed the pre-questionnaires (C1), and 1,459 children from 62 classes completed the post-questionnaires (C2), constituting 94% and 80%, respectively, of the children taking part in CCI during 2022-23. The unmatched sample has a fair distribution of questionnaire responses from girls and boys across the three regions.

Teacher questionnaires, unmatched sample: A total of 63 teachers completed the pre-questionnaire (T1), while 56 teachers completed the post-questionnaire (T2) across the three regions. This subset includes responses with completion rates above 15%, excluding any duplicate entries. Teachers rarely provided cursory answers; therefore, the threshold for inclusion in the teacher questionnaire was deliberately set lower (than the one used for the children questionnaires) to enhance the breadth of qualitative analysis.

2.2.2. Matched questionnaire responses

Children questionnaires, paired sample: The paired sample includes 69% of the 1,912 children who took part in the programme, showing a gender balance in the sample (Table 1). Overall, 59% of children in the matched sample were in Year 5, and 41% were studying Year 6. Sample sizes in the results section will differ between individual questions since not all children answered every question.

Table 1 Paired Children Survey Sample Overview - 2022-23 CCI Surveys

Region	Total responses	Classes	Girls	Boys	Y4	Y5	Y6
North East	696	33	337	359	0	390	306
Humber	295	12	135	160	1	247	47
East of England	336	15	160	176	0	150	186
Grand Total	1327	60	632	695	1	787	539

Teacher questionnaires, paired sample: Fifty teachers from 49 classes in the North East, Humber, and East of England regions participated in both the pre- and post-questionnaires. 59% of these teachers are based in the North East region, with 27% and 14% representing the Humber and East of England areas, respectively.

2.3. Data analysis

The paired samples were employed for quantitative frequency analyses and statistical tests, enhancing the results' validity through matched responses across both questionnaires. The unmatched sample was only examined to extract the number of survey respondents at this stage of the analysis (Section 2.2.1) and select the matched sample (Section 2.2.2).

2.3.1. Quantitative analysis

Frequency distribution analyses and averages were conducted using Microsoft Excel and IBM SPSS Statistics (version 29.0.1.0) software on matched questionnaire samples from children and teachers.

Children's responses on Likert scales were further analysed through paired *t*-tests (H1: μ1 ≠ μ2), evaluating the statistical significance of results and the likelihood of responses occurring by chance. Paired *t*-tests were also employed to explore differences between groups based on gender, academic year, and geographical location of their school.

The five-point Likert scale items were coded 1-5, treating 'I'm not sure' or 'I don't know' as a middle point, and missing responses were labelled as 'NR' with a value of zero. The five levels of agreement in scales are represented by three categories: 'Yes' (grouping 'agree a lot' and 'agree a little'), I don't know, and 'No' (grouping 'disagree a lot' and 'disagree a little'). The scales include mixed-worded items with positively and negatively worded statements (Steinmann et al., 2022). Negative statements in attitude scales were reverse-coded to avoid affecting the responses' mean scores. The Cronbach's alpha of the attitudes towards science (11 Likert items), industry (15 Likert items), and working scientifically (12 Likert items) scales was calculated to assess scale reliability of each.

The internal consistency of the scales was tested using the paired children's samples from both questionnaires. Cronbach's alpha for the science scale was .75 in the pre-questionnaire and .77 in the post-questionnaire. Commonly, 0.7 or higher levels are ideal; hence, these results indicate this scale has internal consistency or is adequately measuring the underlying construct (e.g., attitudes towards science). The Cronbach's alpha statistic measuring attitudes toward industry is .6 in the pre-questionnaire and .66 in the post-questionnaire, suggesting the scale is potentially assessing more than one construct or dimension. The Cronbach's alpha statistic measuring the Working Scientifically scale is .62 in the pre-questionnaire and .74 in the post-questionnaire, indicating enhanced internal consistency in the post-questionnaire. Recommendations regarding scale reliability results are offered in Section 5.3 of this report.

2.3.2. Qualitative analysis

The qualitative analysis primarily examines questions related to participants' experiences of the CCI programme (Tables 2 and 3). Descriptive coding of the open-ended responses was conducted using a predefined set of thematic categories that were produced for the 2021-22 evaluation (Cohen et al., 2018; Braun & Clarke, 2006). Additional inductive codes were introduced to better capture the nuanced experiences of both children and teachers. The applied codes aimed to reveal patterns of response and transform bulky data into visual representations, streamlining the information and emphasising key findings.

Table 2 Condensed list of open-ended questions included in children questionnaire analysis	C1	C2
If there is anybody you know who has really inspired you about science, please tell us who they are.	Y	N
What sort of job do you think you'd like to do in industry?	Y	Y
The thing that you **enjoyed most** about taking part in Children Challenging Industry, and why?	Y	Y
The thing that you **enjoyed least** about taking part in Children Challenging Industry, and why?	Y	Y

Table 3 Condensed list of open-ended questions included in teacher questionnaire analysis	C1	C2
To you, what are the main attractions of taking part in the CCI programme?	Y	N
Is there anything else you would like to add about your expectations of the CCI programme?	Y	N
Were you inspired to do further lessons or activities that were influenced by CCI?	Y*	Y
Please add any comments about the programme.	N	Y

* Question only displayed to prior CCI participants.

3. Children's experience of CCI and its effects on their views about science and industry

3.1. Children's experience of the CCI programme

Compared with the 2021-22 analysis, this year, 5% more children simply said they enjoyed everything about CCI. Moreover, reflecting on what they enjoyed the least, 38% of the children reaffirmed their full enjoyment of the programme (Table 4). In the 2021-22 evaluation, 82% of children indicated the CCI practical activities were their favourite part of the programme. This year, more children favoured learning opportunities (↑ 10%) and the visit to science companies (↑ 13%); thus, the number of children who rated CCI practical activities[3] highest decreased by 30%. However, the CCI practical activities continue to be what children enjoy the most. Some of the children mentioned **more than one aspect** they enjoyed about CCI, usually elaborating on one of the aspects with more emphasis.

Table 4 What children liked/disliked about CCI: A thematic analysis*

What children enjoyed the most (*n*= 1050)	%	What children enjoyed the least (*n*=932)	%
CCI practical activities (all as a whole or something specific about a practical lesson)	52	*Nothing/enjoyed it all*	38
Company site visit	15	*CCI practical activity (a particular aspect)*	27
Learning about science and/or industry	12	*Irrelevant comment/ not enough info*	12
Everything about CCI	7	*Site visit (a particular aspect)*	7
Irrelevant comments/ not enough information	6	*Group work (a particular aspect)*	4
Enjoyed group work and/or roles	2	*Other*	4
Other	2	*Felt frustrated*	3
Nothing	2	*Listening to explanations/presentations*	3
Meeting the CCI ambassadors	1	*Felt bored in general*	2
Meeting the CCI advisory teacher	1		

*Blank and 'I don't know' responses were not included in the percentage calculations.

[3] The CCI practical activities delivered in 2022-23 include: Cough Syrup; Plastics Playtime; Generating Electricity; Kitchen Concoctions; Pinch of Salt; Runny Liquids; Water for Industry; The Science of Healthy Skin; Rough Guide to Gas or a combination of these.

Of the children who enjoyed the CCI practical activities best (52%), most indicated having fun doing the practical activities (Table 5). Learning something interesting related to the investigations came in second as a motivating factor. These experiences and positive feelings could act as catalysts, potentially igniting their curiosity towards science and industry. Moreover, 4% of these children also had more than one reason for liking the practical activities (see e, Table 5), and a few others specifically liked learning science in alternative ways (see d, f, and g). As a Year 5 girl highlighted, *'... children don't only learn in books they also learn with equipment.',* which shows basic awareness of metacognitive aspects related to their learning (i.e., 'learning to learn').

Table 5 Why children enjoyed the CCI practical activities (*n*= 547)

Motivations		%
a.	Had fun, enjoyment, or excitement	47
b.	Learned something new or interesting while having fun/enjoying	29
c.	Enjoyed group work and/or roles	2
d.	Enjoyed the process of making	2
e.	Had fun and other reasons	4
f.	Felt independent/autonomous	1
g.	Felt it was a novel activity	1
h.	Other reasons	9
i.	Did not know/answer	4

Children described something about the practical activities that amused or reflected on how they felt (Box 1). More often than boys, girls provided more detailed explanations. The critical comments about the CCI practical activities show the **filtering challenges** were the least popular, mainly because some children did not like getting wet or dirty, having to wait for results or cleaning cups or workstations afterwards. In addition, 5% of the fully paired sample indicated they **did not enjoy writing** during the CCI activities, yet children from the EE region showed a positive significant change compared to the other regions. The marginal changes in their attitudes towards writing highlight that perhaps children prefer to learn science through hands-on and practice-based styles.

Box 1 Sample of children's comments explaining what they enjoyed about the CCI practical activities

'The thing you enjoyed the most about taking part in Children Challenging Industry…'

Doing experiments with intresting resourses. ***The thrill of it!*** *(Boy, Year 5)*

The experiments and fixed roles. ***The experiments were very educational*** *and fun... (Girl, Year 6)*

All of the experiments and note taking we did. ***It showed us how fascinating industry is****, and how many opportunities there are. (Boy, Year 5)*

Fixing the pipes. It ***made me feal like a scientist****. (Girl, Year 5)*

The egg challenge. Because it ***makes us think like a scientist*** *and helps us improve in the future. (Boy, Year 5)*

I enjoyed doing the pop rockets most! Because it was really fun and I got to work in a team and ***do my own experiments like a real scientist!*** *(Girl, Year 6)*

Seeing what soap was the most luminous. Because I was surprised with the outcome from the soaps and also because ***we got to see someone who works for Johnson Matheys*** *(Boy, Year 5)*

I loved to do the experiments. *We got to make predictions about the experiment then we did it… we would discuss about what we could change and what we could keep the same. (Girl, Year 5)*

That I got to do experiments. I find graphs and conclusions and table results quite difficult. So ***doing experiments*** 🧪 ***is fun****. (Boy, Year 6)*

the leaky pipes test. Because we could learn a little bit more of how to fix leaky pipes ***if you ever decide to work in an industry*** *like Tronox / a place where they have a lot of pipes that may break and leak. (Girl, Year 6)*

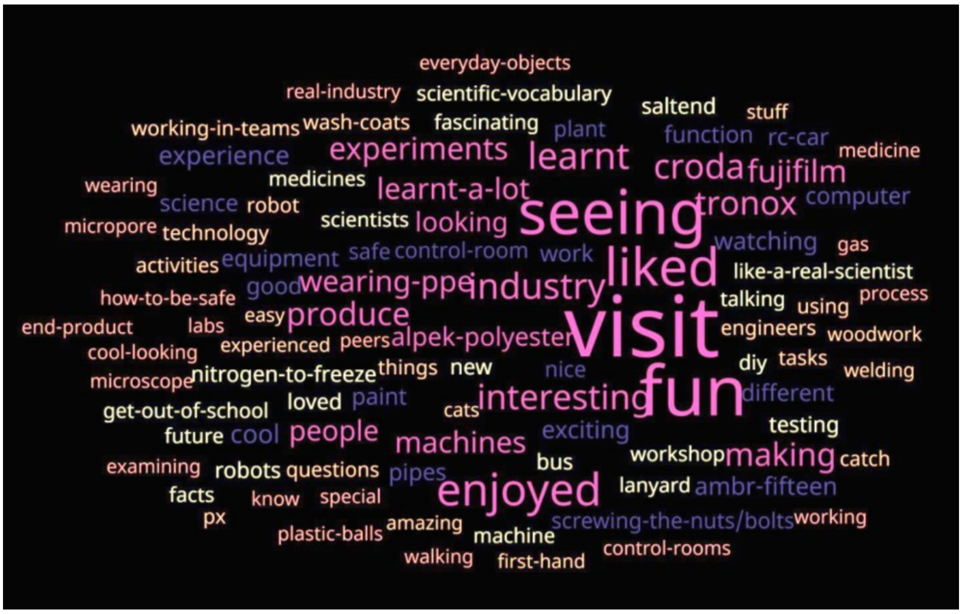
All the experiments we did. Because ***I got to experience a day in the life of a scientist*** *and the experiments were really cool. (Boy, Year 5)*

the experiments. ***it is fun as we get to test/ fix different companies problems*** *and discover our own results... (Girl, Year 5)*

Among the comments of the 15% of the children who indicated that the site visit to industry was their favourite, there are mentions of the names of the companies, descriptions of activities they did, and appreciation for learning and having seen how things are done in a specific company (Figure 1).

Figure 1

Word frequency: Children's feedback on enjoyable aspects of company site visits



Children’s positive impressions of the site visit highlight appreciation for learning and seeing how industrial activities are carried out in real-life scenarios (Box 2). Children also enjoyed other aspects, such as wearing personal protection equipment (PPE) or conducting practical activities at the companies. There are a few critical comments regarding the site visit, but they show that some children did not like walking, listening to explanations, or standing while listening. A small number of children felt bored and did not like the grid-like metal stairs and upper floors where they could see below, and others felt the PPE did not fit them well, which is interesting since other children felt excited about wearing PPE and a lanyard. Examples in Box 2 highlight how children, from a young age, are captivated by authentic experiences in science and industry. This fascination likely stems from two factors: a sense of belonging fostered by these experiences and the demystification of what goes on "behind the gates" of these everyday realities.

Box 2 Sample of children's comments explaining what they enjoyed about company site visits

'The thing you enjoyed the most about taking part in Children Challenging Industry…'

The thing I most enjoyed was when we had our exciting trip to Alpek polyester. Because ***we got to discover how they made plastic*** *and watching all of the experiments was fascinating. (Girl, Year 5)*

The trip was amazing. ***We got to experience industry first hand.*** *(Boy, Year 5)*

Using the lanyard to open doors to keep us safe and for people to know where we are. Because ***it felt like we worked there****. (Girl, Year 6)*

Wearing the safety clothes was fun. I thought we looked good and ***we were like a real scientist****. (Boy, Year 5)*

Going to FujiFilm. Because ***we were in a real industry****. (Girl, Year 5)*

Wearing safety clothing. ***It made me feel like a real scientist.*** *(Boy, Year 6)*

I enjoyed going to Jonson Matthey (in Royston) and seeing all of the interesting experiments they do there. I like science a lot and ***could possibly end up with a career with something to with it*** *in the future. (Girl, Year 6)*

seeing everyone doing the wash coats *and telling us information about the wash coat, but overall I loved all of it. (Boy, Year 6)*

I liked going to Croda. I enjoyed it because ***I got to see scientists*** *and what they create. (Girl, Year 5)*

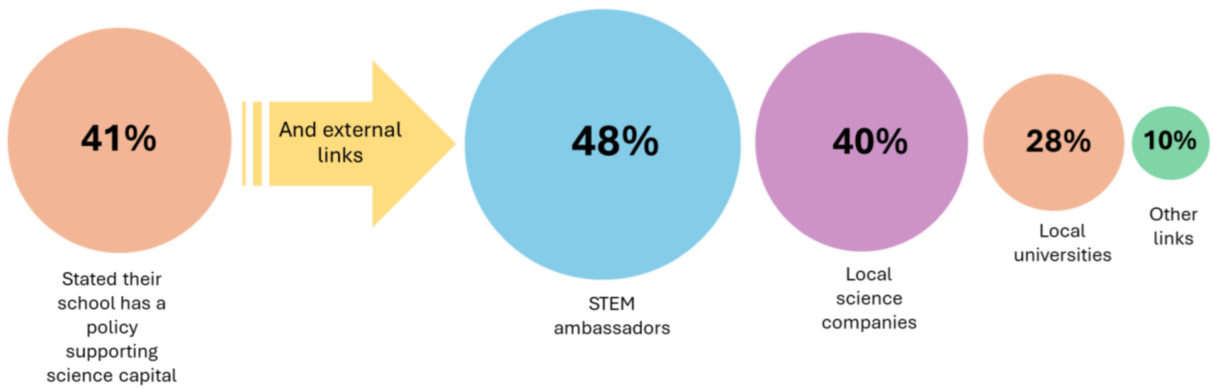
I like industry because it is ***a large place making my everyday objects*** 😺*. (Boy, Year 6)*

I liked going to tronox . Because i liked seeing all the pipes and getting the ***experiance of how people in tronox work****. (Girl, Year 6)*

4.3. Guskey's Impact Level 3. Organisational support and change

CCI has the potential to influence individual, collective, and organisational change through professional development activities for teachers and by suggesting practices that could develop the science capital of children, teachers, and other members of the school community. As suggested by the teachers' awareness of school policy and STEM-focused networks (Figure 11), their schools could expand the formal support for the development of science capital and their networks with industrial companies and beyond. One of the teachers described, *'I feel the project really opened my eyes to how easily science experiments can be linked to real-life industry practises [...]'.* The CCI's CPD activities on science capital focus support teachers to recognise new learning opportunities, use of existing resources, and instigate conversations on cultural change at a school level.

Figure 11 Teachers' perceptions of existing school networks with industrial companies and external organisations (n=50)



The presence of a science capital policy did not affect teachers' confidence in organising industrial visits. After CCI, 84% of teachers in schools with a policy and 82% in those without such a policy felt more confident to organise a future visit to a science company. This indicates strong dispositions towards nurturing children's science capital; however, teachers' confidence to organise site visits and make use of existing resources in schools could be further boosted with policy frameworks and support from the senior leadership team. For instance, five out of seven teachers who had organised such visits had participated in CCI and worked in schools with a science capital policy, although it is unclear if their prior site visit experience was linked to CCI. Nevertheless, this example illustrates the leadership's endorsement of professional development and relevant policy frameworks were perhaps influencing factors. After participating in CCI, 76% of teachers believed children beyond their class and at the school level would benefit from the programme. CCI strengthened teachers' confidence, which could lead to sustained impact and science learning innovations if support for the development of science capital development is formalised and enhanced.

3.2. Working scientifically

The term 'working scientifically' represents the second of three primary objectives in the English primary science curriculum. It promotes skills and ways of working that enhance children's understanding of the principles, processes, and methodologies of science (Department for Education, 2015). CCI incorporates principles of working scientifically, and they are one of the intervention's foci. As part of this evaluation, children assessed whether a list of essential science enquiry skills (Table 6), showed broad awareness of scientific work practices.

Table 6 CCI evaluation 2022-23: Frequency analysis of children's awareness of aspects involved in working scientifically (*n*=1327, all regions)

Prompt: *We would like you to think about what it means to work like a scientist.* ***How much do you agree that the activities below are part of their work?***	**% BEFORE CCI**				**% AFTER CCI**			
	Sample size	*Yes*	*I don't know*	*No*	Sample size	*Yes*	*I don't know*	*No*
a. *Planning and setting up investigations or experiments to test ideas and questions*	*n*=1206	80	11	9	*n*=1229	81	13	6
b. *Using safety equipment (e.g. gloves, safety goggles) when carrying out experiments*	*n*=1159	93	4	3	*n*=1184	93	4	3
c. *Setting up an investigation on a broad topic and without a specific enquiry question**	*n*=1155	35	27	38	*n*=1182	35	27	38
d. *Gathering information about a question or idea that is being tested*	*n*=1141	80	10	10	*n*=1173	83	10	7
e. *Using scientific equipment (e.g. hand lenses, timers, scales) when carrying out experiments*	*n*=1138	85	8	7	*n*=1176	87	8	5
f. *Carefully observing and measuring something*	*n*=1141	89	5	6	*n*=1178	89	6	5
g. *Making conclusions about an idea or question without testing it**	*n*=1141	33	11	56	*n*=1172	35	14	51
h. *Understanding charts, tables, or diagrams*	*n*=1136	83	8	9	*n*=1175	84	10	6
i. *Using results to make conclusions and new predictions*	*n*=1137	82	11	7	*n*=1175	81	12	7
j. *Sharing the conclusions of an investigation with others through presentations or reports*	*n*=1136	71	15	14	*n*=1177	74	16	10
k. *Presenting information in charts, tables, or diagrams*	*n*=1138	78	11	11	*n*=1175	78	12	10
l. *Using correct scientific words when communicating about science*	*n*=1200	84	8	8	*n*=1207	82	10	8

**An increase in responses answering 'no' indicates an improvement in their attitude.*

On average, before and after the programme, 77% of children correctly identified basic aspects of working scientifically, with minor changes in perceptions after the intervention. The scale items that check for acquiescence or agreement bias (i.e., items c and g) and test respondents' attention show children could understand the statements and were intentional in their responses. Overall, there was more hesitation for items addressing the setting up of a research question (i.e., item c) and sharing the conclusions of an investigation (i.e., item j), and the number of children who understood working scientifically principles remained unchanged after the intervention.

3.3. Impact on children's attitudes

3.3.1. Children's attitudes towards science

Across the three regions, children's attitudes towards science show small and mostly positive changes after the intervention in most scale items (Table 7 and Appendix A). However, a few items on the scale had more children stating positive views and yielded significant average changes in the results[4] (Appendix B). The higher means scores suggest the programme had a positive effect. As observed in the 2021-22 evaluation, most children stated that they liked science before and after the programme, but, in turn, the interest in science as a school subject was only expressed by one-third of the sample. Region-focused analysis of the paired sample shows that a consistent proportion of children (over 74%) stated they liked science, with a few from the East of England shifting their preference after CCI. As observed for the whole sample, an average of 75% of children between regions stated they like science, but only an average of 33% indicated that science is their favourite subject.

Table 7 CCI evaluation 2022-23: Frequency analysis of children's attitudes towards science (*n*=1327, all regions)

Individual scale items	% BEFORE CCI				% AFTER CCI			
	Sample size	*Yes*	*I don't know*	*No*	Sample size	*Yes*	*I don't know*	*No*
a. *I like science*	*n*=1324	76	4	20	*n*=1324	75	4	21
b. *We do too much science in school**	*n*=1314	16	7	77	*n*=1321	16	8	76
c. *School science clubs are a good idea*	*n*=1316	68	14	18	*n*=1321	65	16	19
d. *Science is too difficult**	*n*=1307	28	6	66	*n*=1320	25	7	68
e. *I like doing science experiments at home*	*n*=1316	58	9	33	*n*=1322	62	9	29
f. *We have to do too much work in science**	*n*=1317	29	9	62	*n*=1320	27	12	61
g. *We do too much writing in science**	*n*=1311	40	8	52	*n*=1317	37	10	53
h. *I like watching science programmes on TV or online*	*n*=1321	45	9	46	*n*=1327	39	11	50
i. *Science is my favourite subject*	*n*=1302	33	6	61	*n*=1315	34	7	59
j. *I'd like to be a scientist*	*n*=1304	18	20	62	*n*=1311	21	17	62
k. *I'd like to be an engineer*	*n*=1310	24	18	58	*n*=1317	25	20	55

**For the negative statements: an increase in responses answering 'no' indicates an improvement in their attitude.*

***Items where the difference between pre- and post-questionnaire data is statistically significant.*

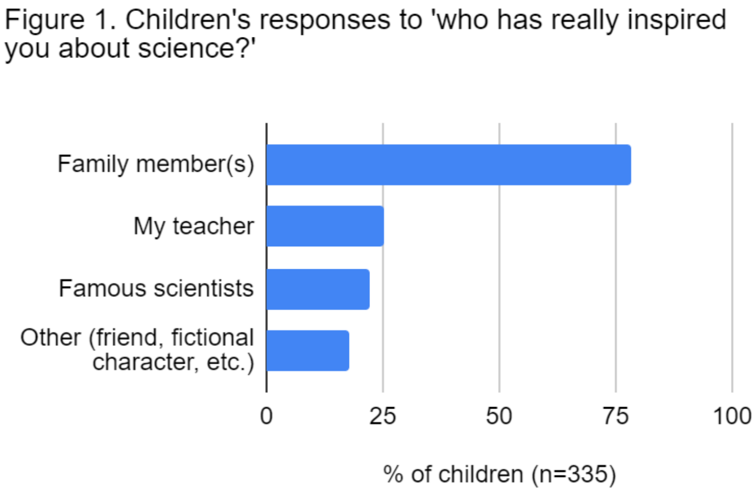
[4] Statistical significance in a paired t-test indicates whether the difference between paired observations (e.g., before and after measurements) is unlikely to have occurred by random chance alone.

Liking science but not choosing it as a favourite subject was also a pattern shared by boys and girls, yet there was a 5% increase and significant difference in the number of boys who preferred science as a subject after taking part in CCI. Likewise, most Y5 and Y6 children stated they like science, in contrast to the 34% average, who stated science is their favourite subject across both groups. However, CCI effectively encouraged children to sustain or enhance their enthusiasm for science beyond the classroom, with more children showing significant average changes after CCI. More children stating they *'like doing experiments at home'* post-CCI resonates with their preference for practical science activities and site visits (Section 3.1.1), underscoring the programme's potential to nourish children's interest in science.

3.3.2. Influence of others and CCI on children's attitudes towards science

Children's perceptions of science might also be influenced by the support or interest they perceive from their parents. Among children in the paired sample, 18% of them (54% boys and 46% girls) ***did not** think their parents/carers think that science is interesting*; this is a 4% increase for the same data point in the 2021-22 evaluation. Interestingly, the majority of these children stated they like science (60% → 61%), which is 14% lower than the post-questionnaire statistic of the whole sample (Table 9). Likewise, fewer of these children indicated that science was their favourite subject (23% → 24%), which is 10% lower compared to the whole sample result in the post-questionnaire. Similar response patterns were observed in the 13% of children (61% boys and 39% girls) who indicated that *their parents/carers **did not** consider learning science important*, a slight uptick of 1%, compared to the 2021-22 evaluation. Even fewer stated liking science (51% → 52%) or indicated that science was their favourite subject (20% → 19%) if they thought their *parents/carers **did not** think science was interesting **or** important*.

Conversely, among the 48% of the children (47% boys and 52% girls) who believed their parents ***did** think science is interesting and important to learn*, the vast majority expressed a liking for science (88% → 85%), with slightly fewer than half considering it their favourite subject (43% → 43%). Likewise, among the 25% of the children (49% boys and 51% girls) who mentioned a person in their lives who inspired them about science (Figure 1), the vast majority of them also expressed liking science (85% → 85%), with approximately half considering it their favourite subject (47% → 48%).



The inspiring figures were mostly famous male scientists (Table 8); however, children showed awareness of female scientists and engineers in the attitudes scale focused on industry (Section 3.3.4). Compared to the overall paired sample statistics, 10% more of the children with positive parental influence stated liking science. More children in these subgroups (9% and 14% respectively) also indicated science is their favourite subject, a contrast when compared to the whole paired sample. CCI's impact on these subgroups was not featured in the analysis.

Table 8 Famous scientists mentioned by children* as personally inspiring

Name	Mentions	Name	Mentions
Albert Einstein	15	Elizabeth Blackwell	1
David Attenborough	8	Elon Musk	1
Issac Newton	5	Galileo Galilei	1
Mark Rober	5	George Stephenson	1
Bill Nye	4	Maggie Aderin Pocock	1
Stephen Hawking	4	Neil Armstrong	1
Marie Curie	2	Scientists off the television	1
Adrian Newey	1	Steve Backshall	1
Alice Augusta Bell	1	Steve Irwin	1
Brian Cox	1	Steve Jobs	1
Charles Darwin	1		

**Pre-questionnaire data*

These results suggest that children's perceptions of their parents or caregivers' interest in science can influence their own attitudes toward science and school science. However, even when children perceive their parents do not value science, a considerable majority—50% or more—still demonstrate a positive inclination towards science. Having a person who inspires them about science or serves as a role model also seems to influence their preference for science. These findings add to our understanding of the potential influence and impact of parents/guardians and knowledgeable others in science on children's disposition towards science.

3.3.4. Children's attitudes towards industry

The 2022-23 CCI evaluation on children's attitudes towards industry continues to highlight significant differences in mean scores and the positive impact of the programme on their awareness of the essential functions and services fulfilled by industry and its workforce (Table 9). Like the findings from the 2021-22 CCI evaluation, the majority of children stated that industry serves a valuable purpose and acknowledged the significant roles played by scientists and engineers within it, with boys showing higher average significant differences in their attitudes towards science this year. In the current evaluation, the group analyses (i.e., gender, academic year, and region) showed significant differences before and after the programme (Appendix A), with the Y5 and the NE region groups showing larger differences in their attitudes towards industry, indicating CCI had a stronger impact in the attitudes of younger children and on children located in the NE region.

There was an increased number of children recognising that 'many scientists work in industry' (↑ 17%) in the post-questionnaire and acknowledging that these professionals 'have important jobs' (↑ 9%) in industry. Group comparisons indicate that Year 5 and children from the NE region demonstrate larger average differences in this aspect. This suggests that CCI may be particularly effective in helping younger children and those in the NE area realise the role of scientists in industry. Post-CCI, many more children stated they could learn about industry from their teachers (↑ 16%), positioning them as knowledgeable and bringing access to the industrial world closer to them. In this case, Y6 and NE children had larger differences in the attitude changes between questionnaires than other groups. There was a slight decline (↓ 3%) in the statement 'I learn about industry from TV or online', suggesting that children may have recognised the value of firsthand learning experiences about industry.

Table 9 CCI evaluation 2022-23: Frequency analysis of children's attitudes towards industry (*n*=1327, all regions)

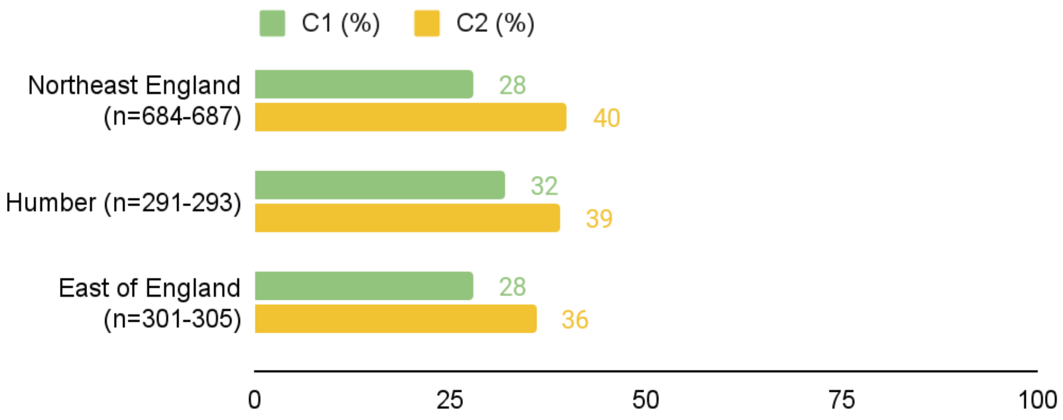
Industry Likert-scale items	% BEFORE CCI				% AFTER CCI			
	Sample size	*Yes*	*I don't know*	*No*	Sample size	*Yes*	*I don't know*	*No*
a. *There are women scientists and engineers*	*n*= 1302	87	9	4	*n*= 1310	91	6	3
b. *Industry is useful*	*n*= 1320	82	11	7	*n*= 1320	88	9	3
c. *Industry makes things we need*	*n*= 1312	78	13	9	*n*= 1312	87	8	5
d. *Scientists have important jobs in industry*	*n*= 1302	78	16	6	*n*= 1309	87	10	3
e. *Engineers have important jobs in industry*	*n*= 1299	75	20	5	*n*= 1304	83	14	3
f. *Many scientists work in industry*	*n*= 1312	64	26	10	*n*= 1316	81	15	4
g. *Many engineers work in industry*	*n*= 1310	66	24	10	*n*= 1312	80	16	4
h. *I learn about industry from my teachers*	*n*= 1311	57	20	23	*n*= 1313	73	13	14
i. *Our lives would be worse without industry*	*n*= 1307	57	22	21	*n*= 1309	67	18	15
j. *Industry causes a lot of pollution**	*n*= 1306	62	24	14	*n*= 1315	60	25	15
k. *Industry is dangerous**	*n*= 1312	55	22	23	*n*= 1313	55	20	25
l. *Industry is safe*	*n*= 1311	48	18	34	*n*= 1313	49	15	36
m. *Young people work in industry*	*n*= 1307	37	31	32	*n*= 1311	47	28	25
n. *Industry causes as little pollution as possible*	*n*= 1307	29	29	42	*n*= 1308	39	27	34
o. *I learn about industry from TV or online*	*n*= 1307	40	18	42	*n*= 1315	37	16	47

*For the negative statements: an increase in responses answering 'no' indicates an improvement in their attitude.

**Items where the difference between pre- and post-project data is statistically significant.

Over half of the children stated that industry 'causes a lot of pollution' and 'is dangerous'. However, there is a noticeable improvement in children's perceptions regarding safety and the environmental impact of industry following the programme. After participating in CCI, 10% more children believed that industry *'causes **as little** pollution **as possible**'*, slightly higher than the 7% increase observed in the 2021-22 evaluation. These results are statistically significant in all the group analyses except for the Humber region, and the NE presented a larger difference in the attitude changes between questionnaires (Figure 2). Furthermore, there was a 6% rise in the number of children who considered industry to be safe (48% → 49%) when compared to the previous year's findings (43% → 43%). These views about industry could become barriers to children's imagery of future selves in industry, highlighting the importance of addressing and exploring them at an early age.

Figure 2 CCI evaluation 2022-23: children's stating 'Industry causes as little pollution as possible' before and after the programme.



To better understand children's concerns about the environmental impact of industry, a qualitative content analysis guided by 18 search terms (Eco-, Enviro-, Polu-, Pollu-, Recy-, Reci-, etc.) was conducted in the pre- and post-questionnaires. There are 26 comments from 22 children (2% of the sample) across both questionnaires (see examples in Box 3); 84% of these comments were found in the post-questionnaire.

Box 3 Children's views on industry's environmental impact and responsible actions: a selection of comments

i would like to manufacture environmentaly healthy packaging. (Year 6, girl)

I hate that industry makes pollution...Because it can kill animals (Year 5, boy)

i like [science] but a lot of the resources are expensive and not eco-friendly, its not the best subject for looking after the enviroment. (Year 6, girl)

I would like to be a scientist and make things to make the polution of industrys as little as possible. (Year 6, boy)

i enjoined knowing that industry is good for us and our world because one more tiny bit of poloution we could die or let animals go instict includuing deforstion...like i said, now i know it dosen't cause poulation or deforstion includeing instict animals. (Year 5, girl)

How some things are good about industry because they make producs that we need but they are also sometimes bad because it causes polution which is bad for the iviroment. (Year 6, boy)

Industry makes a lot of pollution! (Year 5, girl)

Learning about catalitic converters…Because its helps bad gases become good gases. (Year 6, boy)

I liked to find out different ways that my generation will use to completely change the earth and how we live… It's good to know these things from a young age since it's up to [m]y generation and the one's after to make a greener planet for future generations. (Year 6, girl)

I would like a world without pollution. (Year 5, boy)

The comments in Box 3 show that CCI prompted children to think about their environmental concerns in relation to industry. Despite these being only a few examples, they demonstrate that primary school-aged children can begin to understand the links between industrial activity, environmental impact, and the importance of the industrial workforce in tackling those challenges. They also show potential misconceptions (e.g., *'science… is not the best subject for looking after the environment'*) and some of their 'green futures' ideas. These comments also provide insights for future questionnaires designed for the CCI programme.

3.3.5. Children's attitudes towards STEM careers

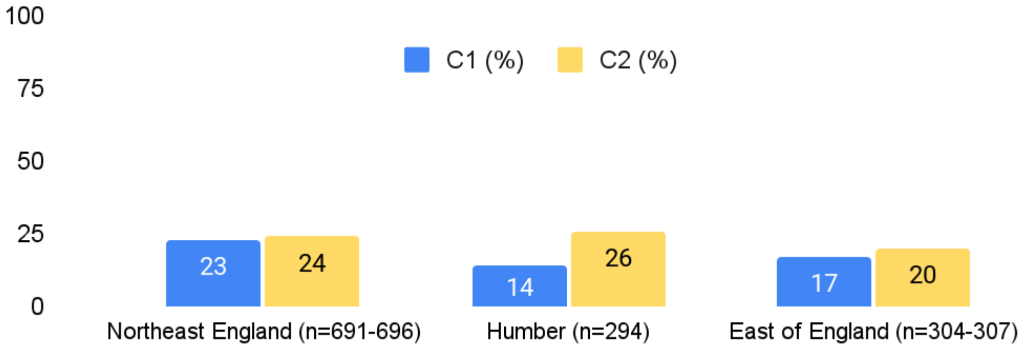
Participating in CCI sparked a slight increase in children's interest in a future career in industry (↑4%) and in becoming a scientist (↑3%) and a minor decrease in perspectives about a future in engineering (↓1%). Overall, the last three programme evaluations show similar statistics on career aspirations (see Table 10), suggesting the transition from remote to in-person delivery has yet to have a stronger impact on this aspect. In the current evaluation, the regional analyses show statistically significant differences before and after CCI, with a 7% rise in children stating they would like to become scientists across the Humber and East of England regions and a 1% increase in this aspect in the North East. In each region, the number of children stating they would like to become engineers also increased slightly for the Humber (↑ 3%) and the East of England (↑ 1%) regions.

Table 10 Children's interest in STEM careers: positive agreement across the latest CCI evaluations.

CCI evaluation	*I'd like to be a scientist (%)*	*I'd like to be an engineer (%)*	*I could work in industry in the future (%)*
2020-21	+4 (18 → 22)	-1 (24 → 23)	Paired sample is not available
2021-22	+3 (21 → 24)	+1 (23 → 24)	+6 (16 → 22)
2022-23	+3 (18 → 21)	+1 (24 → 25)	+4 (19 → 23)

Post-CCI, children in the Humber (↑12%) and the East of England (↑3%) showed a rise in the number of children envisioning themselves as part of the industry workforce, with a minor increase in the North East (↑1%) region (Figure 3).

Figure 3 CCI evaluation 2022-23: Children's stating 'I could work in industry in the future' before and after the programme.



After CCI, there was a 6% rise (14% → 20%) in the number of children describing a career, role, or field relevant to industry. The majority of these children stated they wanted to be scientists or engineers, and a few others mentioned a more specific role within the industrial landscape. Others would like to ***make*** cars, phones, medicine, and other products. In contrast, 2% of the children described other career interests or explained they were not interested in industry. Altogether, these results suggest that, after the programme, 22% of the sample (*n*=1327) could describe future careers, even if briefly.

Children from the Year 5 and Y6 groups wishing to be scientists showed slight increases of 3% (17% → 20%) and 4% (18% → 22%), respectively; these were also statistically significant increases. Post-CCI, the Year 5 and Year 6 children stating they would like to be engineers rose by 2% (23% → 25%) and 1% (25% → 26%), but the Y5 increases were not statistically significant. Interestingly, two cases of Year 5 children from different schools and regions who initially described wanting to be 'litter pickers', stated in the post-questionnaire that they would like to become mechanical engineers. Comparable figures were found among the Y5 (18% → 22%) and Y6 (21% → 24%) children who indicated they could work in industry.

Across the three regions, CCI raised children's aspirations to become scientists or work in industry, but these remained unchanged for engineering. More boys than girls stated they would like to have a STEM career in the future after the programme (Table 11), also observed in the 2021-22 CCI evaluation.

However, girls' aspirations to become scientists or engineers show significant differences compared to boys', indicating the programme successfully encouraged girls to overcome gender stereotypes around science careers. Interest in becoming an engineer changed marginally (1%) for girls and did not change for boys, an improvement compared to the 4% decrease in boy's interest shown in the 2021-22 CCI evaluation.

Table 11 CCI evaluation 2022-23: Gender distribution of attitudes towards STEM careers across the three regions (*n*=1327)

	Girls stating 'yes'			Boys stating 'yes'		
	C1 (%)	C2 (%)	Shift (%)	C1 (%)	C2 (%)	Shift (%)
I'd like to be a scientist	15	18	3	20	24	4
I'd like to be an engineer	15	16	1	34	34	0
I could work in industry in the future	16	21	5	22	26	4

CCI stimulated children's aspirations for STEM careers in between 18% to 23% of them, depending on if this is about science, engineering, or just envisioning themselves in industry. Moreover, after CCI, 29% of the teachers estimated that over 50% of their class had expressed interest in a STEM career; these teachers' classes cover 27% of the children's paired sample. The estimations are subjective, but they also suggest that, in some cases, children might be thinking about a future in STEM but are not ready to express it with certainty in the questionnaires. This is encouraging evidence to support the continued efforts of the CCI team to stimulate children's curiosity and interest in STEM by removing barriers and offering opportunities to observe scientists and engineers in real industrial settings.

3.3.6. Influence of others on children's attitudes towards STEM careers

Across the three regions, among the children who ***did not*** *think their parents thought that science is interesting* (18%), very few changed their interest in becoming scientists (11% → 12%), and fewer stated wanting to become an engineer (24% → 22%) in the future. However, 11% more of these children stated that they could work in an industry in the future (12% → 23%) post-CCI. Similarly, among the group of children who *believed their parents* ***did not*** *think learning science is important* (13%), very few stated an interest in becoming a scientist (10% → 10%) or an engineer (22% → 20%), with the same proportion or fewer of the children showing interest after the programme. Likewise, more children in this group stated they could work in industry in the future (10% → 16%). Similar patterns were found in the group of children (7%) who *stated that their parents/carers **did not** think science was interesting **or** important to learn science*.

In contrast, among the 48% of the children who *perceived their parents **did** find science interesting **and** important*, more stated they would like to be a scientist (25% → 30%) or an engineer (29% → 31%) in the future. A few more of them also indicated they could work in industry (27% → 31%) after CCI. Moreover, 41% of the children (51% boys and 49% girls) believed that their *parents would be happy if they became either scientists or engineers*. Likewise, after CCI, a few more children in this group indicated that they would like to be scientists (28% → 32%) and could work in industry (30% → 33%). Among those who mentioned someone who inspired them about science (Figure 4, section 3.3.2), 8% more children stated they would like to be a scientist (27% → 35%) and 2% more indicated they would like to be an engineer (32% → 35%) in the future.

CCI had a clearer impact on those children who perceive their parents have negative views towards STEM, showing higher increases for 'I could work in an industry in the future' than those with positive parental perceptions. The contrast of these results with those of the whole sample (Table 7, section 3.3.1) indicates that children who have role models in science and/or perceive their parents thinking positively of science and STEM careers are more likely to visualise themselves in a STEM career. Furthermore, the change in attitudes towards STEM careers suggests that the impact of the programme is also slightly higher on these children.

4. CCI's impact on teachers' views and practices

The impact of the programme on teachers is organised according to the five levels of impact proposed in Guskey's (2016) framework for professional training evaluation.

The framework comprises five hierarchical levels, suggesting that the highest achievements are housed in the last two levels. Levels 1 and 2 focus on participants' reactions and learning experiences of the intervention, juxtaposed against their initial expectations. Level 3 delves into the organisational dynamics, while Level 4 examines the evidence of practical application. Level 5 is represented by the programme's impact on children's views and attitudes in Section 3.

To better understand the participating teachers and the factors influencing the varied experiences of implementation, the teachers were asked to describe key professional aspects (Box 4). Their profiles show a combination of a range of experiences and expertise.

Box 4 What do we know about the participating 50 teachers* in the paired sample?
Science qualifications
43% GCSE; 11% A level/Highers; 25% undergraduate degree; 20% postgraduate degree
Professional experience
Avg. 12 years in the classroom
Avg. 2.5 days spent doing Science CPD (last three years)
70% had taught only 'a little' about industry
Nine are science leaders
Prior participation in CCI
17 teachers had previously participated
5 of 7 who had organised a visit to industry had also participated in CCI before
12 of 23 who recognised the '*science capital' concept* had previously participated in CCI Science Capital CPD

*Pre-questionnaire data, *n*=49-50

4.1. Guskey's Impact Level 1: Participants' Reactions

4.1.1. Teachers' expectations of CCI before participation in the programme

The teachers' initial expectations of the programme convey a common desire to offer their class learning experiences that showcase the applications of science and engineering in industry (Table 12), featuring practical science learning and STEM career education. Table 12 is a visual synthesis of their written expectations, such as: *'Showing children how science is used to provide products and solutions in the real world.'* or *'To allow children to be exposed to science in the working environment to engage and encourage possible future careers.'*. An interest in science learning opportunities for children and teacher professional development continue to feature in teachers' initial expectations of CCI, as documented in the three previous impact reports (2018-2022). Nonetheless, the category 'Career learning/ raising career aspirations' saw a 9% rise compared to the results in the 2021-2022 evaluation. The analysis revealed that teachers with 16-20 years of experience and prior CCI experience emphasised that CCI could support children's career awareness in STEM.

Table 12 Thematic analysis of teachers' responses* to *'What are the main attractions of taking part in CCI?'*

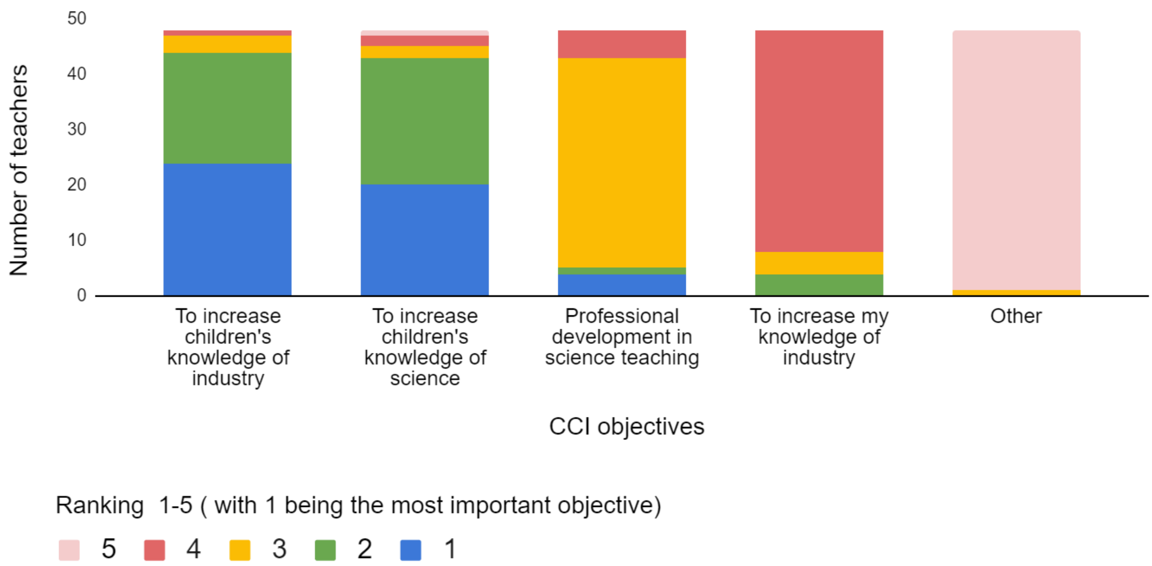
Expectations (thematic categories)		%	Examples
About children's learning	Career learning/ raising career aspirations	**24**	*'[…] Also to develop career aspirations for the children within that industry.'*
	Real-world applications for science	**21**	*'Opportunities for children to see science in real life context'*
	New learning or experiences for children (unspecific)	**18**	*'Different experience for children'*
	Inspiring children about science and/or industry	**10**	*'To encourage enthusiasm about science and to allow the children more time for the subject.'*
About professional development	CPD opportunity and/or teaching ideas	**10**	*'[…] improving my personal subject knowledge.'*
	Gain/expand links with industry	**10**	*'Ability to make links with industry.'*
Both implied	Practical science learning/teaching	**7**	*'To give them a hands on approach to Science'*

*n=68 references in comments

Teachers with 16+ years in the classroom and with prior CCI experience expected CPD opportunities from the programme as well as learning opportunities for children. The CCI newcomers focused on learning goals for the children, but their professional development was less prominent in their initial comments. Teachers are not unaware of their professional development, but naturally, they tend to prioritise setting learning goals for children as their primary expectation. The slight disparity between the expectations of participants with prior CCI experience and new attendees indicates that **CCI encourages teachers to consider their professional development** alongside opportunities for children's learning.

Furthermore, after prompting teachers to describe their expectations, the questionnaire asked them to organise a pre-defined list of the programme's objectives by order of importance. As noted in their initial expectations, all teachers prioritised learning goals for children, followed by their own professional development goals (Figure 4). The CPD activities in CCI are crucial to expanding the programme's reach, potentially creating more opportunities for children to access quality science and industry learning.

Figure 4 Teachers' responses to 'What are the main objectives of the CCI classroom sessions?' (n=48)



4.1.2. Teachers' opinion of the CCI programme after participation

Following participation in CCI, 87% of the **teachers strongly agreed that their expectations of the programme were met** (Figure 5). Furthermore, all the teachers rated the CCI programme positively (Figure 6), with the majority giving it an excellent rating. When compared to the 2021-22 evaluation, these figures signify a 12% increase in meeting the teachers' expectations and a 9% rise in the favourable rating they gave to the programme. These figures are echoed in their comments, which include:

Figure 5 Teachers' responses to 'My expectations of the programme were met' (n=48)

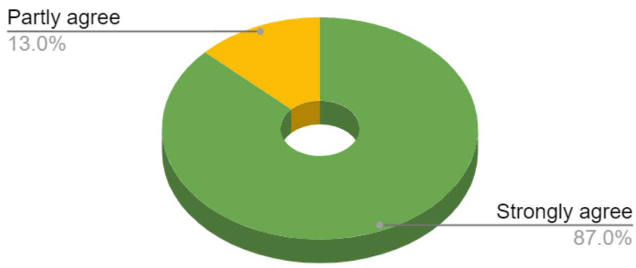
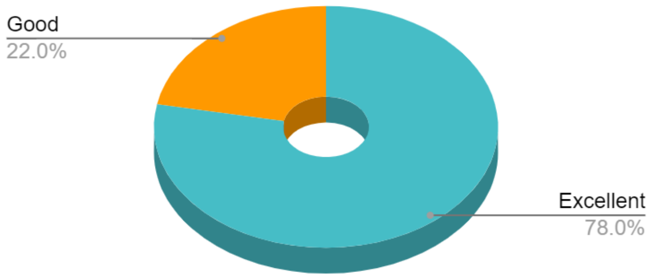


Figure 6 Teachers' rating of the overall CCI programme (n=48)



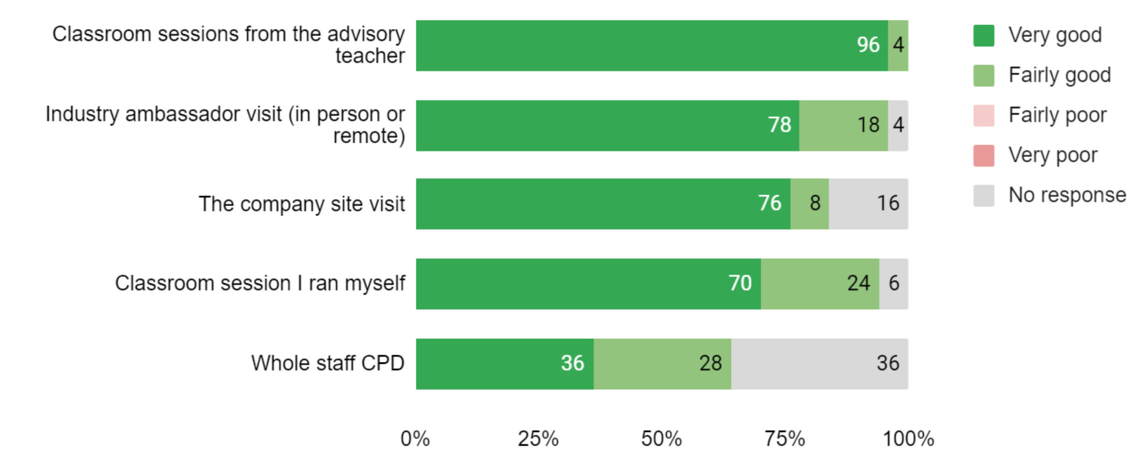
The programme was brilliant to be a part of. The children were so excited to take part in the different sessions and thought the trip to industry was the best trip they had been on!

The programme is well organised, and the links to real life scenarios are powerful. The opportunity for the children to speak to visitors over Zoom is excellent.

The programme was very informative for the children and opened their eyes to jobs around them. It was interesting for us, as adults, to see all the jobs within one company in our local area.

The teachers evaluated the CCI's individual features that are essential to its effective delivery, finding high levels of satisfaction in the majority of the sample (Figure 7). The teachers recognised the expertise of the CCI advisory teachers since almost the complete sample gave the highest rating to the classroom sessions delivered by them. Views about the whole staff CPD session were less certain, but no comments that could explain their perceptions were shared.

Figure 7 Teachers' rating of essential elements of the programme's delivery (n=50)



Teachers' remarks about CCI highlight their satisfaction with the sessions, appreciation for the CCI advisory teachers, and observations of children's engagement with the activities:

The children loved their sessions. They were able to articulate what they had learnt and why they were doing what they were doing. [The AT] was brilliant with the children and very knowledgeable.

[...] The lessons were well thought out and planned in a way that allowed children to vary their skills and gave all children the opportunity to share their thinking.

As a class teacher, I enjoyed being able to observe my class and see them getting involved. I'm sure they appreciated having a visitor and someone with such good subject knowledge. [The AT] was great.

All the teachers indicated that the programme has multiple strengths (Figure 8), selecting *practical science activities*, *industrial context*, and *development of children's investigative skills* as the top three features of CCI. For example, one of them stated, *'[I] felt the investigative Science activities were good and the link to industry was useful for the children to begin to understand the real-life implications of Science'*. Compared to the 2021-22 evaluation, votes for the *industrial context* feature rose 8% this year, while votes for the *expert knowledge of science* feature dropped 15%. This suggests that the company site visits were a determining factor in the assessment of the strengths of the programme – which were limited in the previous year due to the restrictions set in place by the Covid-19 response.

Figure 8 Strenghts of the CCI programme identified by the teachers (n=50)

Similar to the results of the 2021-22 evaluation, the *National Curriculum (NC) coverage* and the *opportunity to observe/assess children* were the least voted features. The National Curriculum (NC) coverage had 40% of the votes, a 10% decrease when compared to last year's evaluation. Further analysis was conducted to identify if the years of teaching experience, science CPD training, or prior participation were influencing factors in recognising the programme's links with the NC, but no positive correlations were found. Nevertheless, CCI was received very well overall, with some teachers leaving enthusiastic comments that acknowledged this success:

An amazing programme from start to finish! *The pupils loved our visitor (the AT) was patient, knowledgeable and enthusiastic. The sessions were engaging and practical; giving each pupil a vital role in their experiment. They were able to find solutions to real life industry problems whilst having fun and developing key working scientifically skills from the National Curriculum.*

I am incredibly happy with the whole service that we received from the CCI programme. The children were inspired by the in school visits from [the AT] as well as everything that they did at CRODA with [CCI ambassadors]. I feel that the whole programme was beneficial for so many reasons and really ***showed the children that a career in STEM or industry is achievable!***

In addition to the met expectations, positive ratings, and high regard for the whole programme, 90% of the teachers strongly believed that CCI provided an effective link with industry. According to 79% of the teachers, the CCI ambassador visit reinforced the classroom sessions, and 77% stated the same about the company site visits. Likewise, 79% of the teachers felt strongly that the CCI ambassador(s) were a valuable aspect of the programme. The following section outlines the effects of the programme on teaching science in an industrial context among other professional development aspects.

4.2. Guskey's Impact Level 2. Participants' learning

The engagement in CCI and with the local companies had a positive effect on teachers' views about industry by making these more nuanced and potentially more informed (Table 17). Teachers stated that *industry has a negative impact on the environment*, and after CCI, many more of them indicated that *industry causes as little pollution as possible*. This suggests that through CCI, teachers gained a new awareness about industrial activity, helping them move away from polarised views and acknowledge industry's input to society. After CCI, 13% more felt positive about industry with certainty, and 26% more of them indicated that it improved their quality of life.

Table 13 Frequency analysis of changes in teachers' attitudes towards industry after CCI (*n*=49-50)

Statements in scale	Strongly agree (%)		Partially agree (%)		I don't know (%)		Partially disagree (%)		Strongly disagree (%)	
	Pre-CCI	**Post-CCI**	**Pre-CCI**	**Post-CCI**	**Pre-CCI**	**Post-CCI**	**Pre-CCI**	**Post-CCI**	**Pre-CCI**	**Post-CCI**
Industry improves our quality of life	28	54	54	40	18	4	0	2	0	0
Industry creates wealth and boosts our economy	48	67	44	27	8	4	0	2	0	0
Industry produces a wide variety of useful products	74	92	22	8	4	0	0	0	0	0
Industry causes as little pollution as possible	2	19	24	42	38	27	28	10	8	2
Industry provides many career opportunities	84	94	14	6	2	0	0	0	0	0
Industry has a negative impact on the environment	4	4	44	41	40	29	8	20	4	6
A job in industry would be tedious	0	2	6	4	44	26	28	29	22	39
I feel negative about industry	0	2	0	4	24	12	30	23	46	59

In addition to the increasing number of teachers who expanded their awareness of industry, 72% of teachers were certain that their knowledge of industry improved (Figure 9), which represents a 12% increase compared to last year's figures for this aspect. In both questionnaires, using a scale from 1-100 points, the teachers scored how comfortable they felt about teaching and learning about STEM, resulting in an average (*n*=46) of 16 additional points after CCI.

'The programme has made me feel more confident about delivering practical science lessons and the questions that I could ask/use alongside this.'

Likewise, the majority of teachers indicated their science teaching confidence had increased to a different extent (Figure 10). The same scoring exercise revealed an average (*n*=45) of additional 20 points in teachers' confidence to teach about STEM in everyday life and an average of 18 more points in their confidence to teach about STEM-related careers to children. The averages demonstrate the positive impact that CCI has on teachers' levels of confidence in general; however, these numbers might look much higher or lower when looking at individual cases.

Figure 9 Teachers' perceptions of changes in their knowledge about industry (n=49)

'My knowledge of industry has improved'

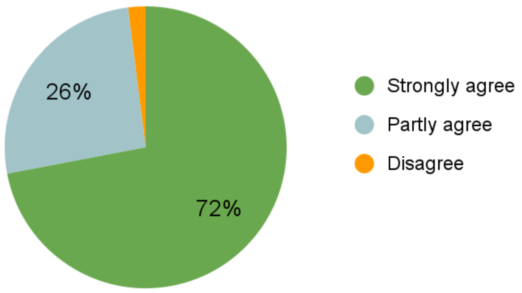
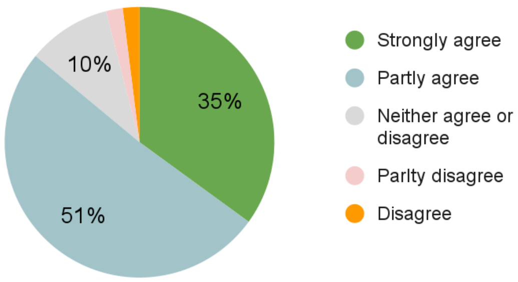


Figure 10 Teachers' perceptions of changes in their confidence to teach science (n=49)

'My confidence to teach science has improved'



4.4. Guskey's Impact Level 4. Participants use new knowledge and skills

Adopting new ideas and evolving teaching practices entails gradual and spiralling processes that prove challenging to fully capture in a survey. Nevertheless, the questionnaires effectively documented shifts in practice reported by teachers with prior experience in CCI, as well as the intentions of those new to CCI to instigate changes. Those with prior experience used ideas and resources from CCI to nurture the development of science capital within and beyond their class, and some engaged in additional professional development. Below are selected remarks from these teachers:

'After your *previous* involvement in CCI, were you inspired to do further lessons or activities that were influenced by your experience of CCI?'

Definitely influenced - getting the children to be more hands on with investigations and leading their own learning.

Yes we used a number of investigations with our partner schools as a science step up day bridging the gap between schools before Y4 attended our school in Y5.

Yes, this was when I had just qualified, many years ago. If I remember rightly, I used one of your programmes linked to medicines and microorganisms.

Yes. I also attended Thinking, talking doing science course with [CCI AT] which impacted on practise.

Yes, I am trying to incorporate practicals in my Science lessons: making yogurt, designing mouse trap (circuts).

Yes. [I] taught some similar lessons in other year groups using the same principles and taught the same lessons as the CCI when we were unable to have them in school.

After our experience of CCI, we definitely tried to include more science capital and real world application of science in our lessons. This is something that we are still keen to include in our science planning going forward. We also still use the planning sheets that were provided by CCI for experiments and give children more and more freedom with them as they get more confident and familiar with the form.

After participating in this year's programme, 58% of teachers reported feeling inspired to make changes in their practice, with 42% of them being newcomers. Similarly to the teachers who have already adopted ideas from the programme or inspired change in their schools, those newly inspired teachers anticipate actions in terms of planning, resource reuse, and expanding the programme's impact on others in their schools. Below are selected remarks from these teachers:

‘After your involvement *this year*, have you been inspired to do further lessons or activities that were influenced by your experience of CCI?’

Although time constraints provide an obvious issue particularly in a Y6 classroom, I would now welcome any further opportunities to be involved with other industrial companies as I feel the children hugely benefited from the opportunity to visit the site itself. Many talked before the visit of family members working on local sites/ plants; when we left the site from our visit, they were about 'their' jobs on site when they grow up.

I plan on linking a future science topic to industry. I really liked the teaching in context. I hope to be able to apply our materials topic to different parts of industry.

We will be using the CCI resources to plan further experiments in Year 5.

I have more confidence to take on 'messy' experiments after seeing how much enjoyment the class got from the opportunity to get 'stuck in'.

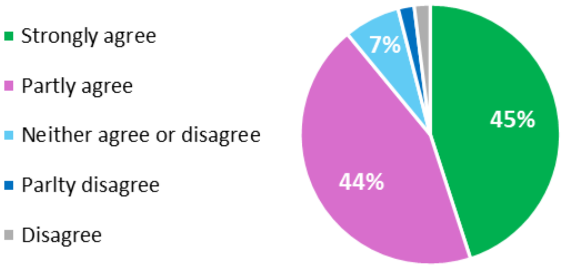
Be more conscious of Science Capital when planning in the long, medium and short term. Give children more ownership during investigations - we've already used the job role badges to allocate roles in science work.

Definitely reuse the practical activities that we did next year and incorporate those practicals into our Science teaching. To ensure that in further teaching I link the Science we are doing more to the real world and industry to try to give it a context.

We would like to be able to incorporate something like this into our yearly cycle to ensure all future year groups have an opportunity of this kind.

The majority of teachers will reuse the CCI resources (Figure 12). Likewise, the majority of teachers either expressed intentions (Figure 13a) or successfully shared their CCI experiences with colleagues (Figure 13b), thereby enhancing the science teaching and learning communities within their schools.

Figure 12 Teachers' responses (n=45) to the statement *'I will use the written [CCI] resources again'*



Sharing the CCI experiences with other colleagues has the potential to extend CCI's impact to more teachers and the children they teach. Furthermore, teachers identified that children also talked to others about CCI and one of them said, *'Children talked to other members of staff about their positive experiences, and it has given them a greater awareness of the role of science in their own lives'*. In line with this, 78% of teachers believed the programme would benefit other classes in their school, which is 9% higher than last year's evaluation.

Figure 13a Teachers' responses (n=45) to the statement *'I have been able to share my CCI experiences with colleagues already'*

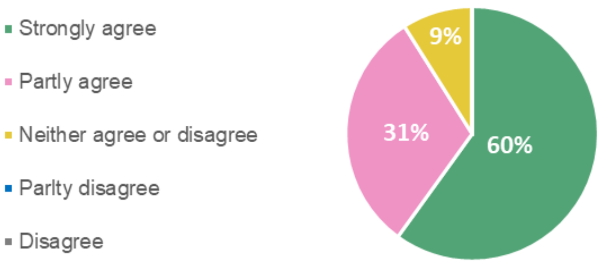
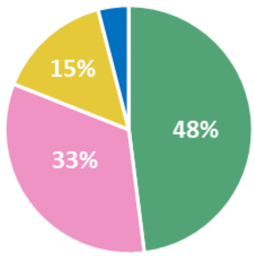


Figure 13b Teachers' responses (n=46) to the statement *'I have managed to enthuse at least one colleague about CCI'*



Overall, these findings indicate that learning how to optimise existing school resources and networks, the increased confidence levels for science and STEM career teaching, and intentions to apply and share newfound knowledge could transform these teachers into catalysts for change within their classroom and science education in their schools.

5. Conclusions

Based on the analysed data for this report, the CCI programme successfully met its primary educational and professional development goals, providing a valuable learning experience for the participating teachers and children. The evaluation assessed the elements of the CCI programme that children found most and least enjoyable, along with the reasons behind their preferences. It also delved into children's awareness of 'working scientifically' principles, paving the way for exploring the programme's impact on children's attitudes towards science, industry, and STEM careers. The assessment of the programme's impact on teachers is organised according to Guskey's (2016) framework for evaluating professional training. The evaluation compares teachers' expectations with their assessment of the programme, revealing overwhelmingly high levels of satisfaction. The report concludes by showcasing teachers' perceived increase in confidence to teach science, self-reported evidence of changes in practice, and their inclination to continue using 'the lessons learned' at CCI in the future.

5.1. Effects of the programme on children

Children enjoyed the CCI practical activities most, a consistent trend observed across the three regions and in previous annual evaluations. The reintroduction of company site visits sparked a renewed enthusiasm for learning about science in industry, igniting excitement in exploring the inner workings of science-based companies. Prior career learning case studies in primary school settings indicate that children are more engaged when they can connect with career visitors, classes, and their aspirations (Kashefpakdel et al., 2018). These findings were further corroborated by the overwhelmingly positive comments made by children in the open-ended questions. While 38% of children said there was nothing they did not like about CCI, there are a few minor aspects to consider that could improve future delivery. For example, some of the minor adjustments could be addressed by exploring negative emotions that arise in children as they are walking around a factory or offering children regular breaks when walking during industry visits. Comparing what children enjoyed the most and the least contributes to understanding the impact of CCI, although any recommendations for future site visits and classroom delivery are better suited for company-level reporting because they are specific to each implementation case.

The programme had a positive prominent effect on children's attitudes towards industry across the three regions. After taking part, the analysis underscores consistent increases in the number of children who responded positively to 14 of the 15 statements on the industry attitude scale. CCI encouraged more children to recognise the important role of scientists in industry, creating opportunities for children to appreciate the role of science in the manufacturing industry and engage with basic notions of applied science in a real-life setting. The science capital theory also recognises that children can benefit from being exposed to the uses of science and engineering in the real world and being made relevant by connecting them to aspects of their everyday lives (Archer et al., 2013; Moote et al., 2019). Some children 'felt like scientists' during practical activities or site visits to companies, illustrating the personal relevance and meaning that science and engineering education can hold for them. For most children, these positive attitudes did not immediately translate into aspirations for careers in science and engineering, but they laid the groundwork for fostering interest and sparking curiosity in STEM subjects and careers (DeWit et al., 2013).

Furthermore, following CCI, 29% of teachers estimated that more than 50% of their class had shown interest in a STEM career. This implies that, in certain instances, children may be contemplating a future in STEM but may not yet be prepared to articulate it in questionnaires. Assessing interest and engagement in the mid- and long-term post-CCI is not within the scope of this evaluation, but teachers are well-positioned to perceive and observe these changes.

From an early age, there should be opportunities to learn about the wide range of career options, as stated in a recent policy report informing the careers education system in England (House of Commons Education Committee, 2023). Early career-related learning interventions for primary school children are recommended because children tend to limit their career aspirations based on a few characteristics they understand about a role, stereotypical ideas about science and engineering, and they might struggle to understand the applications of jobs and careers in the broader economic and social systems (Kashefpakdel et al., 2018; National Academies of Sciences, Engineering, and Medicine, 2023). In fact, the programme successfully encouraged girls to overcome gender stereotypes, presenting significant differences in the number of girls who stated they would like to be scientists or engineers after CCI.

This evaluation showed that CCI encouraged children to expand their notions of careers in industry and entertain visions of themselves as scientists or in other roles in industry. The most recent three programme evaluations reveal consistent statistics regarding career aspirations, indicating that the shift between remote and in-person delivery methods has not significantly influenced this aspect. More importantly, the children who expressed a STEM career interest and those with different preferences were all exposed to careers in industry in a manner that challenges persistent stereotypes based on race, gender or class, an important goal to support diversity and inclusion in the sector.

Children with science role models and positive parental perceptions of science demonstrated higher STEM career aspirations before the programme, and CCI had a more pronounced effect on career aspirations in industry when children held a negative perception of their parents' views on science. Children's perceptions of their parents' attitudes towards science are subjective; nevertheless, a pivotal study in this area found that parental attitudes towards science can have a stronger correlation with children's aspirations in science than any other general parental involvement in their child's education (Archer et al., 2012), stressing the significance of parental perspectives on science and engineering. Moreover, these findings indicate that social disparities and inequalities among children can influence career aspirations, which is particularly evident in the North East region, where the lowest increases are observed. This area has a historical backdrop of deprivation, further underscoring social factors' impact on children's aspirations.

Across the three regions, children's attitudes towards science exhibited minimal changes after the intervention in most scale items measuring this aspect. While most children stated they liked science before and after the programme, only around one-third of the sample expressed an increased interest in science as a school subject. This could be attributed to historical and contextual factors beyond the scope of the CCI delivery, possibly reflecting the perceived reality of science education in primary schools. Additionally, children who had role models or were inspired by someone regarding science tended to favour it as a subject. The findings also revealed that more than three-quarters of children could identify essential practices of working scientifically, although showing minimal to no impact of the programme in this regard but giving insight into children's familiarity with 'working scientifically' principles.

Both before and after the programme, half of the children expressed the belief that industry poses dangers and contributes to environmental pollution. However, post-programme, an increased number of children also acknowledged that industry could operate safely and minimise its environmental impact as much as possible. These contrasting perspectives indicate a heightened awareness of the nuanced discussions surrounding industrial safety and pollution. The results also testify to primary school children’s capacity to connect industrial activities and environmental concerns. Children's perspectives on industry and environmental pollution highlight the importance of addressing children’s concerns by expanding opportunities for them to explore and learn about the responsibility and role of industrial companies in addressing climate and environmental crises.

The slight changes in children expressing positive views about science in the post-questionnaire may suggest that CCI's impact is more pronounced in promoting awareness about industry and that perhaps the science attitudes scale no longer captures CCI's potential to influence children's attitudes towards science. However, the study captured how CCI effectively encouraged children to sustain or enhance their enthusiasm for science beyond the classroom, evidenced by increased interest in conducting experiments at home. Exploring science and engineering through out-of-school activities is also an important recommendation that stems from the science capital theory (Godec et al., 2017), and CCI clearly sparked that curiosity for science beyond school in children.

5.2. Effects of the programme on teachers

The qualitative and quantitative data from teacher evaluations consistently indicate a positive perception of the programme and the expertise of those involved in its delivery. Teachers unanimously recognise multiple strengths within the programme, with company site visits emerging as a pivotal factor influencing their assessment. They increased their awareness of the benefits and importance of industry, bolstering their confidence in science teaching in the context of STEM careers. Furthermore, the evaluation reveals a shift in teachers' perceptions regarding industry's environmental impact, with a significant number expressing a belief in industry's efforts to minimise pollution post-programme. This indicates a broader awareness cultivated through the programme, enabling teachers to move beyond polarised viewpoints and welcome productive and objective conversations on the matter.

Through CCI, teachers increased their confidence in leading similar future collaborations and organising visits to industry. CCI enhanced teachers' awareness of available school infrastructure that could support these visits. While teachers naturally focus on setting learning goals and enriching children's science education, CCI elevates the importance of continuous professional development in science and STEM career learning, as featured in remarks about future implementation plans and testimonials from those teachers who repeat participation in the programme and who have gradually embraced change in their practices. Considering the absence of engineering education in the current English National Curriculum (Bonsall et al., 2022), CCI provides unique professional development opportunities for teachers.

CCI holds promise for instigating individual, collective, and organisational change through targeted professional development activities and recommended practices aimed at nurturing the science capital of students, teachers, and the broader school community. These findings, alongside the positive outcomes observed in children, underscore the programme's effectiveness in achieving its objectives.

5.3. Future directions for the annual evaluation

Between 2018 and 2023, the CCI questionnaires focused mainly on the science capital of both children and teachers. However, the emphasis on this aspect was reduced in the 2023-24 questionnaires, resulting in shorter questionnaires and a new focus in the 2024-25 editions. The questionnaires for 2022-23 introduced a new scale comprising 12 Likert items to evaluate children's awareness of working scientifically after taking part in the CCI activities. Since the assessment following intervention showed no significant changes, this scale was omitted from the 2023-24 questionnaire edition. On the subject of scales, the reliability of the industry scale could be improved by expanding the explanation of what industry is in the pre-questionnaire and following recommendations to exclude inconsistent respondents (Steinmann et al., 2022). The current findings regarding the programme's ability to steer participants away from polarised opinions towards objective assessments of industrial activity and environmental impact indicate the need for further investigation in future evaluations. Likewise, forthcoming iterations of the questionnaires could delve into children's perceived barriers to enjoyment of school science, including aspects they dislike that are not directly tied to their general views on science. Lastly, exploring barriers to envisioning careers in STEM could be beneficial.

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References

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus: how families shape children's engagement and identification with science. *American Educational Research Journa*l, 49(5), 881-908. https://doi.org/10.3102/0002831211433290

Archer, L., Osborne, J. De Witt, J, Willis, B. & Wong, B. (2013). *The ASPIRES project (Children's science and careers' aspirations, age 10-14): Interim research report summary*. Available at: https://kclpure.kcl.ac.uk/portal/en/publications/interim-research-summary-aspires-project(36535cb6-4f7b4772-868e-0152a2419ca4).html

Benavides Lahnstein, A.I. & Parvin, J. (2023) *Evaluation of the impact of the Children Challenging Industry programme 2021 to 2022*. York: University of York

Bonsall, A., Bianchi, L. & Hanson, J. (2022) A scoping literature review of learning progressions of engineering education at primary and secondary school level, *Research in Science & Technological Education*, 40(3), 407-430, DOI: 10.1080/02635143.2020.1799780

Bórquez Sánchez, E. (2022). *Evaluation of the impact of the Children Challenging Industry programme 2020 to 2021.* York: The University of York

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education*. 7th ed. Abingdon, Oxon: Routledge

Department for Education (2015) *The national curriculum in England: key stages 1 and 2 framework document.* Available at: https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study/national-curriculum-in-england-science-programmes-of-study#key-stage-1-programme-of-study---years-1-and-2 (Accessed: 14 Feb 2024).

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis B. & Wong, B. (2013) Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable, *International Journal of Science Education*, 35(6), 1037-1063, DOI: 10.1080/09500693.2011.608197

Godec, S., King, H. & Archer, L. (2017). *The science capital teaching approach: engaging students with science, promoting social justice*. London: University College London.

Guskey, T. R. (2002). Does it make a difference? Evaluating professional development. *Educational Leadership*, 59(6), 45-51.

Guskey, T. R. (2016). Gauge impact with 5 levels of data. *Journal of Staff Development*, 37(1), 32–37

House of Commons Education Committee (2023). *Careers education, information, advice, and guidance.* https://committees.parliament.uk/publications/40610/documents/198034/default/

Kashefpakdel, E., Rehill, J. and Hughes, D. (2018). What works? Career-related learning in primary schools. https://www.educationandemployers.org/research/what-works-primary/

Knief, U. & Forstmeier, W. (2021) Violating the normality assumption may be the lesser of two evils. *Behav Res* 53, 2576–2590. https://doi.org/10.3758/s13428-021-01587-5

Lambrechts, A. A. (2021). *Evaluation of the impact of the Children Challenging Industry programme 2018 to 2020.* York: The University of York

Moote, J., Archer, L., DeWitt, J., MacLeod, E. (2019). Comparing students' engineering and science aspirations from age 10 to 16: Investigating the role of gender, ethnicity, cultural capital, and attitudinal factors. *J Eng Educ*. 109(1), 34–51. https://doi.org/10.1002/jee.20302

National Academies of Sciences, Engineering, and Medicine. (2023). *Rise and thrive with science: teaching PK-5 science and engineering*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26853.

Steinmann, I., Sánchez, D., van Laar, S., & Braeken, J. (2022). The impact of inconsistent responders to mixed-worded scales on inferences in international large-scale assessments. Assessment in Education: Principles, Policy & Practice, 29(1), 5-26. https://doi.org/10.1080/0969594X.2021.2005302

Tabaqchali, H., Turkenburg-van Diepen, M., & Hanley, P. (2018). *Evaluation of the impact of the Children Challenging Industry programme 2016 to 2017*. York: The University of York

Appendices

Appendix A Paired samples *t*-tests results of scales measuring children's science & industry attitudes

Attitude scale	Whole sample	Gender	Academic year	Region
Children's attitudes towards science (n=1210*)	There was no significant mean score change between C2 (M=3.21, SD=.73) and C1 (M=3.20, SD=.71); t (1209) = .55, p=.29, d=.01	No significant mean score change was found in these categories		
Children's attitudes towards industry (n=1190*)	There was a statistically significant improvement at C2 (M=3.75, SD=.43) than at C1 (M=3.50, SD=.42); t (1189) =18.64, p<.001, d=.52	Significant with girls (t (602) = 12.70, p<0.001) and boys (t (586) = 12.83, p<0.001) becoming more positive	Significant with Y5 (t (702) = 13.475, p<0.001) and Y6 (t (485) = 11.98, p<0.001) becoming more positive	There was a statistically significant improvement with children from the North East (t (620) = 12.17, p<0.001), Humber (t (270) = 9.23, p<0.001), and East of England (t (297) = 7.68, p<0.001) regions.

Notes:
C1= pre-questionnaire; C2= post-questionnaire

The scale items in the pre- and post-questionnaires were mostly strongly and positively correlated ($.4 < |r| < .6$, $p < 0.001$)

As indicated by the z-scores, after treating the outliers, the mean scores differences from the sub-samples (region, gender, academic year) were normally distributed or approximately normally distributed. The paired-samples *t*-test is considered "robust" to violations of normality, hence, approximately normally distributed samples were accepted.

*The analysis excluded responses with missing values and outliers.

Appendix B Paired *t*-tests results of individual items in the scale measuring children's science attitudes

Statement*	Whole sample**	Academic year	Gender	Regions
I'd like to be a scientist	Improvement (t (1227) = 3.05, *p*=.001, d=.085)	Improvement with Y5 (t (752) = 2.14, *p*=.016) and Y6 (t (517) = 2.16, *p*=.015) children becoming more positive	Improvement with girls (t (643) = 2.77, *p*=.003) becoming more positive	Improvement with children from the Humber (t (284) = 2.89, *p*=.002) the East of England regions (t (317) = 2.19, *p*=.015) becoming more positive
I'd like to be an engineer	Improvement (t (1284) = 2.69, *p*=.004, d=.075)	Improvement with Y6 children (t (524) = 2.37, p=.009) becoming more positive.	Improvement with girls (t (645) = 3.7, *p*= <.001) becoming more positive	Improvement with children from the Humber (t (285) = 2.19, *p*=.014) and the East of England regions (t (322) = 2.17, *p*=.015) becoming more positive
Science is my favourite subject	*NA*	*NA*	Improvement with boys (t (629) = 2.34, *p*=.010) becoming more positive	*NA*
*We do too much writing in science**	Improvement (t (1284) = 1.74, *p*=.041, d=.048)	*NA*	*NA*	Improvement with children from the East of England region (t (321) = 1.83, *p*=.034) becoming more positive
I like doing science experiments at home	Improvement (t (1294) = 2.76, *p*=.003, d=.077)	Improvement with Y5 children (t (767) = 2.91, *p*=.002) becoming more positive	Improvement with girls (t (649) = 2.41, *p*=.008) becoming more positive	Improvement with children from the East of England region (t (324) = 1.93, *p*=.027) becoming more positive

Notes:
* Items without statistical significance (or effect sizes suggest differences are trivial) across all sub-groups (total and individual regions, school year, and gender) are excluded from the table.
**The analysis excludes responses with missing values and 17 outliers. As indicated by the z-scores, after treating the outliers, the mean scores differences from the sub-samples (region, gender, academic year) were normally distributed or approximately normally distributed. The paired-samples t-test is considered "robust" to violations of normality; hence, approximately normally distributed samples were accepted.

Appendix C Paired *t*-tests results of individual items in the scale measuring children's industry attitudes

Statement*	Whole sample**	Academic year	Gender	Regions
Industry is useful	Improvement (t (1304) = 7.76, *p*<.001, d=.21)	Improvement with Y5 (t (770) = 4.89, *p*<.001) and Y6 (t (532) = 6.49, *p*<.001) becoming more positive	Improvement with girls (t (660) = 4.95, *p*<.001) and boys (t(643) = 6.07, *p*<.001) becoming more positive	Improvement with children from the Humber (t (291) = 5.10, *p*=<.001) and East of England (t (298) =4.98, *p*<.001) becoming more positive
I learn about industry from my teachers	Improvement (t (1288) = 10.37, *p*<.001, d=.29)	Improvement with Y5 (t (763) =6.71, *p*<.001) and Y6 (t (523) = 8.21, *p*<.001) becoming more positive	Improvement with girls (t (653) = 7.42, *p*<.001) and boys (t (634) = 7.26, *p*<.001) becoming more positive	Improvement with children from the North East (t (675) = 7.23, *p*<.001), Humber (t (289) =5.36, *p*<.001) and East of England (t (295) =5.18, *p*<.001) becoming more positive
Our lives would be worse without industry	Improvement (t (1280) = 7.72, *p*<.001, d=.21)	Improvement with Y5 (t (758) =5.3, *p*<.001) and Y6 (t(520)=5.64, *p*<.001) becoming more positive	Improvement with girls (t (650) = 6.58, *p*<.001) and boys (t (629) = 4.37, *p*<.001) becoming more positive	Improvement with children from the North East (t (673) = 6.09, *p*<.001) and East of England (t (291) = 4.47, *p*<.001) becoming more positive
Industry makes things we need	Improvement (t (1288) = 9.69, *p*<.001, d=.27)	Improvement with Y5 (t (762) =6.58, *p*<.001) and Y6 (t 524) = 7.43, *p*=<.001) becoming more positive	Improvement with girls (t (653) = 7.56, *p*<.001) and boys (t (634) = 6.19, *p*<.001) becoming more positive	Improvement with children from the North East (t (675) = 7.44, *p*<.001), Humber (t (289) =4.21 *p*<.001) and East of England (t (295) =4.76, *p*=<.001) becoming more positive

Industry causes as little pollution as possible	Improvement (t (1280) = 7.62, *p*<.001, d=.21)	Improvement with Y5 (t (758) =5.50, *p*<.001) and Y6 (t (520)=5.27, *p*<001) becoming more positive	Improvement with girls (t (648) = 5.74, *p*<.001) boys (t (631) = 5.05, *p*<.001) becoming more positive	Improvement with children from the North East (t (670) = 6.06, *p*<.001) and East of England (t (294) =3.74, *p*=<.001) becoming more positive
Many scientists work in industry	Improvement (t (1292) = 15.84, *p*<.001, d=.44)	Improvement with Y5 (t (763) =12.007, *p*<.001) and Y6 (t (527) = 10.39, *p*<.001) becoming more positive	Improvement with girls (t (655) = 10.90, *p*<.001) and boys (t (636) = 11.50, *p*<.001) becoming more positive	Improvement with children from the North East (t (675) = 11.50, *p*<.001), Humber (t (291) = 7.05, *p*<.001) and East of England (t (297) =7.96, *p*<.001) becoming more positive
Many engineers work in industry	Improvement (t (1286) = 12.86, *p*<.001, d=.36)	Improvement with Y5 (t (760) =9.93, *p*<.001) and Y6 (t(524)=8.14, *p*<.001) becoming more positive	Improvement with girls (t (649) = 9.42, *p*<.001) and boys (t(636)= 8.74, *p*<.001) becoming more positive	Improvement with children from the North East (t (673) = 8.97, *p*<.001), Humber (t (291) = 6.23, *p*<.001) and East of England (t (293) =6.92, *p*<.001) becoming more positive
Young people work in industry	Improvement (t (1282) = 8.19, *p*<.001, d=.23)	Improvement with Y5 (t (756) =6.78, *p*<.001) and Y6 (t(524)=4.58, *p*<.001) becoming more positive	Improvement with girls (t (649) = 5.77, *p*<.001) and boys (t (632) = 5.81, *p*<.001) becoming more positive	Improvement with children from the North East (t (670) = 4.30 *p*<.001), Humber (t (289) =4.98, *p*<.001) and East of England (t (294) =6.19, *p*<.001) becoming more positive
Scientists have important jobs in industry	Improvement (t (1275) = 10.73, *p*<.001, d=.30)	Improvement with Y5 (t (755) =8.50, *p*<.001) and Y6 (t(518)=6.54, *p*<.001) becoming	Improvement with girls (t (645) = 7.39, *p*<.001) and boys (t(629)= 7.78, *p*<.001) becoming	Improvement with children from the North East (t (666) = 7.93, *p*<.001), Humber (t (290) =

		more positive	more positive	5.93, *p*<.001) and East of England (t (291) =3.92, *p*<.001) becoming more positive
Engineers have important jobs in industry	Improvement (t (1268) = 8.54, *p*<.001, d=.24)	Improvement with Y5 (t (751) =6.24, *p*<.001) and Y6 (t(515)=5.90, *p*=<.001) becoming more positive	Improvement with girls (t (644) = 5.70, *p*<.001) and boys (t (623) = 6.37, *p*<.001) becoming more positive	Improvement with children from the North East (t (664) =5.75, *p*<.001), Humber (t (284) =4.41, p<.001) and East of England (t (291) =4.54, *p*<.001) becoming more positive

Notes:
* Items without statistical significance (or effect sizes suggest differences are trivial) across all sub-groups (total and individual regions, school year, and gender) are excluded from the table.

**The analysis excludes responses with missing values, and six outliers were also removed to increase the robustness of the t-test. As indicated by the z-scores, after treating the outliers, the mean scores differences from the sub-samples (region, gender, academic year) were normally distributed or approximately normally distributed. The paired-samples *t*-test is considered "robust" to violations of normality, especially for large samples (Knief & Forstmeier, 2021); hence, approximately normally distributed samples were accepted.

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