Children Challenging Industry

Evaluation Report 2021-2022

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

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I. Report summary

Centre for Industry Education Collaboration (CIEC)

Children Challenging Industry (CCI)

Summary of Evaluation Report 2021-2022

Since 1996, CCI has combined the expert knowledge of primary education specialists and STEM professionals (CCI ambassadors) in an effort to promote meaningful engagement with science and STEM careers through a professional development programme.

The CCI advisory teachers, the CCI ambassadors, and the classroom teachers collaborate to deliver practical problem-solving activities inspired by industry stories. Children meet scientists and engineers in their workplaces, learn about their roles in industry, and present the results from their investigations to them. So far, CCI has engaged 60,000 primary school children and 15,000 teachers across England, stimulating the STEM career aspirations of many.

Participation in 2021-2022

51 continuous professional development (CPD) sessions for 725 teachers

37 primary schools, 51 classes with 1,555 children, and most classes (77%) had live and remote CCI ambassador sessions

The 2021-2022 CCI team of advisory teachers

Focus on children

51% of children said they talk to others about their mainstream science lessons once a week and 96% do it with an average of **two** family members.

77% of children spoke about science with others after CCI: More children talked about the CCI lessons with an average of three people in their close social circles.

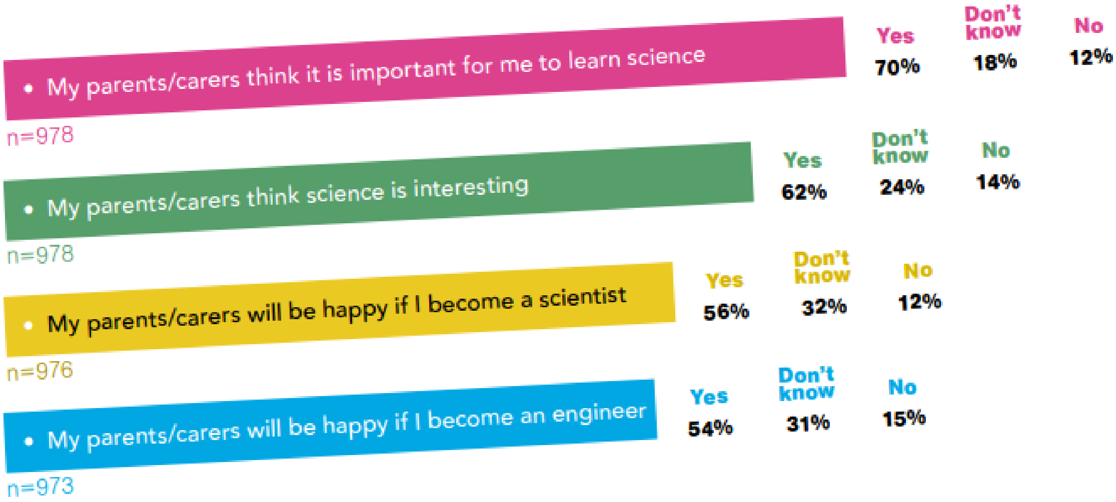
> *'I talked to [my family] about the [CCI] ambassadors and about how fun it was to actually speak to an actual engineer and transporter, and I also said that I would like to do more science in school.' (Girl, Year 6)*

> *'I would tell [mum and grandparent] what I had learnt…They would have a chat saying about say like evaporation and then they would try and find experiments around the house.' (Boy, Year 6)*

> *'I told [family and peers] different activities we did and new things I learnt… They also found out new things they didn't know.' (Girl, Year 5)*

'Talking about science at home is a form of scientific cultural capital that can advantage students at school.' (Archer et al., 2015, p.931)*

How children perceived their parents would appreciate a future career in science or engineering



Among the children whose parents would **not** be happy if they became a scientist or an engineer (n=185):

After CCI, 11% stated *'I could work in industry'* and 6% stated *'I'd like to be an engineer'*, shifting their initially negative views.

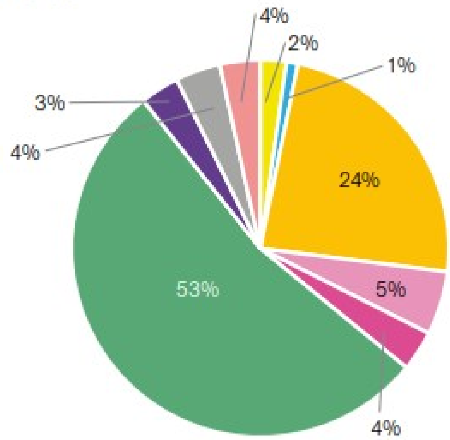
* **Reference:** Archer, L., Dawson, E., DeWitt, J., Seakins, A. and Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. J Res Sci Teach, 52: 922-948. https://doi.org/10.1002/tea.21227

What children enjoyed about participating in CCI

82% of the children enjoyed the CCI practical activities.

Why children enjoyed the CCI practical activities

- They were challenging or felt achievement
- Felt like scientist or like doing real science
- Learned something new, interesting, or surprising
- Enjoyed group work and/or roles
- Enjoyed the hands-on work in experiments
- Had fun, enjoyment, or excitement
- Enjoyed using materials for tests
- Did not know/answer
- Other reasons



I liked the CCI practical activities because…

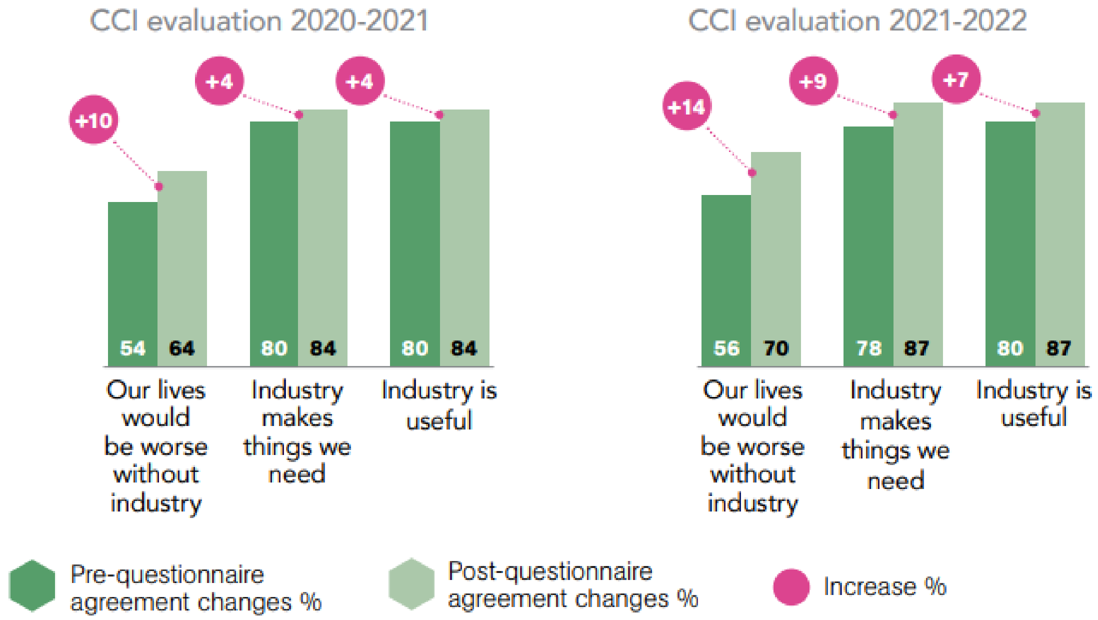
'Because I get to actually do experiments and not just watch other people do them. I get to feel like a real scientist and have fun but also learn a lot from it!' (Girl, Year 5)

'I liked learning how much foam we needed and telling [the CCI ambassador] about it. She also really inspired me to be able to be a scientist.' (Girl, Year 5)

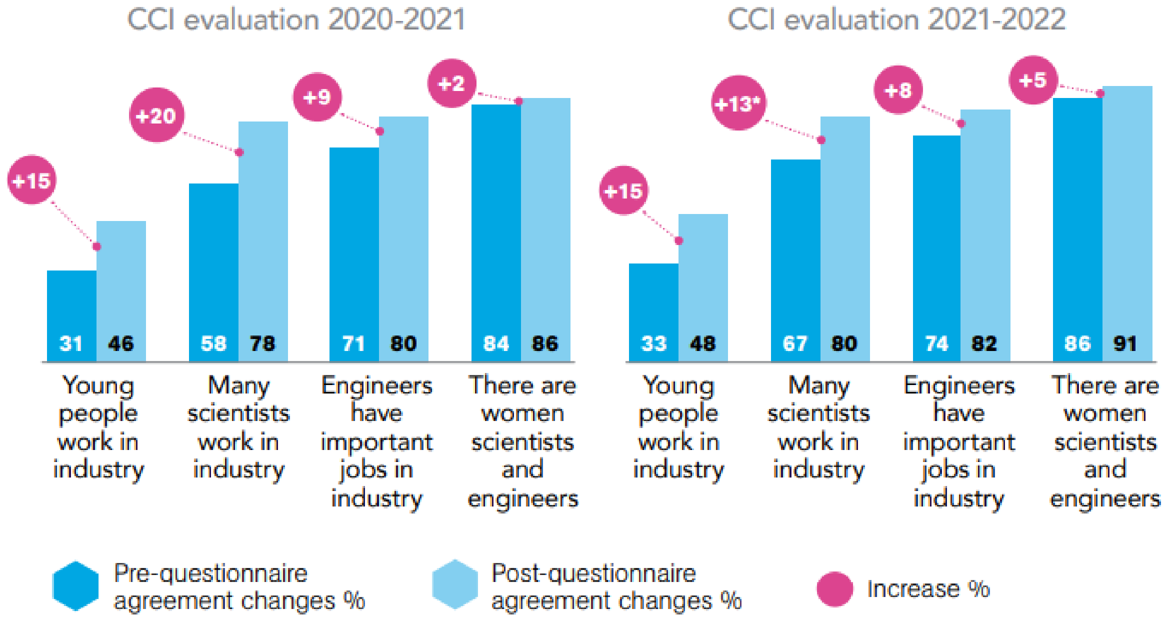
'It was very interesting to see the different types of mould grown on the bread. It was also very interesting to discover why mould can be used in medicines.' (Boy, Year 6)

'It was really fun because it made me like science a little bit more and made me understand it is fun' (Boy, Year 5)

More favourable attitudes towards industry among children



Greater awareness among children about who works in industry

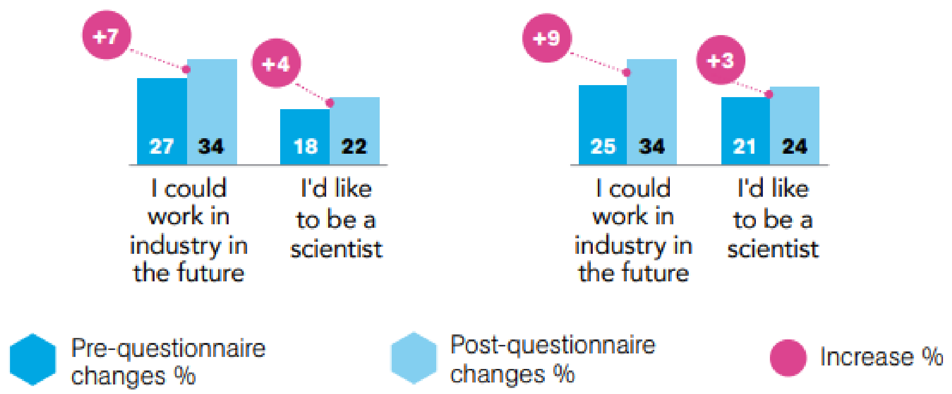


* Missing site visits meant that children did not observe as many scientists as they would normally do.

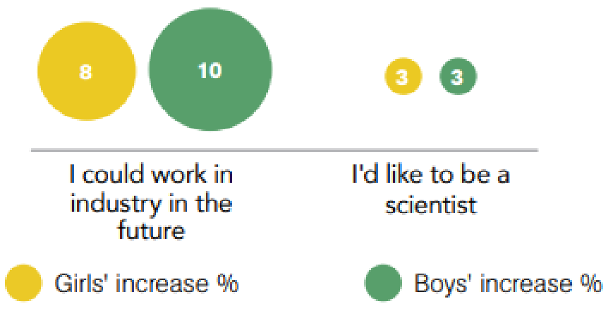
Children's career aspirations were raised after taking part in CCI

CCI evaluation 2020-2021

CCI evaluation 2021-2022



Raised aspirations of girls and boys in CCI 21-22



'In industry I would like to be an engineer. (Boy, Year 5)

'I want to be a enjineer when I am older.' (Boy, Year 5)

'Science is very cool and I want to be an engineer someday.' (Boy, Year 5)

'[I want to] be a scientist that works in creating new cures for illnesses, also I would like to be an mechanical engineer.' (Girl, Year 6)

'I want to be a Cancer doctor.' (Girl, Year 6)

'I told [my family] that I wanted to be an engineer and about how much important science is to me… they agreed and said to follow my dreams.' (Girl, Year 5)

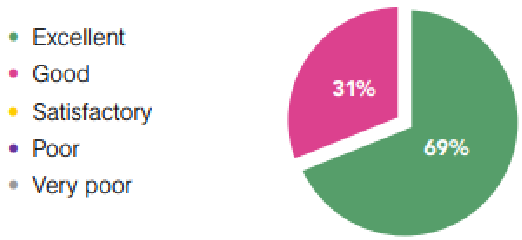
'I want to be a scientist in the future.' (Boy, Year 5)

I would like to be a scientist! (Girl, Year 6)

Focus on teachers

Teachers' opinions of the programme

100% of the teachers (n=42) gave an overwhelmingly positive rating to the CCI programme.

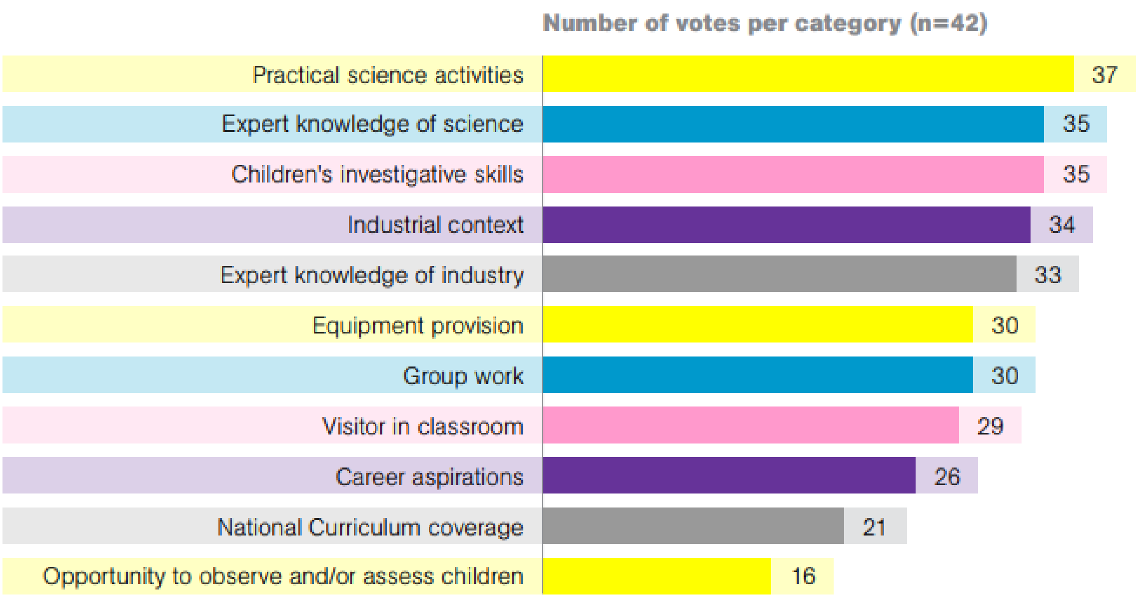


[CCI] is very effective as it created huge enthusiasm and interest in science/ industry (children and staff).

The whole programme is superb and always exceeds our expectations.

[CCI] provided clear explanations and encouraged us as staff to reflect upon Science capital in the lives of the children.

Strengths of the CCI programme according to the teachers



Improved confidence for science teaching

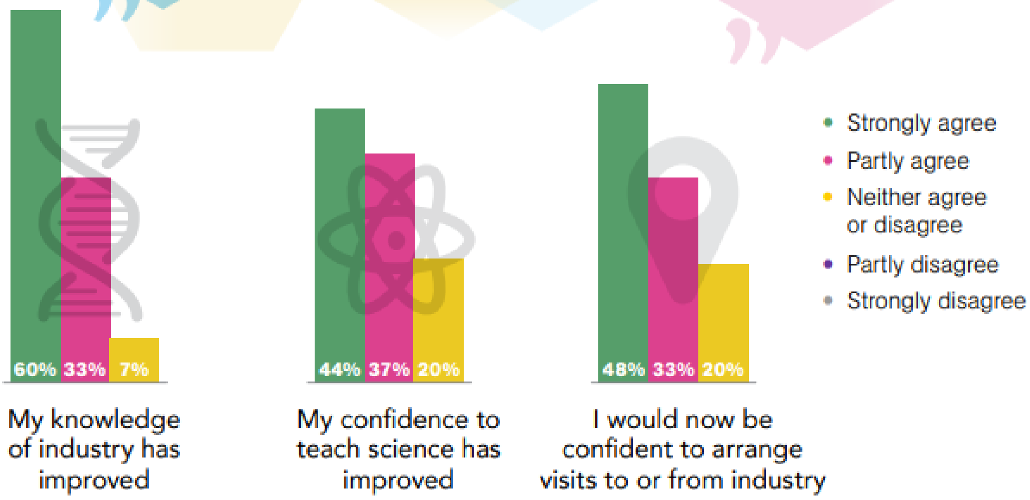
The CCI science professional development sessions and the advisory teachers support helped teachers improve their confidence levels for science teaching and their knowledge of industry.

Here's what teachers said:

I am now more comfortable with teaching and learning from STEM.

I now feel more confident teaching about STEM particularly careers and the practical work ideas.

I feel more confident following the CCI sessions to teach children about industry and STEM careers.



I now feel more confident to make connections with local industries. I am more comfortable to link the learning with the profession so that the children can make connections.

I do feel I can make more links with industry as a whole and will be more aware of doing this more regularly within science lessons.

I feel that I am more confident teaching STEM now as I see the children engaging in activities in a wide range of roles.

CCI can strengthen children's perception of teachers as knowledgeable in science and industry topics.

After CCI, more children (51% >71%) stated that they could learn about industry from their teachers.

Extended impact of the CCI programme in schools

85% Shared their CCI experiences with colleagues.

69% Believed other classes benefit from CCI.

68% Enthused a colleague about CCI.

CCI inspired teachers to make changes in their practice

> *[CCI] inspired me to want to take the children out of school to go on a science trip.*

> *I plan to do more practical activities where the children have more control over the investigation and more control in choosing how to record results.*

> *As science lead, I will be holding a science week in school where we engage in practical hands on experiments and make contact with local scientists, engineers… to speak to the children about how science has helped them in their careers.*

Results summary

The collaboration between the CCI advisory teachers, CCI ambassadors, and classroom teachers produced a positive and innovative learning experience for children. Children enjoyed the practical science activities, engaged in new learning opportunities and held more informed attitudes towards industry after participation. The direct experiences with real-life STEM professionals raised children's aspirations to work in industry or become scientists in the future.

The teachers also successfully engaged with CCI's professional development and had an overwhelmingly positive outlook on the programme. Their increased confidence levels in science teaching is a crucial finding that indicates the programme is meeting its goals. The plans and actions of teachers to reengage with or expand CCI indicate that the programme has the capacity to extend its influence beyond its initial phase and has the potential for significant expansion.

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1. Introduction

The Children Challenging Industry (CCI) has been run by the Centre for Industry Education Collaboration (CIEC) at the University of York since 1996, becoming a flagship programme that connects local science companies and educational communities. Through the support of expert advisory teachers, the programme provides continuing professional development (CPD) for teachers and training for STEM professionals from industry to become CCI ambassadors to deliver a pre-designed science-led learning sequence in schools. CIEC advisory teachers work with children to set up an investigation, following the scientific method (referred to as 'working scientifically' in the English science curriculum) until conclusions are reached, then they meet the CCI ambassadors to discover the links between school science and science in the workplace. The CCI activities are linked to the English National Curriculum (NC) science learning goals and are carefully designed to position science in a real-world context through problems addressed by local industrial companies. The programme aims to develop children's scientific literacy, develop informed attitudes towards science and industry, and raise children's career aspirations.

Since CCI was launched, the programme has engaged over 2000 classes and nearly 60,000 children. During the academic year 2021-2022, 37 primary schools and 51 classes with 1,555 children participated in the CCI programme. Together, four CIEC advisory teachers ran 51 continuous professional development sessions, engaging 725 members of staff across the schools. The CIEC advisory teachers also trained and supported (on-site and online) CCI ambassadors from 63 companies located in the North-East, Humber, and East of England regions.

Despite the ongoing safeguarding restrictions of COVID-19 during the 2021-2022 school year, whenever necessary, the programme was delivered in a blended learning style, combining in-person with live and remote interactions. The advisory teachers delivered the classroom CPD sessions in person and led whole school staff CPD sessions on Developing Science Capital[1]. Site visits were remote and CCI

[1] '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.

ambassadors connected with teachers and children online through video conferencing. The CCI ambassadors posed a challenge for the children and later discussed the results of their investigation and answered children's questions about their jobs/careers.

This report presents the impact of the CCI programme on children's and teachers' attitudes towards science and industry, and it examines their experience of the programme.

2. Methodology

2.1 Evaluation design

The impact of the CCI programme is evaluated annually, through a repeated measures survey study design. The CIEC advisory teachers provide access to classroom teachers and children to the CCI online questionnaires, encouraging the completion of the questionnaires before and after participation in the programme. The advisory teachers and CIEC researcher work in collaboration to track the questionnaire data inputs, maximising the potential of the data collection. The CCI online questionnaires scope teachers' and children's experiences and attitudes towards science and industry. Questionnaire data allows for analysis of changes over time in these aspects and collects crucial aspects of their experience of the programme. The questionnaires include multiple-choice questions, Likert scales (five points), and open-ended questions.

The CCI evaluation mirrors the long-standing and ongoing emphasis of the CCI programme to engage children with science and industry while raising their career aspirations. Since 2018, a few questions were added to the CCI questionnaires to enhance the examination of the impact of the programme in terms of science capital, defining it as 'a measure of engagement or relationship with science, which gives us an insight into why and how some people engage with STEM, while others do not.' (Lambrechts, 2021, p.28). For the evaluation purposes, the science capital theory was broken down into the following elements: (a) What children/teachers know and understand about scientific knowledge; (b) How children's/teachers' thinking refers to their views about science; (c) People that children/teachers know who talk about science with them and encourage them to engage with science; and (d) The science-related things children/teachers do in their spare time.

2.1.1 Children questionnaires

The pre- (C1) and post-participation (C2) questionnaires for children have 23 questions and 24 questions, respectively. The questionnaires for children record basic demographic information such as gender, age, school year, and geographical region. The children's scales measure attitudes towards science (12 Likert items) and industry (16 Likert items) and are mirrored in the pre- and post-questionnaires. Before taking part in the CCI activities, the pre-questionnaire asks children about their out-of-school engagement with science activities at home and elsewhere. In both questionnaires, a free-text question encourages children to freely add anything they want to say about science. In the post-questionnaire, children say what they enjoyed the most and the least about participating in the CCI programme and are encouraged to explain their answer. Children can say if they shared their CCI experience with others and are asked to briefly describe these conversations.

2.1.2 Teacher questionnaires

The pre- (T1) and post-participation (T2) questionnaires for teachers have 35 questions and 26 questions, respectively. Among other aspects, the teacher pre-questionnaire asks about their recent engagement with science professional development and explores their experience leading school field trips to industry sites. In both questionnaires, teachers also describe prior experience conducting science lessons/activities for STEM learning in everyday life at school. The pre- and post-questionnaires record their attitudes towards industry and ask them to self-assess their confidence levels in teaching about STEM careers and STEM in everyday life. Their initial expectations of the programme are also juxtaposed with their post-participation evaluation of CCI. The post-questionnaire prompts them to estimate the impact and transferability of the programme in their school.

2.2 Data collection

2.2.1 Total population of teachers and children responding to CCI questionnaires

Children population: From the 1,555 children who participated in the CCI programme during the 2021-2022 academic year across all regions, 1250 children (80% of all the children who participated in CCI) from 48 classes and 36 schools completed the pre-questionnaires (C1), and 1102 children (71% of children who took part in the programme) from 47 classes and 35 schools completed the post-questionnaires (C2). Table 1 presents a summary of the 'unmatched' children population who responded to the surveys before and after the programme; they are organised according to the geographical location of their schools.

Table 1 CCI survey responses among the 2021-2022 children population

North-East (NE)		Humber		East of England (EE)	
C1 (n=631)	C2 (n=558)	C1 (n=239)	C2 (n=198)	C1 (n=380)	C2 (n=346)
Female respondents					
294	270	103	87	182	169
Male respondents					
337	288	136	111	198	177

Teacher population: Table 2 presents the 'unmatched' teacher population who responded to the surveys according to the region in which their school is located. 47 teachers from 36 schools completed the pre-questionnaire (T1), while 43 teachers from 33 schools completed the post-questionnaire (T2).

Table 2 CCI survey responses among the 2021-2022 teacher population

Questionnaire	North-East (NE)	Humber	East of England (EE)	Population (N)
T1 (n)	25	9	13	47
T2 (n)	24	7	12	43

It is important to highlight that the analysis informing the results of this report did not include pupils or teachers who did not complete both the pre- and post-project questionnaires.

2.2.2 Paired samples of teachers and children

Children and teacher sample size: Pre- and post-questionnaires were returned from 47 schools in the North-East (NE), the East of England (EE) and the Humber regions. In total, 996 pupils completed the 'matched' pre-and post-questionnaires (Table 3); this figure is 64% of all the children who took part in the programme but a significant sample. The sample comprises 46% of girls and 54% of boys, where the gender balance across these regions showed slight differences (Table 3). Overall, 62% of children in the matched sample were studying Year 5, and 38% were studying Year 6.

Table 3 Gender and school academic year distribution in children's sample (n=996)

	Total children and sample distribution	Schools	Girls	Boys	Y5 children	Y6 children
North-East	487 (49%)	24	227	260	327	160
Humber	182 (18%)	9	79	103	124	58
East of England	327 (33%)	14	157	170	167	160
Grand Total	996 (100%)	47	463	533	618	378

The pre-and post-questionnaires for teachers were completed by 42 individuals from 33 schools across the North-East (NE), the East of England (EE) and Humber (Table 4).

Table 4 School academic year distribution in teachers' sample (n=43)

	Total teachers and sample distribution	Schools	Y5 teachers	Y6 teachers	Y5/Y6 teachers
North-East	23 (56%)	19	13	6	4
Humber	7 (16%)	6	4	1	2
East of England	12 (28%)	8	5	7	0
Grand Total	42 (100%)	33	22	14	6

2.3 Data analysis

Key findings reported here are from children and teachers who completed both pre-and post-questionnaires. Matching individuals across both questionnaires helps maximise the validity of the results. Incomplete questionnaires, for example, those only responding to demographic questions, were excluded from the samples across three populations.

2.3.1 Analysis of children's surveys

Statistical analyses were conducted in Microsoft Excel and IBM SPSS Statistics (version 28.0.1.1) software, matching participant responses between the pre-and post-questionnaires. Frequency distributions were employed to study children's and teachers' responses to attitude scales, identifying if their opinions improved, declined, or stayed the same across a range of Likert items.

The five-point Likert scale items in both questionnaires were given values of 1-5, coding the 'I'm not sure' or 'I don't know' answers coded as a middle point. Missing responses were labelled as NR and given a value of zero. The values of negative statements in the attitude scales (e.g., 'Science is too difficult') were reversed-coded, changing a high score (I agree a lot) into the corresponding low score on the scale. This process secures consistency of the mean scores when examining levels of agreement or disagreement across statements phrased positively and negatively.

To test the reliability of the scales, Cronbach's alpha was calculated for the attitudes towards science (12 Likert items) and industry (16 Likert items) scales in both questionnaires. These were calculated using children's data from all regions (the whole sample, including boys and girls from the North-East, Humber and East of England). The Cronbach's alpha statistic for this scale is .797 in the pre-questionnaire and .822 in the post-questionnaire (commonly, 0.7 or higher levels are ideal). These results indicate internal consistency for the scale before and after the programme and that it can be used to gauge an overall score of children's attitudes towards science. The Cronbach's alpha statistic for the 16-item scale measuring attitudes toward industry is .645 in the pre-questionnaire and .723 in the post-questionnaire (again, commonly, 0.7 or higher levels are ideal). These results indicate the scale can be used to measure children's attitudes towards industry, but the pre-questionnaire alpha suggests the scale may need revision of the inter-item covariance.

As in previous CCI annual reports (Bórquez Sánchez, 2022; Lambrechts, 2021; Tabaqchali et al., 2018; Turkenburg & Hanley, 2017), paired *t*-tests were conducted using the pre-and post-questionnaire data to compare the average scores (i.e., means) differences in children's responses before and after the programme. The paired *t*-tests provide statistical significance results, indicating the likelihood of responses resulting from chance or not. The *t*-tests were performed to investigate differences between groups by gender, year group, and geographical location of their school in relation to their attitudes towards science and industry. In parallel, the qualitative data were analysed through descriptive coding (Cohen, et al., 2018). The applied codes were examined to identify significant themes through patterns and differences among the open-ended responses of children.

2.3.2 Analysis of teachers' surveys

Descriptive statistics were employed to analyse the response distribution of demographics and multiple features in the questionnaires. As described for the children's qualitative data analysis, the analysis of teacher qualitative data was also coded and thematically analysed.

3. Results

3.1 Children survey outcomes

3.1.1 Science capital: children's out-of-school engagement with science

In the pre-questionnaire, children could indicate how often they engage in science-related activities in their free time or outside of school. Across the three regions, at least a third of children said they engage in a science-led activity with some regularity; they also stated that they frequently engage in conversations about science with family and/or watch science-related television (Table 5). If available at all and considering the continued effects of the COVID-19, most children indicated that they visit museums or science-related centres once an academic school term or once a year. Also, 29% of children indicated that they engage in science activities (nature walks or experiments) outside of school once a week.

Table 5 Frequency of engagement in science activities outside school (n=996, all regions)

Individual statements in scale	Sample	At least once a week (%)	At least once a month	At least once a term (%)	At least once a year (%)	Never
Talk with someone in my family about what science I've learnt in school	n=981	**51**	18	8	7	16
Watch a TV programme about science or nature	n=980	**32**	28	13	12	15
Do science activities (e.g., nature walks, experiments)	n=984	**29**	27	18	14	12
Visit websites about science	n=986	**25**	18	13	11	33
Read a book or magazine about science	n=984	20	22	16	12	**29**
Visit a science centre, science museum or zoo	n=978	12	12	21	**35**	20
Go to a museum that is not about science	n=986	6	10	16	**42**	27

*The **bolded figures** emphasise the highest percentage of frequency for each activity.*

Only 27 of 996 children (3%) stated they were part of a science club. Before participating in CCI, children were asked to indicate, from a list of nine popular science activities, those they had done in the past. The majority had experience practising at least three popular hands-on science activities at home (Table 6). Children had experienced making slime, mixing coke and mentos, and testing the 'bottle flip' the most. Comparing this report's results with the CCI evaluation report 2018-2020 shows that making slime, doing a fruit battery, and bouncing a raw egg, among others, became much more popular among children in the 2021-2022 period. This could be related to the encouragement that parents and children received to practice home-based science during the COVID-19 pandemic period.

Table 6 Popular science activities and children's engagement (n=996, all regions)

Suggested science activities in questionnaire	Sample size	Yes (%)	I don't know (%)	No (%)
Done the bottle flip	n=984	**89**	3	8
Made slime	n=983	**73**	4	23
Tried the coke and mentos experiment	n=982	**60**	4	36
Made 'gloop' from cornflour and water	n=981	36	9	**55**
Made a 'lava lamp'	n=976	33	6	**61**
Bounced a raw egg, after putting it in vinegar	n=979	29	5	**66**
Made a bubble snake	n=974	18	7	**75**
Made rainbow milk	n=979	14	5	**81**
Made a fruit battery	n=973	13	10	**77**

[1]*The **bolded figures** emphasise the highest percentage of frequency for each activity.*

Over half of the children responded positively to how parents would appreciate a future career in science or engineering (Table 7). Parents' attitudes and dispositions towards science can be essential in motivating children to see themselves in future STEM careers. Hence, it was a positive result that across the different items in this scale, the majority or half of the children (depending on the statement) believed their parents had positive attitudes towards science and engineering.

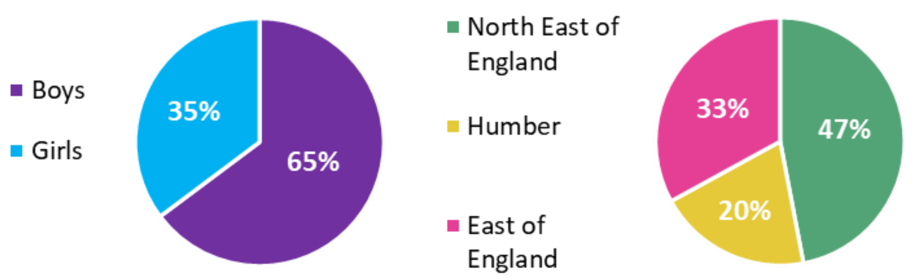
Table 7 Children's perception of parents' views about science and engineering as career paths (n=996, all regions)

Statements in scale	Sample size	Yes (%)	I don't know (%)	No (%)
My parents/carers think it is important for me to learn science	n=978	**70**	18	12
My parents/carers think science is interesting	n=978	**62**	24	14
My parents/carers will be happy if I become a scientist	n=976	**56**	32	12
My parents/carers will be happy if I become an engineer	n=973	**54**	31	15

*[1]The **bolded figures** emphasise the highest percentage of frequency for each statement.*

On average, 13% of children thought their parents are not interested in science learning or careers in science. Of the children who thought their parents would not support their science (12%) or engineering (15%) aspirations (Table 7), it was found that the majority are boys and are in the North of East of England (Figure 1 and Figure 2).

Figure 1 (Pre-questionnaire results) Gender and region distribution of children (n=122) who believe their parents would not support their **science** career aspirations



Some of the children (n=185) who indicated that their parents would **not** support their science **and/or** engineering aspirations showed statistically significant improvement in their attitudes towards engineering and working in industry after taking part in CCI (Figure 3). Further demographic information and analysis would be needed to understand the real potential impact of these factors on their disposition towards science in the future. Children's attitudes towards science, engineering, and industry for the whole sample are presented ahead in Section 3.1.2.

Figure 2 (Pre-questionnaire results) Gender and region distribution of children (n=145) who believe their parents would not support their **engineering** career aspirations

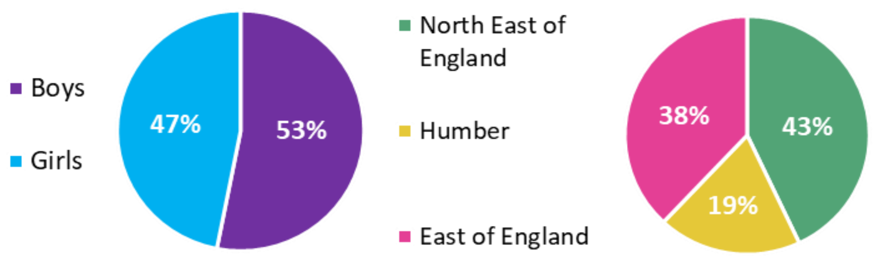
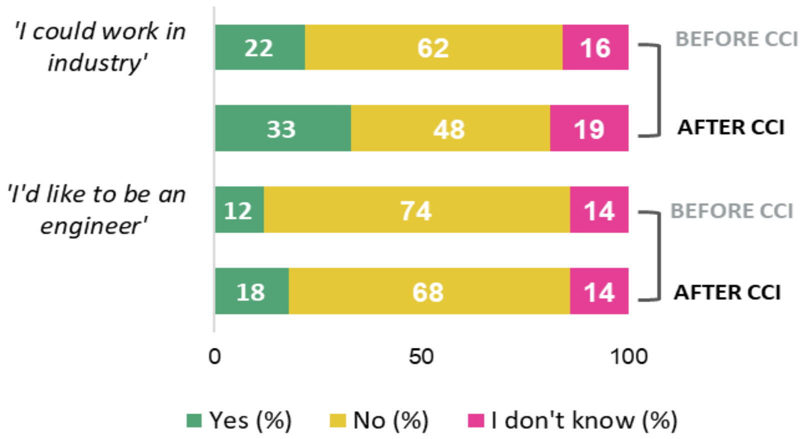


Figure 3 Attitudes towards career aspirations in industry and engineering from children with self-identified lack of parental support in science/engineering (n=185)



In the pre-questionnaire, 96% of children stated that they talk with family members about the science they learn in school, showing they speak with an average of two people from their family.

Predominantly, children speak to their mum (70%) and/or dad (58%) about science The conversations children have about science with their parents can have multiple purposes, including grasping their parents' attitudes towards careers in science and engineering.

3.1.2 Children's attitudes towards science and industry

Children's attitudes towards science

Statistical analysis of children's responses to individual questionnaire items measuring attitudes towards science in the pre- and post-questionnaire are represented in Table 8. For the negative statements (e.g., *'Science is too difficult'*), we are looking for an increase in responses answering 'no' to indicate an improvement in their attitude.

Across the three regions (North-East, Humber and East of England), a high percentage of the children answered positively to *'I like science'* in both the pre- and post-questionnaire (78% and 77% respectively), showing a one percent decrease in the post-questionnaire. Children's responses to the science attitude scale show no significant statistical improvement (Appendix B). The analysis of individual Likert items shows that 6 out of 12 items in the scale implicate no change or negative changes across the pre-and post-questionnaires (Table 8 and Appendix C 1.1). However, some positive changes across a few items in the scale also yielded statistically significant results. The children's sample from all three regions shows a slight improvement in their career aspirations after participating in CCI, as judged by the percentage changes and the overall mean scores on the *'I'd like to be a [scientist/engineer]'* Likert items (Appendix C 1.1).

In total, 24% of children responded positively to the statement *'I'd like to be a **scientist**'* in the post-questionnaire; an improvement compared to the 21% before the programme. These figures are slightly lower than the results presented in the 2020-2021 CCI annual report (Bórquez Sánchez, 2022), where an increase of 4% in *'I'd like to be a **scientist**'* was reported. In the current report, 24% of children also responded positively to the statement *'I'd like to be an **engineer**'* in the post-questionnaires, showing a minor improvement from the 23% of children who responded positively before the programme. Although a slight change, this was an improvement in children's attitudes when compared to the 2020-

2021 CCI annual report (ibid.), where a 1% decline was reported for the statement *'I'd like to be an **engineer**'*.

The *'I'd like to be a [scientist/engineer]'* Likert items showed a statistically significant improvement in children's attitudes based on gender, year, and region. Across the three regions, 21% of girls and 27% of boys responded *'I'd like to be a **scientist**'* in the post-questionnaire, increasing a few percentage points from the 18% of girls and 24% of boys who responded positively in the pre-questionnaire. There was almost a statistical improvement for Year 5 but not Year 6 children. Children from the East of England showed statistically significant improvement compared to the other two regions, with 22% of children stating *'I'd like to be a **scientist**'* in the post-questionnaire, a 3% improvement compared to the 19% in the pre-questionnaire.

In parallel, 17% of girls stated that they *'I'd like to be an **engineer**'* in the post-questionnaire, an improvement compared to the 11% of girls who responded positively in the pre-questionnaire. In contrast, fewer boys (4%) stated they *'I'd like to be an **engineer**'* after the programme. In this same item, there was significant statistical improvement from Y5 children, but not from Year 6 children. Children from the North-East showed statistically significant improvement compared to the other two regions, with 26% of children stating *'I'd like to be an **engineer**'* in the post-questionnaire, a 3% improvement compared to the 23% in the pre-questionnaire.

Compared to boys, girls' responses show statistically significant mean score changes and improvement for the *'I'd like to be a [**scientist/engineer**]'* Likert items. The whole sample of children had statistically significant improvement in the scores recorded for the *'I like doing science experiments at home'* Likert item. Across the three regions, more children (5%) responded positively to the statement *'I like doing science experiments at home'* in the post-questionnaire (Table 8). The statistical improvement was also true for girls and boys separately and Year 5 children but not Year 6.

Table 8 Frequency analysis of children's attitudes towards science (n=996, all regions)

Science Likert-scale items[1]	% BEFORE CCI				% AFTER CCI			
	Sample size	Yes	I don't know	No	Sample size	Yes	I don't know	No
I like science	n=992	78	3	19	n=993	77	4	19
We do too much science in school	n=990	17	5	78	n=982	**15**	9	76
School science clubs are a good idea	n=978	68	12	20	n=985	68	13	19
Science is too difficult	n=989	28	6	66	n=984	**24**	8	68
*I like doing science experiments at home**	n=987	60	8	32	n=987	**65**	11	24
We have to do too much work in science	n=985	26	8	66	n=982	27	10	63
We do too much writing in science	n=976	39	6	55	n=990	**36**	8	56
I like watching science programmes on TV or online	n=987	45	8	47	n=990	45	8	47
Science is my favourite subject	n=965	38	6	56	n=982	36	6	58
*I like reading science stories**	n=990	43	11	45	n=988	36	14	50
*I'd like to be a scientist**	n=981	21	19	60	n=986	**24**	19	57
*I'd like to be an engineer**	n=988	23	16	61	n=984	**24**	19	57

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

[1]*The **bolded figures** highlight positive improvement after the programme.*

Children's attitudes towards industry

After taking part the CCI programme, the whole sample of children from all the regions showed significant improvement in the *'attitudes towards industry'* Likert scale (Table 9). The analysis of individual Likert items shows that 15 out of 16 items on the scale showed a significant positive change in opinion (Table 9 and Appendix D 1.1). Improvement was also found for separate analyses of girls and boys, Year 5 and Year 6, and the individual regions (Appendix B). There were only a few exceptions where opinions did not change or changed slightly after CCI. For example, the views of Humber about *'Many engineers work in industry'* barely changed, only showing a 1% improvement after the programme. Scores declined or did not improve for aspects such as safety and the environmental impact of industry.

Table 9 Frequency analysis of children's attitudes towards industry (n=996, all regions)

Industry Likert-scale items[1]	% BEFORE CCI				% AFTER CCI			
	Sample size	Yes	I don't know	No	Sample size	Yes	I don't know	No
There are women scientists and engineers	n=987	86	11	3	n=984	**91**	7	2
Industry is useful	n=993	80	14	6	n=988	**87**	9	4
Industry makes things we need	n=986	78	15	7	n=987	**87**	9	4
Scientists have important jobs in industry	n=985	77	18	5	n=980	**86**	11	3
Engineers have important jobs in industry	n=986	74	21	5	n=984	**82**	15	3
Many scientists work in industry	n=992	67	25	8	n=987	**80**	15	5
Many engineers work in industry	n=989	70	23	7	n=985	**79**	17	4
I learn about industry from my teachers	n=985	51	18	31	n=984	**71**	11	29
Our lives would be worse without industry	n=978	56	25	19	n=982	**70**	19	11
Young people work in industry	n=982	33	30	37	n=983	**48**	28	24
Industry is safe	n=980	43	21	36	n=982	43	19	38
I learn about industry from TV or online	n=981	33	18	49	n=981	**39**	13	48
Industry causes as little pollution as possible	n=985	28	31	41	n=985	**35**	30	35
I could work in industry in the future	n=985	25	24	51	n=983	**34**	26	40
Industry is dangerous[2]	n=983	48	26	26	n=983	48	22	**30**
Industry causes a lot of pollution[2]	n=988	62	26	12	n=982	58	27	**15**

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

*[1]The **bolded figures** highlight positive improvement after the programme.*

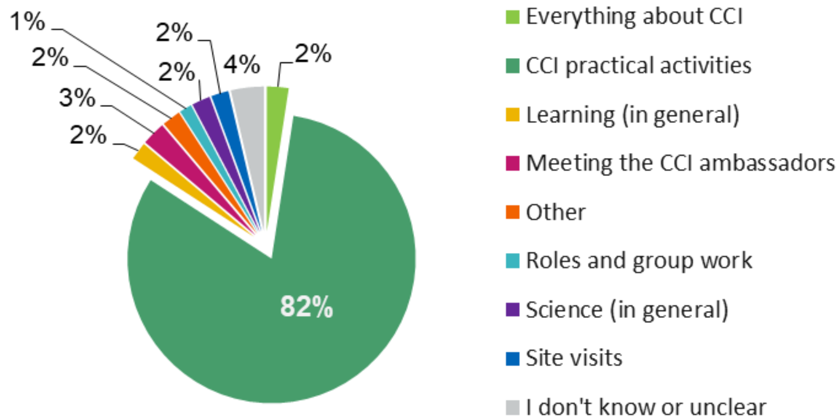
[2] These figures were corrected on 20.05.24. Please see the Addendum at the end of this document.

Separate analyses of Year 5 and Year 6 children show a few differences. Year 6 children across all the regions showed a statistically significant decline for the statement *'Industry causes a lot of pollution'*. Compared to Year 6, Year 5 children from across all the regions showed significant improvement for the *'I learn about industry from TV or online'* with 39% positive response in the post-questionnaire, an 8% improvement from the 31% in the pre-questionnaire. A similar pattern was observed for children from the Humber region compared to the other two. Although this was not a feature of CCI initially, the global COVID-19 pandemic made it necessary for remote and semi-remote delivery of the CCI programme. In contrast, compared to Year 5, Year children showed further improvement to the statement, *'There are women scientists and engineers'* with 90% positive response in the post-questionnaire and 87% in the pre-questionnaire.

3.1.3 Children's experience of the CCI programme

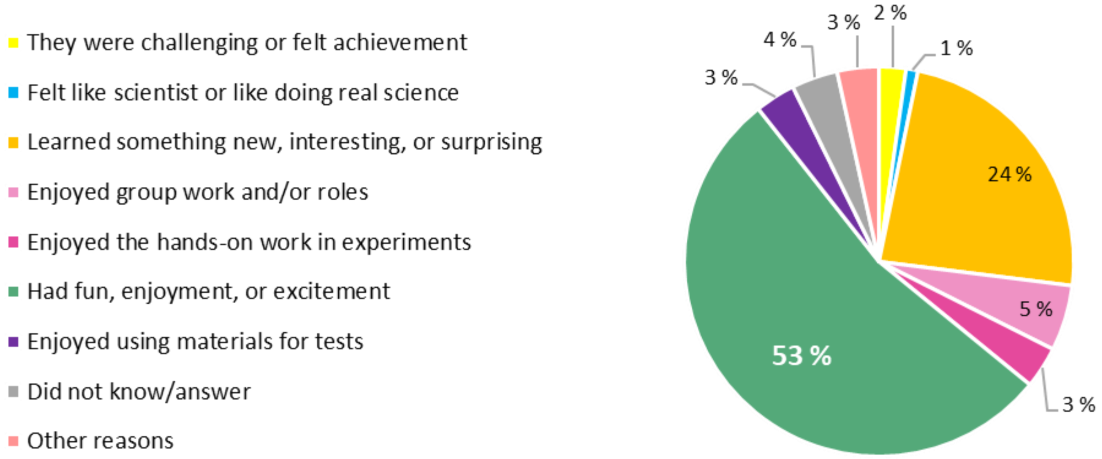
In the post-questionnaire, an open-ended question asked children to say what they enjoyed the most about the CCI programme. Across the three regions, 82% of the 864 children who responded to this question stated that they enjoyed the CCI practical activities called *experiments* by most of the children (Figure 4).

Figure 4 What children enjoyed the most about the CCI programme



The majority of children enjoyed the CCI practical activities because they are fun, exciting, interesting, or educational (Figure 5).

Figure 5 Why children enjoyed the CCI practical activities



In some instances, children said that they enjoyed the experiments because they were fun and interesting, but these notions were counted separately during the analysis. Below there is a selection of children's comments explaining why they enjoyed the CCI activities.

> *'Because I think it's creative.' (Boy, Year 5)*
>
> *'Because it was fun to do and I really enjoyed it and it was like proper science' (Girl, Year 5)*
>
> *'I like finding the outcome of an experiment' (Boy, Year 5)*
>
> *'It was really fun because it made me like science a little bit more and made me understand it is fun' (Boy, Year 5)*
>
> *'Because I liked reasoning with myself how fast the balloons were inflating and when the quantity of carbon dioxide would create enough pressure for the balloon to pop I figured a few weeks.' (Boy, Year 6)*
>
> *'Because I like doing experiments and I was fun watching [the balloon] grow' (Boy, Year 6)*
>
> *'It was very interesting to see the different types of mould grown on the bread. It was also very interesting to discover why mould can be used in medicines.' (Boy, Year 6)*
>
> *'Because everyone had an important job like keeping people safe and everyone worked in teamwork.' (Girl, Year 5)*

'I enjoyed it because I like doing crafty things and science experiments and that activity had both of them in it and it was fun working with other people.' (Girl, Year 6)

'Because I liked learning how to sound a buzzer, install a switch, light a bulb and turning a motor. I also liked the feeling when we succeeded in the tasks.' (Girl, Year 5)

'Because it was like a real experiment that is really fun.' (Boy, Year 6)

'Because it is interesting to see if you can do the experiment right or wrong and learn from it.' (Girl, Year 5)

'I liked the soap experiment the most because a lot of things were optional and it was good teamwork even though it didn't really turn out right.' (Girl, Year 6)

'I enjoyed it because we had the freedom to make it how we liked and choose our own style. I also liked how we got to work in teams.' (Girl, Year 5)

'Because I get to actually do experiments and not just watch other people do them. I get to feel like a real scientist and have fun but also learn a lot from it!' (Girl, Year 5)

'Because I liked learning how much foam we needed and telling [CCI ambassador] about it ❤️ She also really inspired me to be able to be a scientist 👩‍🔬.' (Girl, Year 5)

'Because we all worked as a team and shared ideas.' (Girl, Year 6)

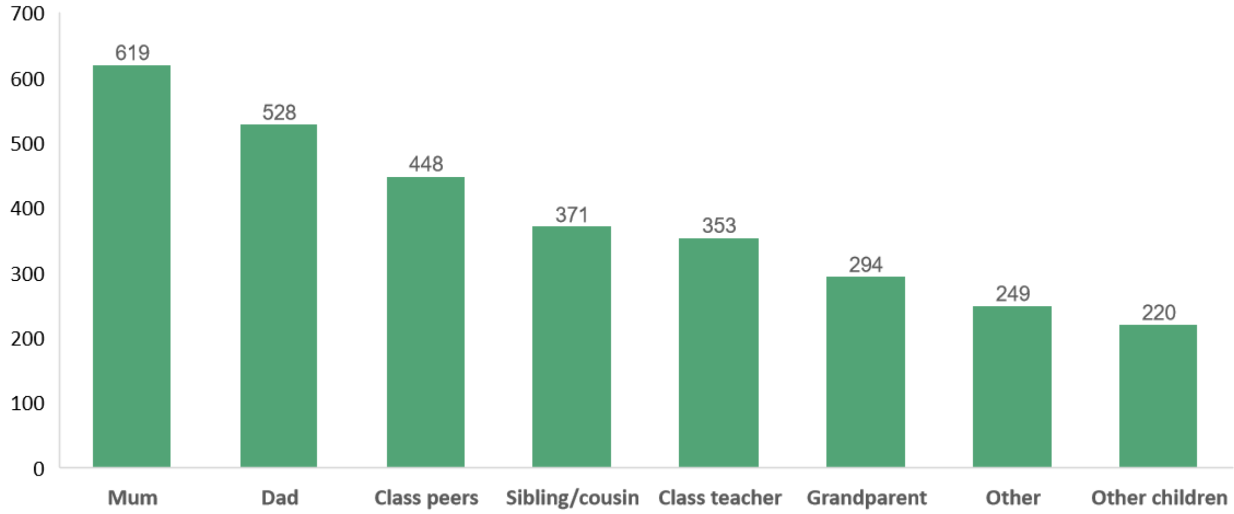
'Because it will help me if I encounter any problems at home with science.' (Girl, Year 6)

Across the pre- and the post-questionnaires, girls generally produced more complete accounts of their experiences than boys. Cultural and contextual factors contribute to gender differences in language skills of school aged children (Millard, 1997). Yet, research suggests that girls have a small advantage by expressing a larger vocabulary and more advanced language comprehension (Marjanovic-Umek & Fekonj, 2017). The latter provides some explanation to the predominance of fuller accounts from females.

3.1.4 Science capital: Engagement with science outside the programme after CCI

Participation in CCI prompted children to talk about science in their everyday lives. In the post-questionnaire, children were asked, *'Did you talk to anyone about science after your lessons from a visiting teacher or the visit from a CCI ambassador?'*. For the answer, children were given the choice to select people from their close social circles (e.g., mum, dad, classroom teacher) from a drop-down list menu. 77% of the children spoke to an average of 3 people from their family and class about the CCI lessons. The majority of these children spoke about science to their mum (62%) and half of them talked to their dad (53%) (Figure 6). At home, children had conversations mostly with their parents, followed by other close relatives and friends.

Figure 6 Who did children talked to about science after the CCI lessons



These results show the programme can support the embedding of science in everyday life by giving children additional talking points on science. The science capital theory describes engaging in conversations about science with close social circles as a science-related resource or capital (Archer et al., 2012). Girls provided more details about the comments or conversations they exchanged than boys.

The following quotes exemplify what children said when they were asked, *'What did you tell them [family/teacher/peers] about the lessons?'* and *'What did they say?'*:

> *'I told [family and peers] different activities we did and new things I learnt... They also found out new things they didn't know.' (Girl, Year 5)*
>
> *'[I told parents and sibling/cousin said] that we did lots of experiments and we talked to engineers... [they said] that they really want to meet engineers.' (Girl, Year 5)*

'[I told siblings/cousins and friends] about what industry is about and how it makes stuff from every day life and how to secure the pipes… they were a bit impressed.' (Girl, Year 5)

'[I said] it was fun and I also tell my family members what I did and how i do thoughs things… They say good things about my work and ask who tout me about it and they sometimes they even ask if I can help them!' (Girl, Year 5)

'[I told mum] about how fun it was, and if the experiment went wrong, and how we prevented it… [Mum] asked me if it was fun or not, and I said "yes".' (Girl, Year 5)

'I told [parents] how fun it was to learn how to grow yeast and that I didn't know what it was before the lesson I also said which ingredient worked best for the yeast… They said they were glad that I learned a new thing and said they were surprised about the ingredient that won.' (Boy, Year 6)

'I told [family and others] it was fun but messy… [They said] cool, so you could be a scientist.' (Girl, Year 6)

'[I asked another peer in my class] What job do you want to do in industry? [They said] "I'd like to work with cars".' (Boy, Year 5)

'I told [family and others] what I learned in the lessons and explain what experiment I did…They ask questions and tell me something that they did at work that is relevant to the conversation about the science experiment I did at school.' (Girl, Year 6)

'I told [parents] about what type of experiments and what we were learning about… [They said] *That's amazing, what do you want to be if you work in an industry.' (Girl, Year 5)*

'[I told my family] about how sick and cool it was because my mom is so supportive and EVEN also likes science… They always say it sounds cool so later in the day if we have time we do one or two things I learnt and even make slimeeee.' (Boy, Year 6)

'I told [family and friends] that it was great fun and we had great fun doing all the fun activities... 'Wow, My cousins remembered when they learnt about science and they told me some funny stories from when they did it.' (Girl, Year 5)

'[I told other children] That we did science experiments with Sartorius and it was fun to do especially the balloon one because ours exploded… [they said] "Oh I'm doing that with my class too" and it sounded like it took up a lot of lesson time.' (Boy, Year 5)

'I would tell [mum and grandparent] what I had learnt…They would have a chat saying about say like evaporation and then they would try and find experiments around the house.' (Boy, Year 6)

'I told [my family] that i wanted to be a engineer and about how much important science is to me… they agreed and said to follow my dreams.' (Girl, Year 5)

'How fun it was and I gave the soap to my mum as a gift and she loved it! All the people I told said that they wanted to be in the lessons now they heard what it was like.' (Girl, Year 5)

'I talked to [my family] about the [CCI] ambassadors and about how fun it was to actually speak to an actual engineer and transporter, and I also said that I would like to do more science in school… My mum was also very excited about me actually talking to an Engineer and Transporter. My dad thinks that I am very clever and that I should be a engineer or scientist and so did my gran and grandad. My uncle and aunt pretty much just listened and said that that was a one in a lifetime opportunity.' (Girl, Year 6)

'[I told family] that we had a real person from croda but they didn't now much about it so I told [them] everything… They said "Oh that cool I didn't now that" , and my mum said she now [...] about the suncream and shampoo.' (Girl, Year 5)

'[I told parents] that even if I don't want to be a scientist, I really like doing the experiments…That's fine you can enjoy something without wanting to have a job involving science.' (Girl, Year 5)

Children's accounts show that most family members and/or friends were glad the children had enjoyed themselves and encouraged them by saying it sounded like fun or interesting. Other family members and/or friends showed interest by asking further questions about the lessons; a few others shared similar experiences from school or work. A few of the family members or others proposed repeating the experiments at home or finding other experiments they could do at home. There are also a few examples where children and parents have engaged in a conversation about children's future career. Negative comments were minimal, with only two children describing demotivating comments. Since children were given a range of choices to say who they spoke to about the CCI lessons, it was often difficult to identify exactly with whom they had the conversations they briefly described in the post-survey.

3.2 Teacher survey outcomes

In total, 42 teachers completed both the pre- and post-questionnaires (Section 3.2.1). This section first introduces the teachers' recent experience in science professional development. Then, this results section is sequenced following the professional training evaluation levels suggested by Guskey (2016). Each succeeding level in Guskey's framework builds on the previous (Guskey, 2002), representing the interdependence between results and the increased complexity of the information gathered at each level. Guskey's professional evaluation levels are the following:

(1) Participants' reactions;

(2) Participants' learning;

(3) Organisational support and change;

(4) Participants' use of the new knowledge and skills;

(5) Student learning outcomes.

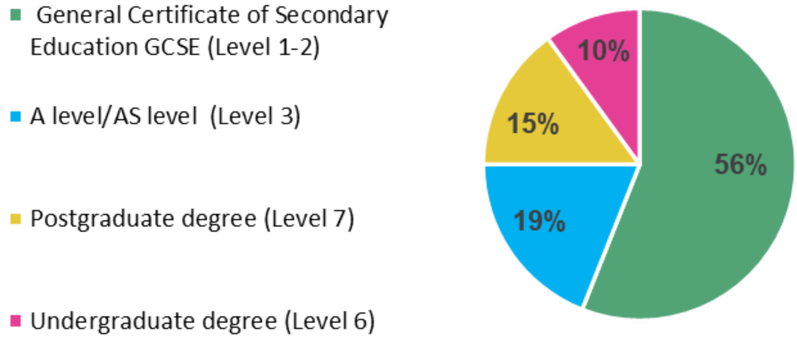
According to Guskey (2016), levels 1 and 2 consider participants' reactions and perspectives about the learning experience; these are contrasted with their pre-programme expectations. Level 3 focuses on the organisational support for implementation. Level 4 examines the way participants are using the new knowledge and skills. Level 5 focused on the learning children might have experienced or gained as a potential impact of the programme and, more specifically, the professional development of their teachers. Level 5 is related to the outcomes in Section 3.1 'Children survey outcomes'; however, the current evaluation does not isolate the direct and single influence of teachers on children's learning and attitude changes towards science and industry.

3.2.1 Teachers' science professional development

The majority (75%) of the teachers in the sample had Level 1-3 qualifications while the rest had university studies as the highest level of qualification (Figure 7). In contrast, the teacher cohort of the CCI 2020-2021 evaluation study had fewer teachers (33%) with a GCSE (Level 1-2) as the highest qualification and more teachers (37%) had obtained university degrees (Bórquez Sánchez, 2022). The subject area (e.g., science) was not specified in any of the responses.

Among the sample, 12 teachers were science leaders and stated they help plan science lessons for other teachers in their school. Similarly, 13 non-science leaders also indicated helping colleagues with lesson planning. This means that over half of the sample of teachers share science teaching practices and, therefore, have increased potential for scaling up CCI's impact in their school communities. From this

Figure 7 Qualification levels of the teachers (n=42) in the sample

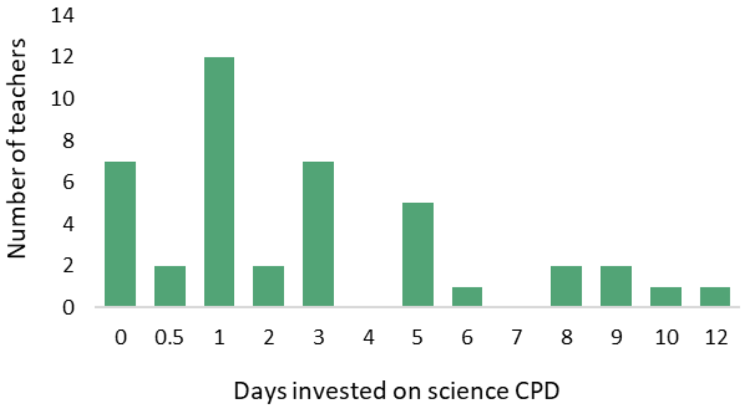


cohort, nine teachers planned to model CCI recommendations for science learning in their class or more broadly in their school. Among those who shared their plans, one described: *'I plan to do more practical activities where the children have more control over the investigation and more control in choosing how to record results etc.'*. Also, from the cohort of those helped others with lesson planning, 11 had made a change or taken concrete actions after being inspired by the programme. These findings are covered in more detail in Section 3.2.5.

In the last three years, half of the teachers (50%) in the sample completed one day, less than a day, or no training in science Continuing Professional Development (CPD). Therefore, the CPD provided during the CCI programme is significant for these teachers in increasing their knowledge of teaching science, and the links with careers and the STEM workplace. Also, before the CCI programme, 29% of the teachers had not delivered any lessons concerning industry, and 64% of them had only taught 'a little' of it in the past.

Seven of the 42 teachers in the sample had participated in CCI prior to the 2021-2022 academic year; the rest of the teachers were new to the programme. Five of seven teachers who previously participated in CCI had spent at least 3 days doing science CPD potentially including the CPD provided by the CCI programme. The other two invested a day or less doing science CPD, indicating that CCI was their only recent science training experience.

Figure 8 Time spent by teachers doing science CPD in the last three years



3.2.2 Level 1. Participants' reactions

This section introduces teachers' initial expectations of the CCI programme and their reactions to the professional development experience through evidence of satisfaction levels and opinions of the programme.

3.2.2.1 Teachers' expectations of CCI before participation in the programme

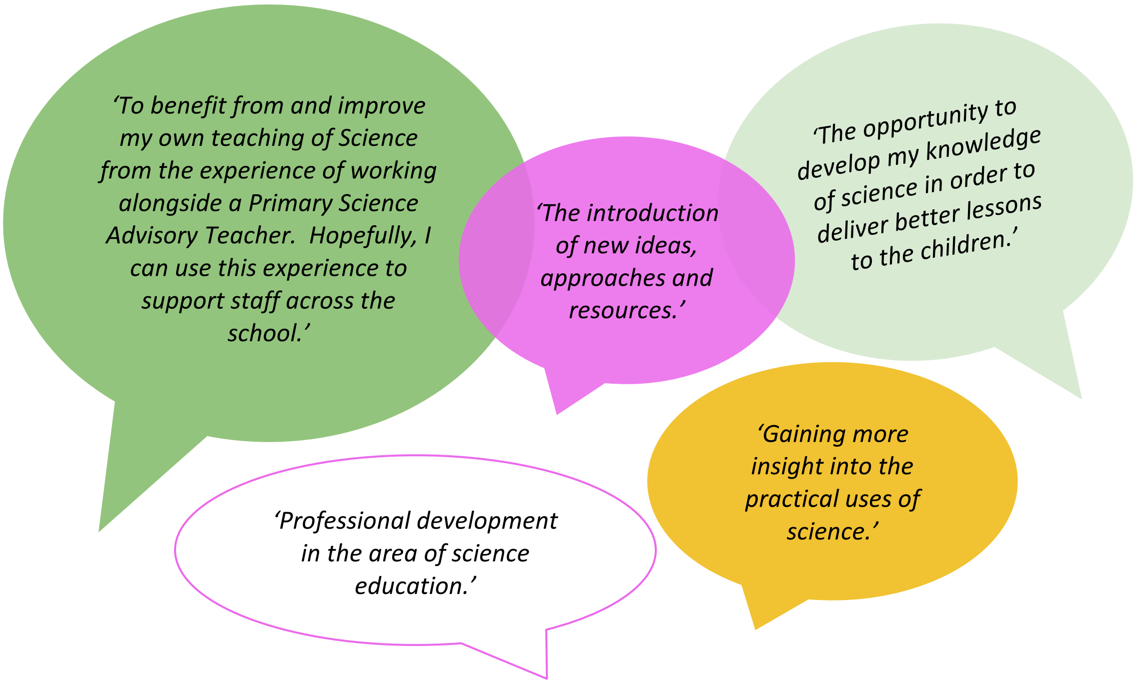
Before taking part in CCI, teachers were asked, *'What are the main attractions of taking part in the CCI programme?'.* Overall, 59% of the teachers were attracted to the CCI programme because it supports children's science learning, 31% sought professional development and networking opportunities, and 10% mentioned other related goals. The comments about support for children's learning valued opportunities to:

- Engage children in practical science activities and/or real-life experiences in industry **(51%)**

- Teach STEM career education **(16%)**
- Develop children's science capital **(14%)**
- Promote positive attitudes towards science and/or industry **(12%)**
- Increase children's knowledge of science and/or industry **(7%)**

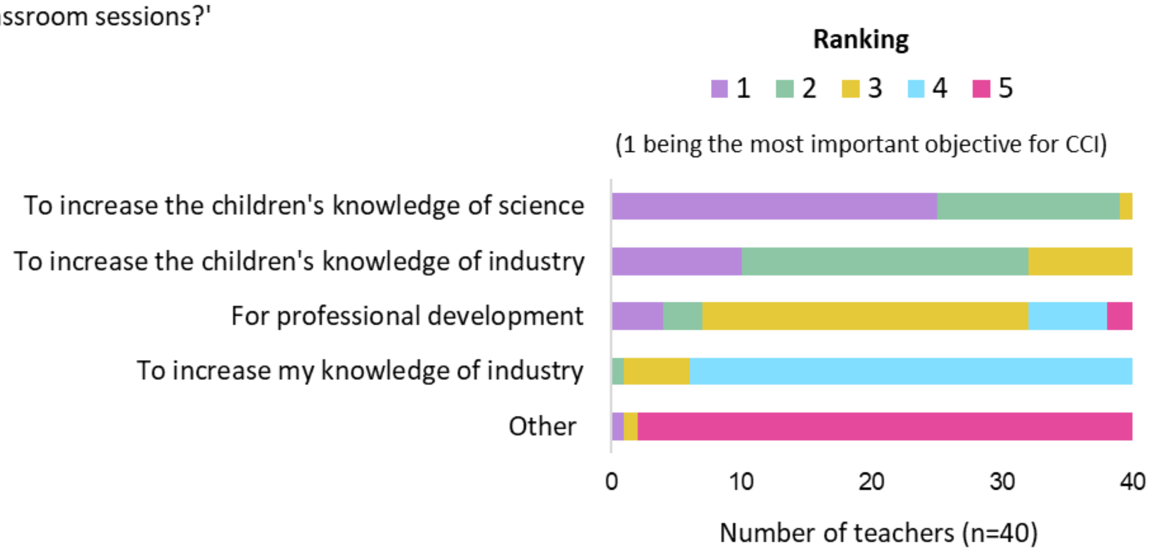
Teachers who stated they felt attracted to CCI for the professional development and networking opportunities valued the expertise of those delivering the programme and the practical science activities, among other aspects. Some examples are shown below:

Teachers' voices on
'What are the main attractions of taking part in the CCI programme?'



Before participating in the programme, teachers were shown a list of CCI objectives[2] and asked to rank these from one to five according to their view (one being the most important objective). The majority ranked increasing children's knowledge of science and industry as the main objectives of the programme (Figure 9). While children's learning was considered at the core of the programme's objectives, the teachers also perceived the programme as an opportunity to develop their professional skills for science teaching and to increase their knowledge of industry.

Figure 9 Teachers' responses to 'What are the main objectives of the CCI classroom sessions?'



In Figure 9, those teachers who placed the option 'other' in the last position when ranking the programme's objectives could use the free-text box to specify. Only two teachers specified what the fifth objective was for them. One said the additional goal was to 'Promote STEM subjects', and the second stated 'Using different materials and methods linked to how industry uses them.'.

3.2.2.2 Teachers' opinion of the CCI programme after participation

After taking part in CCI, the vast majority of the teachers (76%) expressed that their expectations of the programme were met (Figure 10). Also, 100% of the teachers gave an overwhelmingly positive rating to

[2] This list was selected from the most frequently referenced reasons for participating in CCI as indicated by responses to open-ended questions to teachers in previous CCI research.

the CCI programme (Figure 11), with the majority rating it as excellent. This was also reflected in their comments about the programme, including:

> *A great programme, as always. It really inspires the children to learn about 'real-life' science.*
>
> *A superb opportunity to make real connections between science in school leading to the workplace / industry.*

Figure 10 Teachers' responses (n=42) to *'My expectations of the programme were met'*

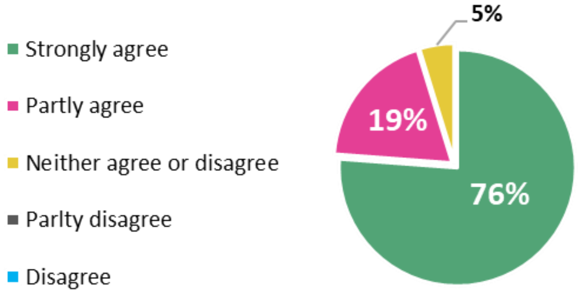
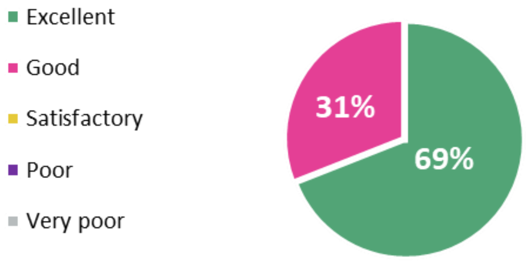


Figure 11 Teachers' (n=42) rating of the overall CCI programme



The participant teachers also showed high levels of satisfaction about the professional development support they received from the CIEC advisory teachers. Table 10 shows they only had positive ratings for CCI professional development activities across collective, individual, and independent events.

Table 10 Teachers' rating of the CPD elements of the programme
(Rating: very poor –> very good)

	Very good (%)	Fairly good (%)
Classroom sessions from the advisory teacher (n=42)	90	10
Whole staff CPD (n=32)	69	31
Classroom sessions I ran myself (n=39)	69	31

Some of the teachers' comments further demonstrate the positive impression they had of the advisory teachers' delivery, including:

> *'[...] [The advisory teacher] was excellent in her delivery and coordination of the programme.'*

'Was a great day and [the advisory teacher] did a fantastic job! The children were engaged and they thoroughly enjoyed the investigations.'

'[The advisory teacher] was brilliant with the children, good knowledge and input in lessons and it was great to present the information to the scientists at the National Horizon Centre.'

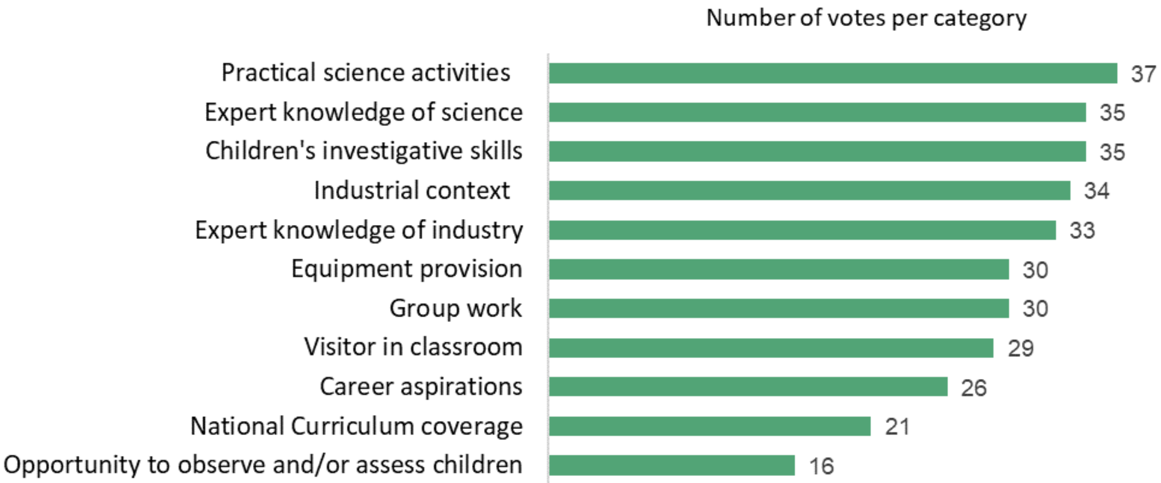
'I think having another teacher to come into the classroom really helps the children appreciate the subject.'

'[The advisory teacher] provided two engaging and informative sessions for the children, creating a real buzz of excitement and awe in the classroom.'

'[The advisory teacher's] enthusiasm was infectious and she really inspired the children during the session.'

The majority of teachers (>70%) went on to say that the programme had multiple strengths (Figure 12), identifying the practical science activities, expert knowledge, and development of children's investigative skills as the top three features of CCI.

Figure 12 Strenghts of the CCI programme identified by the teachers (n=42)



The chosen strengths of the programme are also reflected in the teachers' comments, which provide greater detail about their experience of the CCI programme:

'Whole programme is superb and always exceeds our expectations.'

‘Children loved engaging with real scientists and seeing them in their workplaces. Children enjoyed the practical activities and the links to how that worked in real industry were very clear[...]’

‘The CCI programme has provided our children with an inspiring context for learning in science and broadened their knowledge and understanding of STEM careers. Having the opportunity to directly report back to the business, encouraged complete engagement and nurtured their curiosity and enthusiasm. [...] We will certainly be looking to take this further in our school. Thank you to all involved.’

‘The children thoroughly enjoyed the programme and have since asked if they can complete more sessions! The programme was very informative, covered objectives from the curriculum and was enjoyable.’

On the topic of raising children’s science capital, 67 % of teachers felt that the CCI programme had been very effective, with a further 29% stating it was ‘quite effective’; with 86% of these teachers substantiating this in open-ended responses, as exemplified below:

‘Children gained insights into industry which they wouldn’t have experienced otherwise.’

‘Very effective as it created huge enthusiasm and interest in science/ industry (children and staff).’

‘[CCI] makes the link between the classroom and the real world/positions in industry, more explicit.’

‘[CCI] shows children how their skills learnt in the classroom transfer to the workplace and have a positive impact on communities.’

‘[CCI] provided clear explanations and encouraged us as staff to reflect upon Science capital in the lives of the children.’

Linking an ‘industrial context’ and ’expert knowledge of industry’ with school science is a challenging target that the CCI programme delivers effectively. Almost the totality of the teachers in the sample (98%) affirmed that ‘the classroom sessions offered an effective link with industry’. Also, 97% indicated that ‘the [CCI] ambassador visit reinforced the classroom sessions.’. There was a 100% agreement among the teachers that the (virtual) visits of the CCI ambassador(s) was a valuable part of the programme.

3.2.3 Level 2. Participants' learning

This section presents the changes in teachers' attitudes towards industry, changes in their confidence towards science teaching in an industrial context, and the learning they gained by participating in the programme. Overall, the teachers in the sample manifested increased positive attitudes towards industry after the programme (Table 11). After the programme, there was significant increase (24%) in the number of teachers that agreed that *'Industry causes as little pollution as possible'*; there was an 8% reduction in the number of teachers who agreed that *'Industry has a negative impact on the environment'*. Teachers' environmental concerns display critical thinking and consideration of current environmental issues.

Table 11 Frequency analysis of teachers' attitudes towards industry (n=42, all regions)

Statements in scale	**% BEFORE CCI** (n=41)			**% AFTER CCI** (n=42)		
	Agree	I don't know	Disagree	Agree	I don't know	Disagree
Industry provides many career opportunities	95	3	2	**100**	0	0
Industry produces a wide variety of useful products	95	3	2	95	5	0
Industry improves our quality of life	78	20	2	**88**	7	5
Industry causes as little pollution as possible	29	29	42	**53**	21	26
Industry has a negative impact on the environment	58	22	20	50	31	**19**
A job in industry would be tedious	5	46	49	14	24	**62**
I feel negative about industry	7	29	64	7	19	**74**

[1]*The **bolded figures** highlight a more informed opinion on industry after the programme.*

The majority of teachers indicated that their knowledge of industry improved, with only a few feeling undecided (Figure 13). Improved knowledge is an important factor in feeling confident to teach about the subject. This could be related to most teachers asserting that their confidence in teaching science also improved (Figure 14).

After taking part in CCI, 28 felt more confident about teaching **STEM in everyday life** (Figure 15), which could impact how teachers approach science lessons and shape the real-life examples they use to illustrate ideas. More teachers also increased their confidence to teach about **STEM-related careers** since 27 improved their initial self-assessments after taking part in CCI (Figure 16). In multiple ways, the CCI activities model ways in which teachers can 'weave' career learning goals in science lessons, helping teachers feel more confident to talk about this subject with children in a more informed way. Lower

Figure 13 Teachers' responses (n=42) to the statement *'My knowledge of industry has improved'*

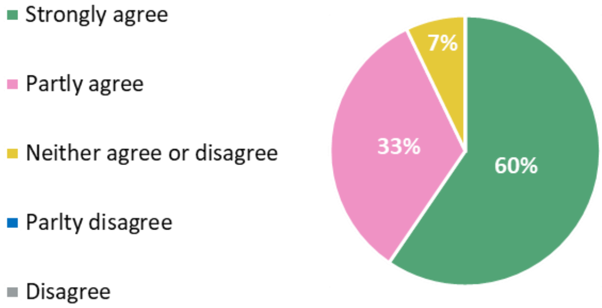
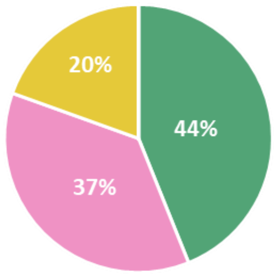


Figure 14 Teachers' responses (n=41) to the statement *'My confidence to teach science has improved'*



confidence levels in a few teachers could be due to feeling underprepared after engaging more deeply with science learning in an industrial context and/or due to the implicit subjectivity of responding to an affective question at two different moments in time.

After the programme, the teachers were also asked, 'To what extent are you comfortable with teaching and learning about STEM?' 34 of 42 teachers left positive responses. For example:

> *'Fairly comfortable in most areas.* ***I do feel I can make more links with industry*** *as a whole and will be more aware of doing this more regularly within science lessons.'*
>
> ***'I now feel more confident teaching about STEM*** *particularly careers and the practical work ideas.'*
>
> ***'I am now more comfortable with teaching and learning from STEM****. Lots of the curriculum covers STEM and industry and you are already teaching about it without actually recognising.'*
>
> ***'I feel more confident following the CCI sessions*** *to teach children about industry and STEM careers. I am fairly comfortable teaching Science across KS1 and KS2.*
>
> *[...] I need to consider how I can* ***plan future projects/investigations with 'real-world'*** *applications.'*

'I now feel more confident to make connections with local industries. *I am more comfortable to link the learning with the profession so that the children can make connections.'*

'I feel that I am more confident teaching STEM now *as I see the children engaging in activities in a wide range of roles.'*

Figure 15 Changes in teachers' (n=39) confidence scores (from 1 to 100) for 'teaching about STEM in everyday life' after participating in CCI

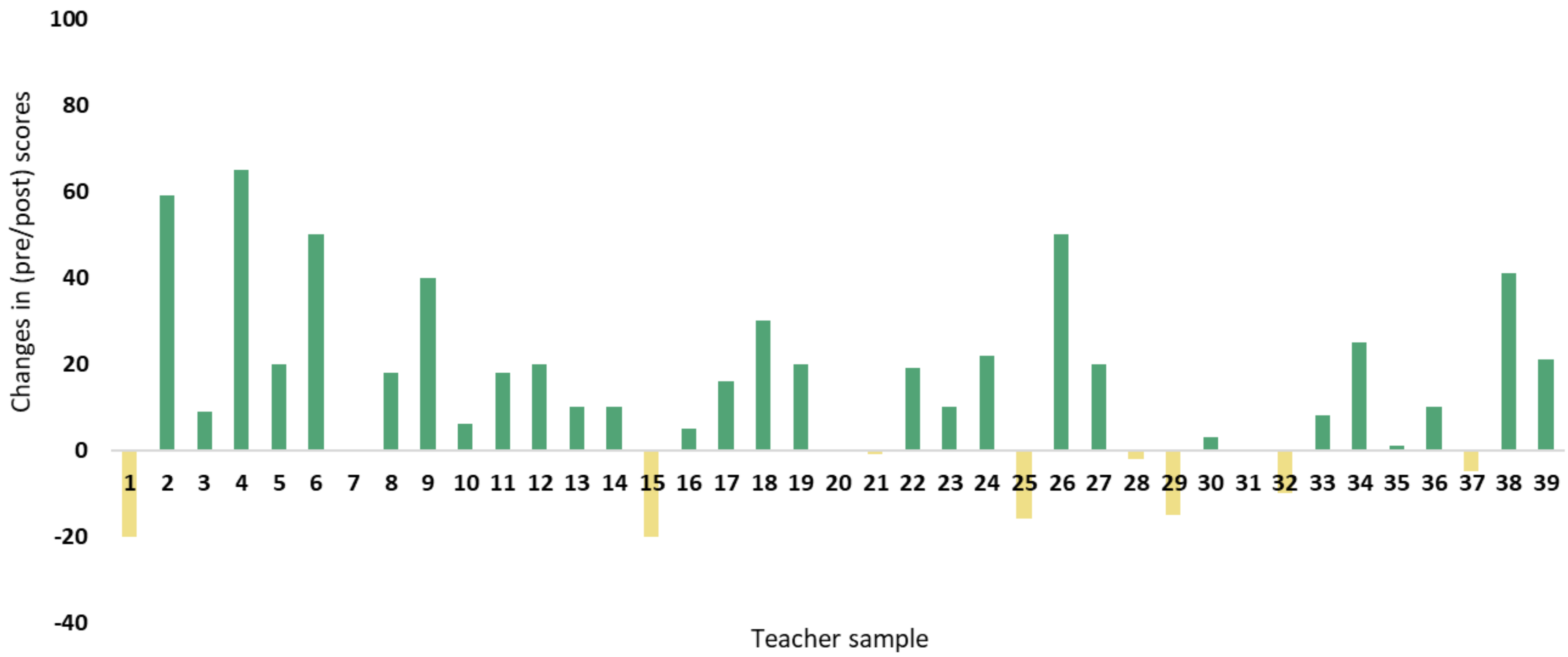
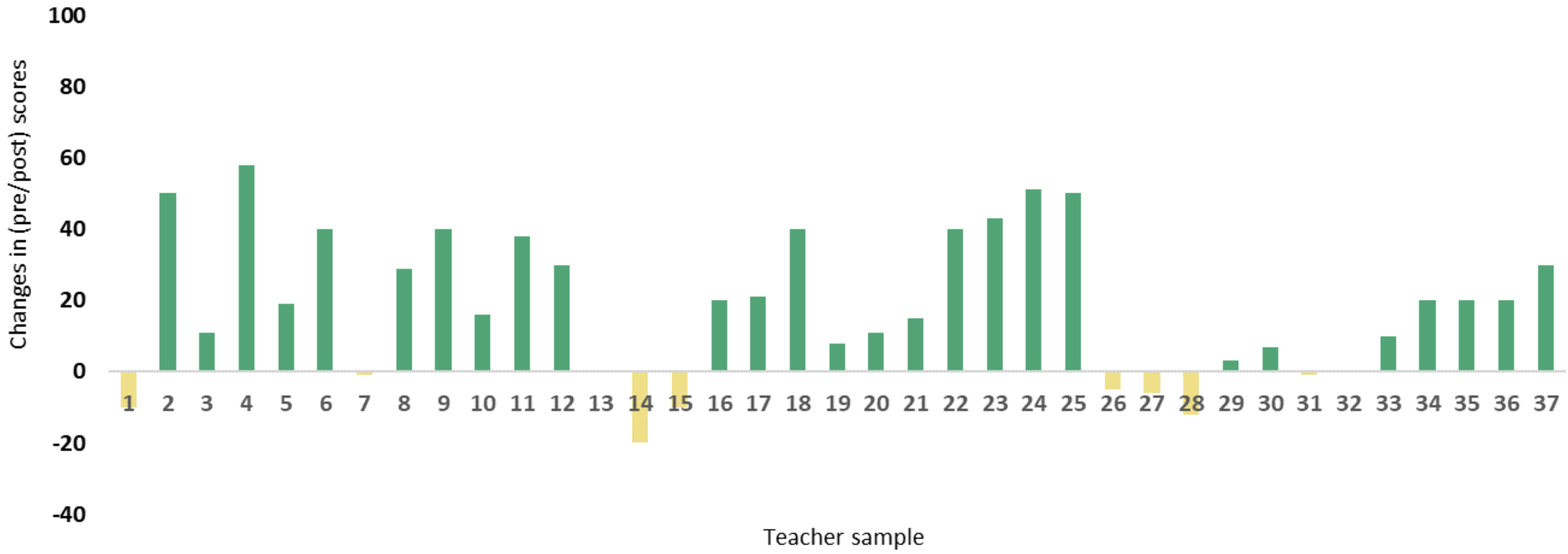


Figure 16 Changes in teachers' (n=37) confidence scores (from 1 to 100) for 'teaching about STEM-related careers' after participating in CCI



Two teachers expressed concerns in relation to their levels of confidence. These included not feeling confident enough *'in finding resources for other industries'* or feeling like their *'knowledge is not deep enough and would benefit for more CPD'*. Both concerns further reinforce the need to continue to provide teachers with professional development support and access to science and industry learning resources.

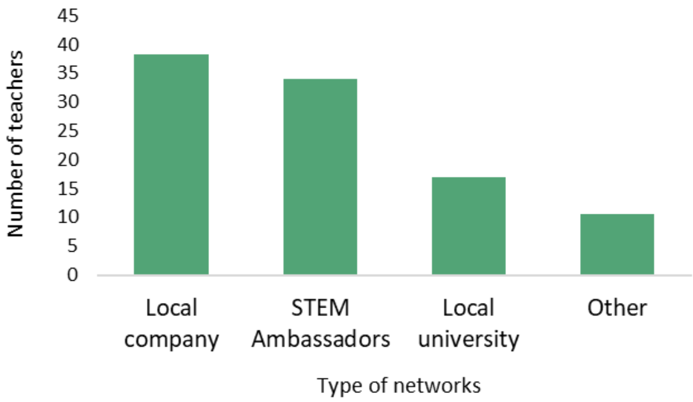
3.2.4 Level 3. Organisational support and change

The results in this section present aspects of existing school support for Science Capital development. Sixteen of the 33 schools in the paired sample have policies that support and promote the development of Science Capital in children. The majority of teachers described their schools as having "a few" existing links with external organisations (74%), with a further 19% having no links at all. Like the CCI programme, these STEM links might provide important pathways and sources of support for children to experience science and technology in real-life settings.

Two of the 42 teachers had worked with industry before taking part in CCI, and one of them had participated in CCI in the past. This suggests that, predominantly, the teachers in the sample had limited experience of industry before CCI, and this research did not ascertain the nature of the schools' links with local companies and STEM ambassadors (Figure 17), but purely their existence. Eight of the 42 teachers had organised visits to industry, with five of them having taken part in CCI before. Seven teachers said they receive visitors as part of their schools' strategy to support the development of science capital.

In Figure 17, the category 'other' was selected by a few teachers to indicate their schools had links with charities (Tees Rivers Trust, Brightwater Project, and Children's University), international companies (Siemens), or other primary and secondary schools. After taking part in CCI, teachers expressed their desire to start using their network and plan out-of-school days to teach science in a real-life context (more is described in the following section).

Figure 17 Links with industrial companies or other organisations identified by the teachers (n=42) in their school



3.2.5 Level 4. Participants use new knowledge and skills

This section presents how teachers envisaged using their learning from CCI for science teaching or to influence others in their school. The majority of teachers showed intentions to use the CCI resources (Figure 18a) and felt more equipped to organise school trips to or from industry (Figure 18b). Participating in CCI seemed to encourage teachers to recognise their existing resources and support. For example, one teacher stated, '*[The programme] made me think outside of the box about who I knew and what they could offer',* suggesting that the CPD encouraged teachers to make the best of their existing network to potentially enrich their science lessons at school.

In the post-questionnaire, teachers were asked, *'After your involvement this year, have you been inspired to do further lessons or activities that were influenced by your experience of CCI?'*. In total, 36 of 42 teachers responded, with 12 of them having already made changes to their practice. Only three indicated that they had not made any changes since participation in CCI. Below Figure 18 is a selection of comments showing teachers' intentions or a description of their actions.

Figure 18a Teachers' responses (n=40) to the statement *'I will use the written [CCI] resources again'*

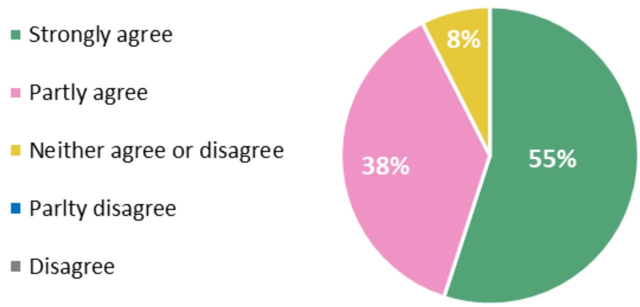
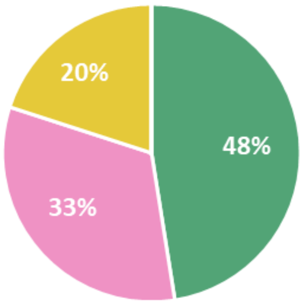


Figure 18b Teachers' responses (n=40) to the statement *'I would now be confident to arrange visits to or from industry'*



Teachers' intentions to change something in their practice after CCI

As science lead, I will be holding a science week in school where we engage in practical hands on experiments and make contact with local scientists, engineers, in fact as many different professions as possible to speak to the children about how science has helped them in their careers.

The children enjoyed the activities and the context given. I might complete some of the other units available on the CIEC website.

Definitely. I would adapt my current planning to complete the investigation with next year's class.

I plan to do more practical activities where the children have more control over the investigation and more control in choosing how to record results etc.

Inspired me to want to take the children out of school to go on a science trip.

Teachers' examples of changes they have implemented after taking part in CCI

Yes, we did a lot of extra work linked to the mouldy bread investigation and linked it to reports and line graphs etc in maths and other areas of the curriculum (ICT, completing tables).

I have placed a larger emphasis on how the science has a positive impact on our everyday lives and who must be doing this work in order for it have an impact.

I intend to use the CCI investigations and link them into the CREST awards but with greater links with industry.

We held a science day in school where we gave the children opportunities to generate their own investigations and follow them through, improving their practise along the way.

[...] We are also holding a whole school Science Day off the back of the strength of this programme and the CCI.

Furthermore, the majority of the teachers had intentions (Figure 19a) or had managed to share their CCI experiences with other colleagues (Figure19b), contributing to the science teaching and learning communities of their schools.

Figure 19a Teachers' responses (n=38) to the statement *'I intend to share my CCI experiences with colleagues before the end of the school year'*

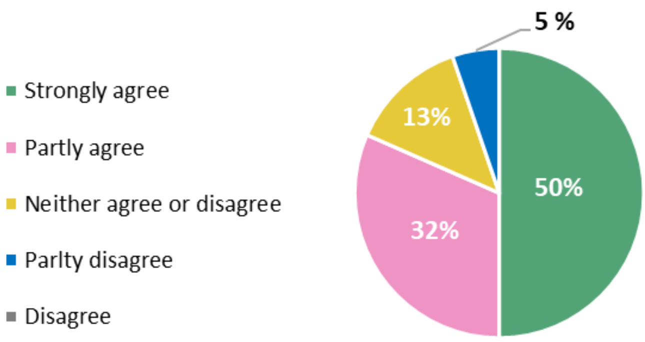
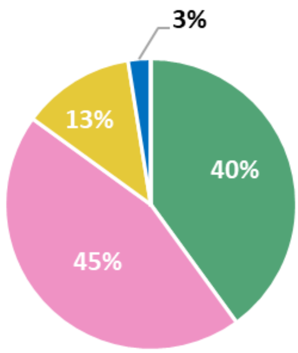


Figure 19b Teachers' responses (n=40) to the statement *'I have been able to share my CCI experiences with colleagues already'*



Sharing the CCI experiences with other colleagues has the potential to increase the impact on more teachers and the children they teach. Similarly, the majority of teachers perceived the programme would benefit their school (Figure 20a), and they had got someone else excited about CCI (Figure 20b).

Encouraged by increased levels of confidence, their intentions to apply new learning, and their potential science teaching innovation, these teachers might continue to promote the development of Science Capital among children and the broader communities in their schools.

Figure 20a Teachers' responses (n=39) to the statement *'Other classes in my school benefit from CCI, in addition to my own'*

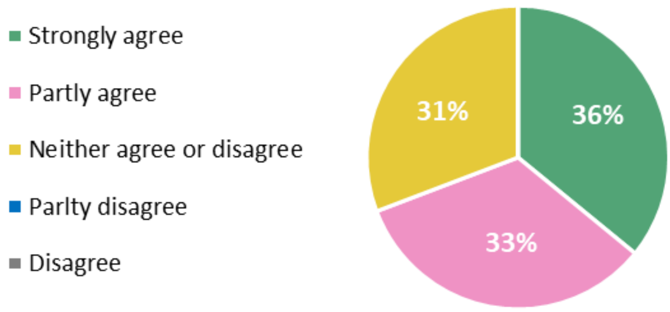
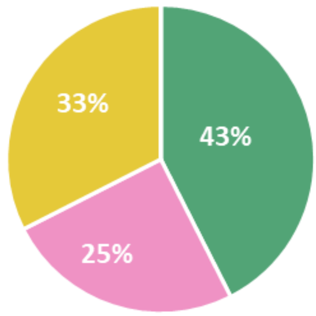


Figure 20b Teachers' responses (n=40) to the statement *'I have managed to enthuse at least one colleague about CCI'*



4. Summary and recommendations

4.1 Reflections on children results

CCI fostered positive attitudes towards industry among more of the children who participated in the programme; it also raised their STEM career aspirations. This is line with a recent UK Government report which states *'Starting careers provision at an early age is essential in supporting children to learn about the world of work and develop high aspirations for their futures'* (House of Commons, 2023, p.4). Science learning in schools has the potential of nurturing children's interest and engagement in science beyond the school walls by involving the local science and education communities in a sustained effort. However, regular engagement with science (e.g., once a week) outside of school was only common among one third of children who participated in the programme during the 2021-2022 academic year. Furthermore, as stated in the *Careers Education, Information, Advice and Guidance* UK government report: 'pupils from disadvantaged backgrounds often need more support than their peers to access opportunities and raise their aspirations.' (Ibid, p.39). In this respect, the evaluation shows that CCI raised the aspirations of children who indicated that their parents might not support their science and/or engineering aspirations, and who might also be from disadvantaged backgrounds. Although most children were also familiar with popular science experiments, but it can be argued that these alone will not be enough to enhance their scientific reasoning, understanding of professional careers in science, and raise their aspirations.

As in the 2020-2021 evaluation of the CCI programme, children's initial attitudes towards school science did not change after the intervention. When compared with previous evaluation reports (Lambrechts, 2021; Tabaqchali et al., 2018; Turkenburg-van Diepen & Hanley, 2017), these results are unusual and could be correlated with the effects of the COVID-19 pandemic in formal education. We will continue to study and compare these results in future evaluations. Although children's attitudes towards school science did not change, their enthusiasm for the CCI science activities remains at a high level. The majority of the children enjoyed the CCI practical activities mostly because they were hands-on and fun, and others emphasised that they liked learning about science and industry. Comments of a small portion of children highlight that they appreciated having autonomy to conduct the activities, working with others in teams, and meeting the ambassadors.

More research is needed to explore the extent to which children are exposed to science in real-life and professional scenarios. The CCI pre-programme evaluation suggests that the range of practical science activities and settings is not in authentic scenarios or framed in industrial activity. In this sense, CCI offers children a unique opportunity to appreciate the value of science in real industrial settings, encouraging them to see themselves as active participants, potential future contributors, and as problem solvers in science and/or engineering professions. CCI widens children's experience and helps bridge the gap between school science and professional science in a local context, making science and engineering feel more accessible to children.

4.2 Reflections on teachers' results

The teachers had an overwhelmingly positive outlook of the programme and became more informed about professional careers in industry. In relation to the delivery of the programme, the results show positive comments and perspectives throughout. Teachers perceived their engagement with the different levels of professional development to be effective and their confidence levels to teach science in an industrial context improved. These are crucial findings that, along with the children's outcomes, indicate the programme is meeting significant goals. Moreover, the post-programme planned changes and actions taken by half of the teachers speaks volumes about the potential of the programme to impact the practice of other teachers in schools that participate in CCI.

Acknowledgements

The authors would like to thank all the teachers, children, and CCI ambassadors that took part in the programme during the 2021-2022 academic year. We would also like to thank the following:

The CIEC advisory teachers who delivered the CCI project during 2021-2022:
Mackayla Millar, Clare Docking, Nicky Waller and Katherine Forsey

The CIEC advisory research group:
Maria Turkenburg-Van Diepen, Researcher Associate, Science Education Group, Department of Education, University of York
Charlotte Evans, Associate Professor, School of Food Science and Nutrition, Faculty of Environment, University of Leeds
Pam Hanley, Research Fellow (retired), York Trials Unit, Department of Health Sciences, University of York

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Appendices

Appendix A Details of children's sample (n=996) by region, school, and gender

North East				East of England				Humber			
School code	Gender		Total	School code	Gender		Total	School code	Gender		Total
	Boy	Girl			Boy	Girl			Boy	Girl	
4492	8	9	17	8081	12	13	25	9009	15	9	24
4493	13	12	25	8083	10	15	25	9010	1	1	2
4494	13	7	20	8084	16	14	30	9011	13	10	23
4495	14	8	22	8085	4	5	9	9012	11	15	26
4496	12	6	18	8087	10	17	27	9013	14	11	25
4497	14	6	20	8088	13	8	21	9014	7	10	17
4498	23	12	35	8089	10	14	24	9015	14	9	23
4499	13	15	28	8090	11	11	22	9016	16	9	25
4500	13	9	22	8091	16	9	25	9017	12	5	17
4501	6	6	12	8092	10	9	19	**Total**	**103**	**79**	**182**
4502	8	10	18	8093	13	9	22				
4503	12	7	19	8094	11	15	26				
4504	6	10	16	8095	17	7	24				
4505	20	20	40	8096	17	11	28				
4506	11	7	18	**Total**	**170**	**157**	**327**				
4507	1	5	6								
4508	13	12	25								
4509	15	10	25								
4510	4	8	12								
4511	15	14	29								
4512	7	8	15								
4513	10	12	22								
4514	9	14	23								
Total	**260**	**227**	**487**								

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

Attitude scale	Change for whole sample	Gender differences	Region differences
Children's attitudes towards science (n=832*)	There was no significant difference at C2 (M=3.22, SD=.76) than at C1 (M=3.23, SD=.80); t (831) = .67, *p*=.49, d=.02	No statistical significance was found across genders	No statistical significance was found in the individual regions
Children's attitudes towards industry (n=839)	There was a statistically significant improvement at C2 (M=3.67, SD=.48) than at C1 (M=3.41, SD=.45); t (838) =15.95, *p*<.001, d=.55	Significant with girls (t (382) = 12.19, *p*<0.001) and boys (t (455) = 10.60, *p*<0.001) becoming more positive	There was a statistically significant improvement with children from the North-East (t (404) = 12.19, *p*<0.001), Humber (t (152) = 8.36, *p*<0.001), and East of England (t (280) = 7.01, *p*<0.001) regions.
*Analysis excludes responses with missing values in both attitude scales.			

Appendix C 1 Mean scores of children's attitudes towards science before and after the programme

Region	Phase of the programme	Mean score	Standard deviation
All regions (n=832*)	Before CCI	3.23	.76
	After CCI	3.23	.78
North-East (n=412)	Before CCI	3.28	.81
	After CCI	3.30	.82
Humber (n=160)	Before CCI	3.20	.69
	After CCI	3.20	.74
East of England (n=260)	Before CCI	3.16	.77
	After CCI	3.13	.78
*Analysis of sample and sub-samples exclude responses with missing values across the full science attitudes scale.			

Appendix C 1.1 Dependent samples t-tests results of individual items in the scale measuring children's science attitudes

NB. Likert items for which no statistical significance was found in any of the sub-samples (all and individual regions, school year, and gender) are not included in the table.

Significant changes in mean scores of attitudes towards science regarding individual scale items

Statement	Whole sample (n=996)	Y5 (n=620) & Y6 (n=376)	Girls (n=463) & Boys (n=533)	Regions: NE (n=487); Humber (n=182); and EE (n=327)
I'd like to be a scientist	Improvement (t (970) = 2.645, *p*=.008, d=.084)	Improvement (t (606) = 3.01, *p*=.003) with Y5 children becoming more positive	Improvement (t (446) = 2.092, *p*=.037) with girls becoming more positive	Improvement with children from the East of England (t (316) = 2.645, *p*=.009) becoming more positive
Science is my favourite subject	No statistical significance was found	No statistical significance was found	No statistical significance was found	Statistically significant decline with children from the East of England (t (305) = 2.085, *p*=.038) becoming more negative
I'd like to be an engineer	Improvement (t (976) = 2.299, *p*=.022, d=.073)	Almost improvement (t (609) = 1.88, *p*=.060) with Y5 children	Improvement (t (452) = 3.477, *p*<.001) with girls becoming more positive	Improvement with children from the North-East (t (477) = 2.723, *p*=.007) becoming more positive
I like doing science experiments at home	Improvement (t (977) = 3.542, *p*<.001, d=.113)	Improvement (t (610) = 3.35, *p*=<.001) with Y5 children becoming more positive	Improvement with girls (t (457) = 2.239, *p*=.026) and boys (t (518) = 2.743, *p*=.006) becoming more positive	Improvement with children from the North-East (t (389) = 1.949, *p*=.052), Humber (t (179) = 2.077, *p*=.039) and East of England (t (317) = 2.353, *p*=.019)

				becoming more positive
*We have to do too much work in science**	No statistical significance was found	Statistically significant decline (t (370) = 2.68, *p*=.008) with Y6 children becoming more negative	Statistically significant decline with boys (t (520) = 2.08, *p*=.038) becoming more negative	Statistically significant decline with children from the East of England (t (314) = 2.01, *p*=.045) becoming more negative
I like reading science stories	Statistically significant decline (t (981) =3.576, *p*<.001, d=.113) becoming more negative	Statistically significant decline with Y5 (t (609) = 2.93, *p*=.003) and Y6 (t (371) = 2.04, *p*=.042) children becoming more negative	Statistically significant decline with girls (t (457) = 2.934, *p*=.004) and boys (t (523) = 2.16, *p*=.031) becoming more negative	Statistically significant decline with children from the North-East (t (479) = 3.00, *p*=.003) becoming more negative
* This statement was reverse coded during analysis.				

Appendix D 1 Mean scores of children's attitudes towards industry before and after the programme

Region	Phase of the programme	Mean score	Standard deviation
All regions (n=839*)	Before CCI	3.41	.45
	After CCI	3.67	.49
North-East (n=405)	Before CCI	3.44	.45
	After CCI	3.74	.51
Humber (n=153)	Before CCI	3.40	.41
	After CCI	3.68	.46
East of England (n=281)	Before CCI	3.39	.45
	After CCI	3.60	.46
*Analysis of sample and subsamples exclude responses with missing values across the full industry attitudes scale.			

Appendix D 1.1 Dependent samples t-tests results of individual items in the scale measuring children's industry attitudes

NB. Likert items for which no statistical significance was found in any of the sub-samples (all and individual regions, school year, and gender) are not included in the table.

Significant changes in mean scores of attitudes towards industry regarding individual scale items				
Statement	Whole sample (n=996)	Y5 (n=620) & Y6 (n=376)	Girls (n=463) & Boys (n=533)	Regions: NE (n=487); Humber (n=182); and EE (n=327)
Industry is useful	Improvement (t (984) = 8.79, *p*<.001, d=.28)	Improvement with Y5 (t (614) = 7.77, *p*<.001) and Y6 (t (369)=4.24, *p*<.001) becoming more positive	Improvement with girls (t (455) = 6.00, *p*<.001) and boys (t(528)= 6.42, *p*<.001) becoming more positive	Improvement with children from the North-East (t (483) = 6.24, *p*<.001), Humber (t (178) = 2.79, *p*=.006) and East of England (t (321) =5.51, *p*<.001) becoming more positive
I learn about industry from TV or online	Improvement (t (965) = 2.04, *p*=.041, d=.06)	Improvement with a slight improvement from Y5 (t (602) =1.95, *p*=.052) becoming more positive	No statistical significance was found	Improvement with children from the Humber (t (175) = 3.45, *p*=.001) becoming more positive
I learn about industry from my teachers	Improvement (t (972) = 10.97, *p*<.001, d=.35)	Improvement with Y5 (t (610) =9.11, *p*<.001) and Y6 (t (361)=6.14, *p*<.001) becoming more positive	Improvement with girls (t (521) = 7.78, *p*<.001) and boys (t (523)= 7.82, *p*<.001) becoming more positive	Improvement with children from the North-East (t (478) = 7.88, *p*<.001), Humber (t (176) =8.88, *p*<.001) and East of England (t (316) =3.35, *p*<.001) becoming more positive
I could work in	Improvement (t	Improvement with	Improvement with	Improvement with

industry in the future	(971)= 5.95, *p*<.001, d=.19)	Y5 (t (604) =4.46, *p*<.001) and Y6 (t (366)=3.97, *p*<.001) becoming more positive	girls (t (447) = 3.79, *p*<.001) and boys (t (523)= 4.59, *p*<.001) becoming more positive	children from the North-East (t (477) = 3.18, *p*=.002), Humber (t (174)=2.75, *p*=.006) and East of England (t (318)=4.48 , *p*<.001) becoming more positive
Our lives would be worse without industry	Improvement (t (963) = 8.86, *p*<.001, d=.28)	Improvement with Y5 (t (602) =7.61 , *p*<.001) and Y6 (t(360)=4.62, *p*<.001) becoming more positive	Improvement with girls (t (446) = 6.85, *p*<.001) and boys (t (516)= 5.73, *p*<.001) becoming more positive	Improvement with children from the North-East (t (469)= 6.16, *p*<.001), Humber (t (176) = 3.16, *p*=.002) and East of England (t (316)=5.58, *p*<.001) becoming more positive
Industry makes things we need	Improvement (t (976) = 8.47, *p*<.001, d=.27)	Improvement with Y5 (t (608) =8.57, *p*<.001) and Y6 (t (367)=2.85, *p*=.005) becoming more positive	Improvement with girls (t (449) = 7.20, *p*<.001) and boys (t (526)= 5.01, *p*<.001) becoming more positive	Improvement with children from the North-East (t (477) = 6.31, *p*<.001), Humber (t (178) =5.85, *p*<.001) and East of England (t (319) =2.83, *p*=.005) becoming more positive
Industry causes as little pollution as possible	Improvement (t (973) = 4.91, *p*<.001, d=.15)	Improvement with Y5 (t (606) =4.40, *p*<.001) and Y6 (t(366)=2.29, *p*.022) becoming more positive	Improvement with girls (t (447) = 3.13, *p*<.001) boys (t(525)= 3.77, *p*<.001) becoming more positive	Improvement with children from the North-East (t (474) = 4.12, *p*<.001) and East of England (t (320) =2.36, *p*=.019) becoming more positive
Many scientists work in industry	Improvement (t (982) = 10.76, *p*<.001, d=.34)	Improvement with Y5 (t (6.11) =8.32, *p*<.001) and Y6 (t (370)=6.81, *p*<.001) becoming more	Improvement with girls (t (455) = 7.51, *p*<.001) and boys (t (526)= 7.71, *p*<.001) becoming	Improvement with children from the North-East (t (479) = 7.41, *p*<.001), Humber (t (177) =

		positive	more positive	4.72, *p*<.001) and East of England (t (324) =6.20, *p*<.001) becoming more positive
Many engineers work in industry	Improvement (t (977) = 7.79, *p*<.001, d=.24)	Improvement with Y5 (t (611) =6.36, *p*<.001) and Y6 (t(365)=4.49, *p*<.001) becoming more positive	Improvement with girls (t (451) = 5.03, *p*<.001) and boys (t(525)= 5.96, *p*<.001) becoming more positive	Improvement with children from the North-East (t (479) = 6.42, *p*<.001) and East of England (t (322) =4.44, *p*<.001) becoming more positive
Young people work in industry	Improvement (t (969) = 9.72, *p*<.001, d=.31)	Improvement with Y5 (t (605) =8.40, *p*<.001) and Y6 (t(363)=4.99, *p*<.001) becoming more positive	Improvement with girls (t (448) = 8.24, *p*<.001) and boys (t (520)= 5.71, *p*<.001) becoming more positive	Improvement with children from the North-East (t (474) = 8.06, *p*<.001), Humber (t (173) =4.97, *p*<.001) and East of England (t (320) =3.36, *p*<.001) becoming more positive
Scientists have important jobs in industry	Improvement (t (968) = 7.89, *p*<.001, d=.25)	Improvement with Y5 (t (606) =6.21, *p*<.001) and Y6 (t(361)=4.86, *p*<.001) becoming more positive	Improvement with girls (t (443) = 5.32, *p*<.001) and boys (t(524)= 5.83, *p*<.001) becoming more positive	Improvement with children from the North-East (t (473) = 4.16, *p*<.001), Humber (t (173) = 3.80, *p*<.001) and East of England (t (320) =6.03, *p*<.001) becoming more positive
There are women scientists and engineers	Improvement (t (975) = 5.19, *p*<.001, d=.16)	Improvement with Y5 (t (607) =6.21, *p*<.001) becoming more positive	Improvement with girls (t (450) = 4.06, *p*<.001) and boys (t(524)= 3.32, p<.001) becoming more positive	Improvement with children from the North-East (t (474) =4.51, *p*<.001), Humber (t (176) = 1.98, *p*=.049) and East of England (t (323) = 2.03, *p*=.043) becoming more

				positive
Engineers have important jobs in industry	Improvement (t (973) = 7.38, p<.001, d=.23)	Improvement with Y5 (t (606) =7.02, p<.001) and Y6 (t(366)=2.99, p=.003) becoming more positive	Improvement with girls (t (450) = 5.29, p<.001) and boys (t (522)= 5.16, p<.001) becoming more positive	Improvement with children from the North-East (t (473) =6.19, p<.001), Humber (t (175) =2.95, p=.004) and East of England (t (323) =2.99, p=.003) becoming more positive
*Industry causes a lot of pollution**	Significant change (t(973) = 2.33, p=.020, d=.75) becoming more negative	Significant with Y6 (t (363) = 3.04, p=.002) becoming more negative	Significant with girls (t (449) = 2.57, p=.010) becoming more negative	Significant with children from the East of England (t (321) =2.40, p=0.17) region becoming more negative
* This statement was reverse coded during analysis.				