

**Children Challenging Industry:
All regions study of the effects of industry-based science activities
on the views of primary school children and their teachers**

2006-8

By Cliff Porter, Joy Parvin and John Lee

January 2010

**Children Challenging Industry:
All regions study of the effects of industry-based science activities on the views of
primary school children and their teachers**

2006-8

By Cliff Porter, Joy Parvin and John Lee

Section	Page
Executive summary	iii
1 Introduction	1
2 National perspective	4
3 Children's data	5
4 Children's views of the CCI programme	6
5 Children's views of science and science-based industries	7
6 Teachers' data	9
7 Conclusions	12
References	13
Appendix 1 – CCI activities	14
Appendix 2 – Children's questionnaires	15
Appendix 3 – Teachers' questionnaires	20
Appendix 4 – Statistical analysis	24

Executive summary

The Children Challenging Industry (CCI) programme provides opportunities for primary school children to experience science in an industrial context. Children undertake a series of scientific investigations in school before visiting a local industrial partner to see how the scientific concepts are applied. In addition to working with children, the programme also delivers high quality professional development in science to primary school teachers.

Between September 2006 and July 2008, the programme reached over 8,200 children, trained 2,140 primary teachers and arranged 259 visits to participating companies. In addition, 213 industrial personnel were given guidance and training on working effectively with primary school children and their curriculum.

Children are motivated by the CCI activities

Children were questioned before and after participating in the CCI programme. Results show that there is a very positive effect on their enjoyment of, and perceived learning in science. 97% of children said that they had learned something new, 85% said they enjoyed the challenges (of the classroom science), and 92% enjoyed learning about industry. The CCI programme encourages children to investigate practical scientific concepts actively in the classroom. This gives a degree of freedom, encourages group work, discussion and thinking skills, and demonstrates the application of their science. This approach helps to motivate children, whilst the site visit provides a new and memorable experience of modern science-based industry.

CCI changes attitudes in teachers and children

A clear indication of the success of the programme is that 82% of the children questioned stated that they now enjoyed science more after taking part in the CCI activities. By comparing responses to statements before and after participating in the programme, teachers' and children's attitudes to science and industry were measured.

After participating in the programme, children showed significantly more positive attitudes to industry related to areas such as safety, pollution, career opportunities and industry's contributions to daily life. Girls and boys were more likely to consider a career in industry after participation on the programme.

The data shows that the CCI programme is successful in giving children a more realistic and positive view of science-based industry.

Similar analysis of teacher questionnaires showed that they were more likely to be positive about industry in relation to the available careers opportunities. In itself this is a valuable tool in encouraging children to take a view of science as a long-term pursuit. Teachers showed slightly more positive attitudes towards industry in respect of the economy, environment and quality of life, although these were not statistically significant changes.

98% of teachers reported that the training was either excellent or good. Following participation in the programme, teachers reported that their knowledge of science teaching had improved and their understanding of industry enhanced. They saw the value of the industry visit in linking with the classroom science but remained unsure about being able to arrange an industrial site visit themselves. Whilst not statistically significant, improvements were seen in teachers' understanding of industry over a range of areas such as career opportunities, contribution to the economy, pollution and products made.

Conclusions

The Children Challenging Industry programme is shown to have a significant impact in schools. It successfully delivers classroom activities that enthuse and motivate primary children. Teachers involved in the programme receive high quality professional development in the teaching of science. Exposure to industry improves understanding and attitudes in children and their teachers.

1 Introduction

1.1 The CCI Programme

The Children Challenging Industry (CCI) programme is run by the Chemical Industry Education Centre, based in the University of York. Launched in 1996, it allows children and teachers to engage with science-based industries in real-life contexts. Nationally, CCI activities cover West Yorkshire and Humber, the North West and the North East regions of England.

During the period of September 2006 to July 2008, the programme reached 8,228 children, trained 2,140 primary teachers and arranged 259 site visits to participating companies.

The CCI programme aims to:

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

1.2 Science in primary schools

In April 2009, Sir Jim Rose published a review of the primary school curriculum (Rose, 2009). In science, the proposed changes closely link scientific and technological understanding. The Children Challenging Industry programme therefore remains highly relevant to the new primary school curriculum. With regards to scientific and technological understanding, the report comments:

This area of learning develops children's ability to explore and understand the natural and made worlds.

They learn to appreciate how science supports the development of technology and how technological needs lead to new scientific discoveries, shaping how we live in our rapidly changing society.

Teachers will now be required to combine scientific principles with their real-life application. The CCI programme is better placed than ever before to fulfil teachers' needs for classroom activities and professional development to meet these new demands.

An international study looked at primary science in 59 countries (Michael, Mullis and Foy, 2008). When comparing the science achievement of 10-year olds (year 5), children in England performed well and were only significantly weaker than those in Singapore, Chinese Taipei and Hong Kong. It did however, also report a decrease in positive attitudes towards science from the previous study in 1995, and found that just 16% of children were taught by a teacher with specialist primary science training. Whilst entrants into primary teacher training are required to possess at least one GCSE science at grade A to C equivalent, it is not untypical for primary teachers to lack confidence in the teaching of scientific concepts. The professional development opportunities offered by the CCI programme are important in helping to enhance primary teachers' skills.

1.3 Children's attitudes to science

Science-based industries are seen as important to the well-being of the UK economy. Central to the success of these industries is a flow of skilled and innovative entrants into the workforce. A recent poll showed that by the age of nine, 84% of children had either a firm idea or at least some views on the career they wanted to follow, but only 4% said they wanted to follow a career in science (Porter & Parvin, 2008). There is clearly a role to be played at an early age to encourage children to have a greater and up-to-date understanding of the science-based industries. CCI encourages local companies to host a site visit and this is a memorable way of giving children first hand experience of how the science they learn about in the classroom is applied in the science-based industries.

1.4 CCI and science in a real-life context

Research has shown that children are more motivated, gain a greater understanding and have a more positive attitude to science when it is taught in a real life context (Bennett, Lubben & Hogarth, 2006; Jarvis & Pell, 2005). Previous research into the effects of the Children Challenging Industry programme have shown that it has positive and lasting effects on children's attitudes to science and industry (Evans, Hogarth & Parvin, 2004). Five years after participation in the programme, nearly a third of the pupils remembered the classroom activities and two thirds remembered their industrial visit.

The Children Challenging Industry programme is based on the concept of taking curriculum science and exploring its application in real-life contexts. It consists of several elements:

- a range of written and web-based materials have been developed which frame curriculum science in real life contexts (see Appendix 1);
- teachers receive professional development from the advisory teacher (1.5 hour session with whole school staff, 2-3 x 2.5 hour sessions classroom-based);
- a CCI advisory teacher delivers a series of classroom investigations set in an industrial context (2-3 x 2.5 hour sessions);
- a CCI advisory teacher delivers a training session (typically a half-day) for industrial partners and liaises with them on how to provide an effective site visit, linking site practices with scientific concepts from the classroom sessions;
- the class spends half a day on the industrial site.

The following comments are typical of the views expressed by teachers after they have participated in the programme:

Our aim was to enhance the investigative science in school, and to provide the teaching staff with training which would give them a range of industry links. Our pupils have thoroughly enjoyed solving real life scientific problems through class based investigations. Following our industry visit to Grosvenor Chemicals, many children expressed the wish to be a scientist when they grew up. Their follow-up work and comments demonstrated how their perception of the chemical industry had changed from a negative to a positive one.

Catherine Jubbs, Lindley Junior School

An integral part of the programme is the site visit. Industrial partners receive training to ensure that the visit is successful, relevant to the classroom activities, and aimed at an appropriate level. Partners recognise the need to encourage children to view science as a positive career choice but additional benefits can also be seen in the company itself. In 2007, Janet Gillboy of Chemtura wrote:

We were experiencing a shortage of chemical engineers as a result of students not choosing to study chemistry at university. We felt that the opportunity to educate

teachers, some of the major influencers in children's lives, at the same time as educating their pupils was a great bonus of CCI.

The children had lots of unexpected questions and it was great to see the company from a completely different perspective. The whole team thoroughly enjoyed themselves and it felt great to be working as a team on such a novel project.

Since 1996, the Children Challenging Industry programme has built a reputation for delivering high quality professional development, classroom activities and links with local industry. This report summarises the achievements and areas for further development.

2 National perspective

As part of on-going quality assurance, and to ascertain the impact of the CCI programme, data are gathered from all teachers and a random sample of children, before and after participation. This is achieved through questionnaires which can be seen in Appendixes 2 - 3. A description of the statistical analysis can be found in Appendix 4.

2.1 Participation in the Children Challenging Industry programme

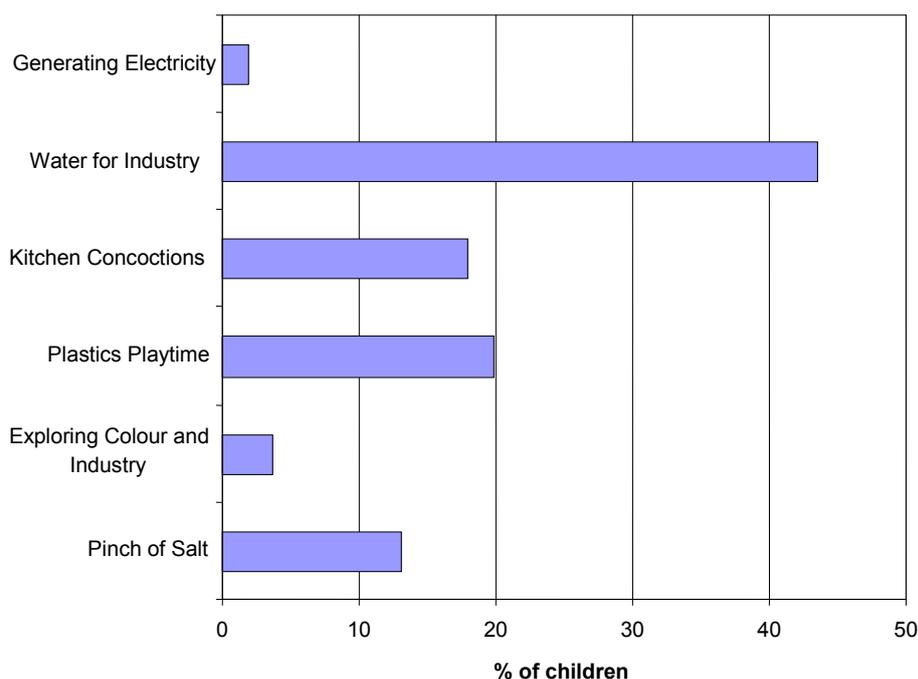
The CCI programme runs in the English regions of the North West, North East, Yorkshire and Humber. Table 2-1 summarises the activities in these areas. Each region works with different numbers of schools according to the funding available, resulting in 1.0-2.0 fte advisory teachers working in each region.

Table 2-1: Reach of the CCI programme (all regions, Sept 2006 to July 2008)

Numbers involved	North East	Yorks & Humber	North West	All CCI regions
Schools	91	130	68	289
Children	2,640	3,602	1,986	8,228
Teachers	784	940	416	2,140
Site visits	106	89	64	259
Site personnel trained	88	54	71	213

The programme offers a range of classroom activities that link the science curriculum with real-life industrial contexts (see Appendix 1). Figure 2-1 shows the spread of activities that were chosen by the schools returning data. Often the choice is driven by the availability of a suitable site visit locally.

Figure 2-1: Range of classroom activities



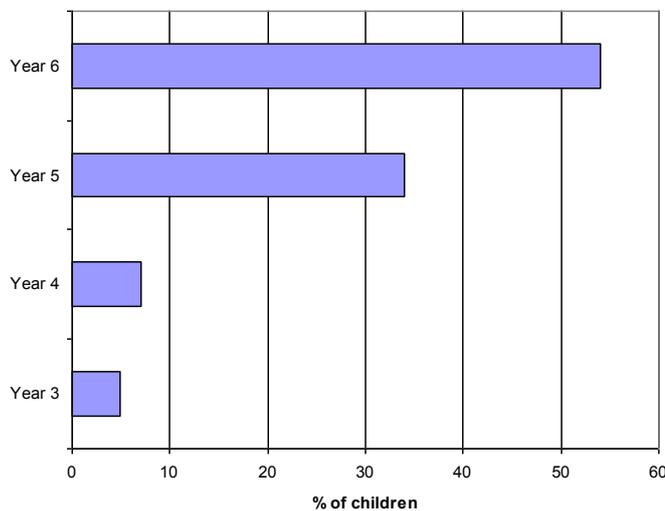
3 Children's data

The results of statistical analysis of the completed children's questionnaires are presented. Representative data were obtained from all regions.

Analysis of pre-programme data collected since 1996 has not changed significantly over time, therefore, the sample size used in this study was reduced. Baseline data were collected from 264 children from 44 schools. This sample was sufficient to confirm that the views of the current cohort matched those expressed in an earlier, larger study (Evans, Hogarth & Parvin, 2004), and readers are referred to this study for a detailed analysis of pre-programme attitudes to science and industry.

Post-programme data have been collected and analysed from 978 children from 163 schools. Data were gathered using random sampling from six children in each school. There was a similar number of boys and girls and so the samples showed no gender bias. The age range of the children ranged from year 3 to year 6, with the majority being in year 6 (see figure 3-1).

Figure 3-1: Age range of children



4 Children's views of the CCI programme

Following completion of the CCI activities, children were presented with a range of statements relating to their views of the programme. They were able to respond with 'yes', 'no' or 'don't know.' Figure 4-1 summarises responses to the statements and demonstrates that overwhelmingly the CCI programme is received well by the children who take part. Some additional children's comments are shown below:

I like it because I didn't know a lot about science but now I know a lot more I love it.

I enjoyed science industry when we worked in a group because we can discuss our ideas.

It was a bit hard but very fun.

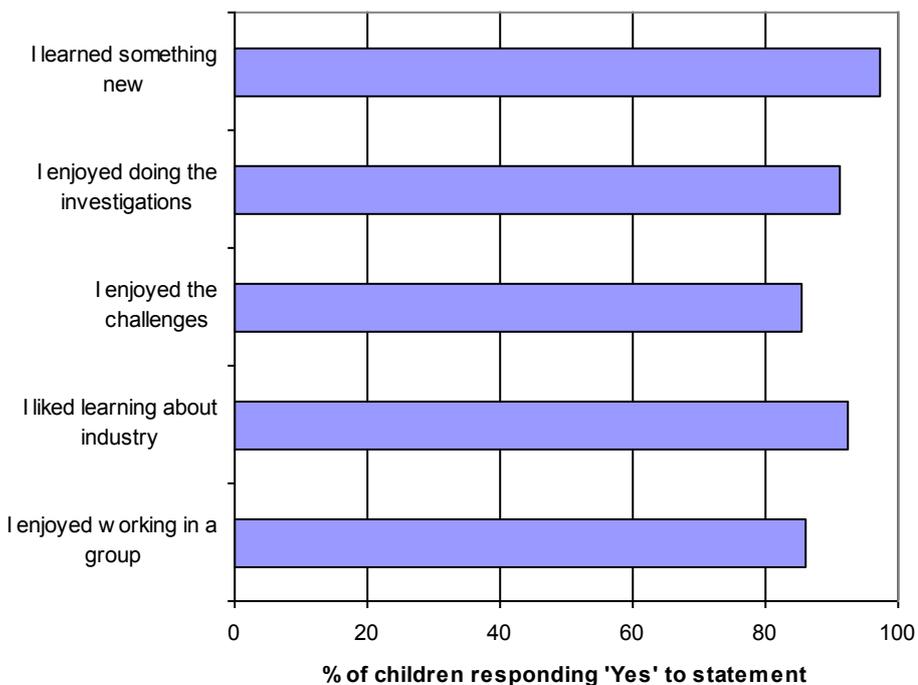
I enjoyed all of it but we had to use a lot of paper towels because it was so messy.

I enjoy the trip because I like to go to places I haven't been before.

The results show that the programme has a very positive effect on children's enjoyment of their school science. 97% of children said that they had learned something new, 85% of children said they enjoyed the challenges and 92% enjoyed learning about industry. This is further evidence that setting science-based investigations in an industrial context remains a popular and effective approach. Methods that include practical enquiry help to engage children in the science curriculum and increase their enjoyment. The site visit gives the children a new and memorable experience of modern science-based industry. To add to this, previous research has shown that the CCI programme has long-lasting positive influence on participating children, well in to their teens (Evans, Hogarth & Parvin, 2004).

In addition to giving a valuable experience of modern industry, the CCI process is an effective way of progressing children's learning in science.

Figure 4-1: Children responding 'Yes' to the statements relating to children's CCI experience.



5 Children's views of science and science-based industries

Overall, the programme successfully resulted in an increase in positive attitudes towards science and the science-based industries. A clear indication of the success of the programme is that 82% of the children questioned stated that they enjoyed science more after taking part in the CCI activities.

The children's questionnaires contained statements to probe their attitudes and views towards science and science-based industries. The children could make responses that were scored as stating positive, negative or neutral attitudes towards science (see Appendix 3). Identical statements were repeated in the post-participation questionnaire and so a direct comparison of any changes in attitudes could be made.

5.1 Increase in positive attitudes towards science and industry

Statistical analysis of the responses showed that children held more positive views of science and industry following participation in the CCI programme. 19 statements showed a significant increase in positive attitude to science and there were no statements that showed a significant deterioration in views. The statements below all indicated a significant improvement in positive attitudes towards science and industry:

- I like science
- I'd like to be a scientist
- Science is my favourite subject
- Scientists are important in industry
- We do too much writing in science*
- Industry is useful
- Industry is safe
- Many scientists work in industry
- Industry is dangerous*
- Industry causes pollution*
- Many engineers work in industry
- Young people work in industry
- I learn about industry from my teachers
- Scientists have important jobs in industry
- Our lives would be worse off without industry
- There are women scientists and engineers
- Industry makes things we need
- Engineers have important jobs in industry
- I could work in industry in the future.

* Less agreement with these statements following participation.

* Less agreement with these statements following participation.

The data clearly show that after the CCI programme children enjoyed their school science more. It is also encouraging to see how their attitudes to industry have improved. Following participation, the children have a greater understanding of the role of scientists and engineers in industry and are therefore aware of the career opportunities available.

Children, and many adults, have their attitudes towards industry shaped by its portrayal in the media. This often only reports negative views such as climate change, pollution and safety incidents. It is therefore very welcome to see that the CCI programme helps to add balance to some of these views. Following the activities, children were less likely to agree with the statements that industry is dangerous and polluting and more likely to agree that industry is safe. A greater understanding of industry by teachers and children is a valuable outcome of the programme.

5.2 Gender differences

There were some differences in the responses of boys and girls. Whenever there was a significant improvement in boy's attitudes, this was accompanied by a significant increase displayed by girls. However, there were several statements where girls showed a significantly more positive attitude whilst there was no change for the boys. The statements below show the statements where a significant increase in positive views was seen in girls alone.

- I'd like to be a scientist
- Science is too difficult*
- We do too much writing in science*
- I like doing science experiments at home
- Industry is dangerous*
- There are women scientists and engineers.

* Less likely to agree with statement after participation.

There was a significant increase in girls saying that they would like to be a scientist, along with recognition of women scientists and engineers.

The CCI programme helps to increase girls' understanding of industry. Girls became more aware of the opportunities for young people and especially women scientists in industry. The programme has increased their understanding of future possible career choices at a formative time in their developing attitudes towards science.

5.3 No overall change in attitudes

Some of the statements, when analysed, showed no significant changes in attitudes following participation. The majority of these statements showed an increase in positive attitudes towards science and industry but the increase was not found to be statistically significant. No statements showed a significant deterioration in attitudes. The statements which showed an improvement in attitudes were:

- I like watching science programmes on TV
- I like doing science experiments at home
- School science clubs are a good idea
- We have to do too much work in science
- I like reading science stories

When all results are considered, the data demonstrate that, whilst the CCI programme has a positive effect, there is a continuing need to present children with opportunities to learn about and gain experience of science-based industries as they progress through their school journey. In particular, to demonstrate the range of job opportunities available in science-based industries.

6 Teachers' data

Data were gathered from teachers by completion or pre- and post-participation questionnaires (see Appendix 3).

6.1 Teachers' professional development

During the programme, teachers participate in a 90 minute professional development training session, delivered by a CCI advisory teacher. In addition, teachers observe and co-teach (in part) two or three half-day classroom sessions with the advisory teacher. In this way, the programme helps to deliver teacher professional development in pedagogy as well as giving valuable experience of the science-based industries.

Prior to starting the programme, teachers were asked to indicate the amount of science-specific professional development they had undertaken in the preceding three years. Somewhat worryingly, the average was just 3 hours per year. The data reflected a wide variety of exposure to science, with the range being from no training at all to 20 hours over three years. Even the top end of the scale though represents just a few hours a year devoted to CPD in science teaching.

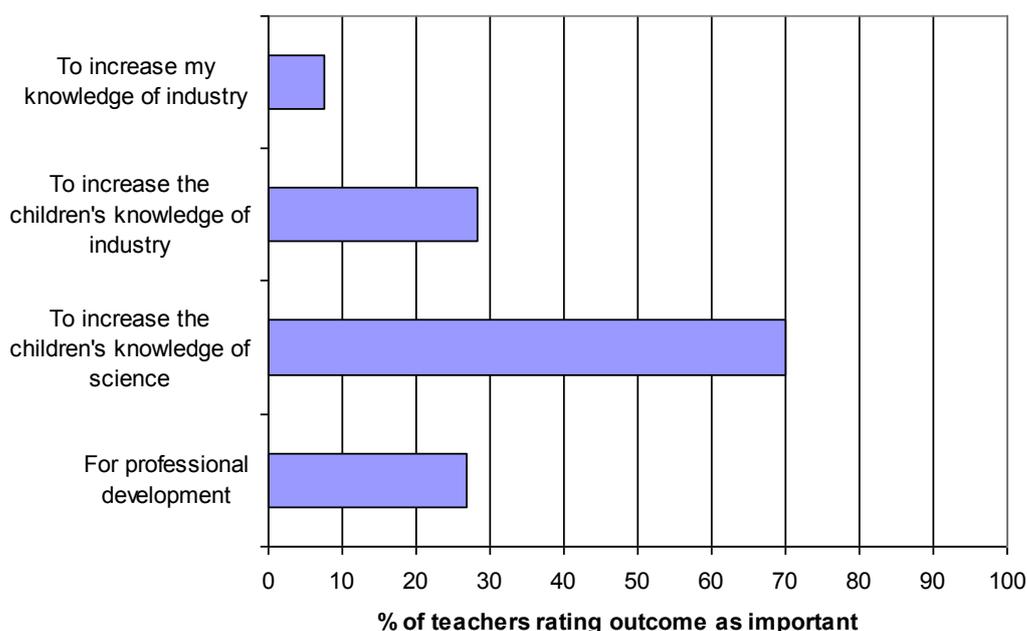
When asked about links with local industry, the results were expectedly poor. The lack of industrial links is reflected in the 66% of teachers who had never organised a trip to a local industry and the 76% of schools that did not have a policy on schools-industry links.

To explore teachers' expectations of the programme, they were asked to consider four of the outcomes of the CCI training. These were to:

- contribute to teachers own professional development;
- increase children's knowledge of science;
- increase children's knowledge of industry;
- increase teachers knowledge of industry.

Teachers rated each outcome on a scale of 1 to 5 to express how important they felt the outcome was. Figure 6-1 shows the percentage of 'most important' choices for each outcome.

Figure 6-1: The most important programme outcomes, as rated by participating teachers



Teachers also saw the programme as being able to inspire children and give them a taste of science in a real life context. Typically, teachers expressed the following objectives:

To give the children chances to explore science from an industry point of view. To help them understand how the things they learn will be used in the future.

To add interest to the children's science learning because curriculum and revision is very boring.

A chance for children to learn about science in the real world, a different approach [to usual science teaching].

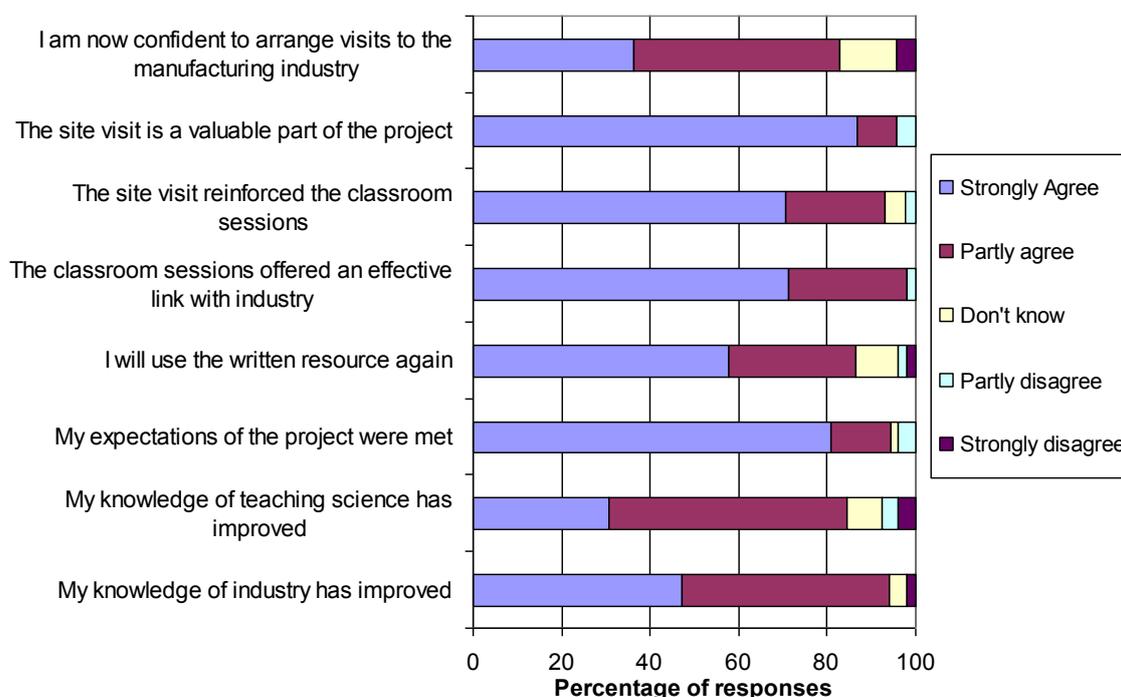
To increase the children's enthusiasm and joy of science, and give science a real life context.

Following training, 98% of teachers rated it as either excellent or good. It is encouraging to note that 73% of teachers rated the industrial context, and 75% the expert knowledge of industry, as being strengths of the training. One of the major values of the CCI programme is that it helps to develop teachers' skills, and so enhance their teaching of science, whilst also giving an experience of science-based industries.

6.2 Teachers' views of the programme

85% of teachers agreed that their knowledge of science teaching had improved and 87% that they would use the written resource(s) independently after completion of the programme. Teachers were positive about the effects of taking part in the CCI activities and Figure 6-2 shows teachers' responses to statements relating to the programme. Previous research shows that the programme has a lasting effect on teachers (Evans, Hogarth and Parvin 2004). When sampled five years following participation, teachers recalled that the activities were practical and engaging. The majority were still using the written materials, as well as the teaching methods they had been exposed to during the CCI programme; and the project had helped widen teachers' perceptions of science and industry.

Figure 6-2: Responses of teachers following participation in the CCI programme.



There were few negative responses to the statements but the results show that some areas of the programme were valued more than others. 81% of teachers strongly agreed that their expectations of the programme had been met. 87% strongly agreed that the site visit was a valuable part of the programme, 71% that the classroom sessions were an effective link with industry and 71% that the visit reinforced the classroom activities. Teachers' knowledge of industry was improved but only 36% of teachers felt strongly that they were confident to arrange a site visit. A further 47% partly agreed with this statement. This emphasises the importance of the CCI advisory teacher in brokering between schools and industrial partners. School teachers typically lack a network of contacts and the experience in dealing with industrial partners. CCI advisory teachers are therefore essential in the process of organising successful site visits.

6.3 Teachers attitudes to industry

As with the children's questionnaire, teachers were presented with a set of identical statements before and after participating in the programme. These enabled any significant changes in attitudes to be identified. Table 6-3 summarises the findings.

None of the statements demonstrated a statistically-significant change but it is encouraging that teachers had slightly more positive views in relation to the statements shown below:

- Industry produces a wide variety of useful products
- Industry causes pollution*
- Industry provides many career opportunities
- I feel negative about industry*
- Industry improves our quality of life
- Industry creates wealth and boosts our economy
- Industry offers interesting and rewarding jobs.

* Less likely to agree following participation.

There is clearly more work to be done to change many of the attitudes that teachers possess about industry. This is unsurprising as much of the everyday information about the science-based industries is negative. It would be ambitious to hope that the involvement in the CCI programme alone would be able to alter opinions on areas such as pollution, the economic value of industry and environmental impacts.

7 Conclusions

From September 2006 to July 2008, the Children Challenging Industry (CCI) programme reached over 8,000 children and 2,140 teachers in 289 primary schools. The most popular CCI activity was Water for Industry. 259 site visits were organised and 213 personnel from participating companies were trained.

The CCI programme presents curriculum science within real life contexts. Two of the key objectives of the programme are to increase children's enjoyment of science and to improve their perceptions of science-based industry. The data indicate that the programme succeeds in achieving these goals. 82% of the children questioned stated that they enjoyed science more after taking part in the CCI activities and there were significant positive changes in attitude towards industry. Research has shown that views of future career choices are formed very early (Porter and Parvin, 2008) and it is hoped that children involved in the programme will be more likely to continue with science once they leave compulsory education.

The CCI programme also aims to enhance primary school teachers' ability to teach science. It is worrying that the teachers involved in the programme had received, on average, just 3 hours per year professional development training in science. The CCI training consists of a 90 minute session before starting the programme and three half-day sessions working in the classroom alongside a CCI advisory teacher. This is clearly significant, valuable and much-needed professional development.

98% of teachers reported that the training was either excellent or good. Following participation in the programme, teachers reported that their knowledge of science teaching had improved and their understanding of industry enhanced. They saw the value of the industry visit in linking with the classroom science but remained unsure about being able to arrange an industrial site visit themselves. Longitudinal studies on CCI have revealed this in the past. As a consequence, the CCI team tried to hand over more responsibility to teachers to arrange the site visit. However, this resulted in visits potentially or actually not going ahead. This is now considered an essential role as s of the advisory teacher, as school teachers often do not have the same experience of dealing with industrial partners to ensure that a successful site visit is arranged.

Teachers' attitudes to industry were measured before and after participation. Whilst not statistically significant, improvements were seen in teachers' understanding of industry over a range of areas such as career opportunities, contribution to the economy, pollution and products made.

The Children Challenging Industry programme is shown to have a significant impact in the participating regions. It delivers classroom activities successfully, which enthuse and motivate primary children. Teachers involved in the programme receive high quality professional development in the teaching of science. Finally, exposure to industry improves understanding and attitudes in children and their teachers.

References

Bennett, J., Lubben, F. and Hogarth, S. (2006). Bringing science to life: a synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. Science Education, Wiley InterScience

Evans, C., Hogarth, S. and Parvin, J. (2004). Children Challenging Industry: analysis of CCI project data 5 years on. University of York.

Jarvis, T. and Pell, A. (2005). Factors influencing elementary school children's attitudes towards science before, during and after a visit to the UK National Space Centre. Journal of Research in Science Teaching 42(1), 53-83

Michael O.M, Mullis I.V.S and Foy P. (2008). TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades

Porter, C. and Parvin, J. (2008). Learning to Love Science: harnessing children's scientific imagination. Report for Shell Education Services.

Rose, J. (2009). Independent Review of the Primary Curriculum: Final Report. DCSF Publications

Appendixes

Appendix 1: Current CCI activities

A Pinch of Salt	A cross-curricular approach to the topic of salt is presented. The main focus is the science related to the use of salt as a de-icer on roads in cold weather. The children are guided through a range of investigations, including the effect of salt on ice, and the purification of salt from rock salt. Children learn about solutions, evaporation and filtration.
Generating Electricity	This set of activities is initiated by problems in an isolated African village, and its need for a good supply of electricity and clean water. Children then investigate wind power, and create and record electrical circuits in real contexts. Visits are often then to power stations to look at electricity generation in the UK.
Plastics Playtime	Children test and classify plastics before investigating their thermal insulation and shock resistance properties. Children design and make packages for fragile items and test their designs with the help of the Royal Mail.
Water for Industry	Children look at the use of water as it moves through an industrial site where it is treated, used as cooling water, and treated again before being returned to a river. They explore solutions for leaky pipelines, investigate filtration techniques and materials, and learn about heat exchange.
Exploring Colour and Industry	Classroom activities focus on pigments and natural/synthetic dyes whilst modelling real quality control processes used in the colour industry. An interactive website accompanies these activities, www.colour-ed.org .
Kitchen Concoctions	The theme running through these activities is the similarities between mixing ingredients using recipes to cook in the kitchen, with mixing ingredients to make useful products in industry. Activities include making a soap bar, developing a bubble mixture, investigating the effectiveness of washing products and scourers, and making a simple fire extinguisher.
Runny liquids	The real context is that of a company making a solution based on a wood resin needs. The company needs to meet specific criteria for optimum manufacturing conditions for this 'sticky and thick' solution, which 'won't flow through the pipes, and the pipes keep breaking'. Children classify liquids, and investigate viscosity of liquids, and the effects of warming on this property.

Appendix 2

Children's questionnaire pre-programme

Children Challenging Industry

Code:

Children's questionnaire 1

Name:

Please tick the right boxes:

girl

boy

year 4

year 5

year 6

All of the questions below are about how you feel about science and industry. Try and answer as many as you can with **your ideas**.

1. Please tick the topic you are doing

A Pinch of Salt

Exploring Colour & Industry

Plastics Playtime

Kitchen Concoctions

Water for Industry

Tick a box for each question, which says how you feel about science:

2. I like science

3. I'd like to be a scientist

4. Science is my favourite subject

5. Science is too difficult

6. Scientists are important in industry

7. We do too much writing in science

8. I like watching science programmes on TV

9. I like doing science experiments at home

10. We do too much science in school

11. School science clubs are a good idea

12. We have to do too much work in science

13. I like reading science stories

14. We have to do a lot of planning in science

Yes	No	I don't know

Tick a box for each question, which says how you feel about industry:

	Yes	No	I don't know
15. Industry is useful			
16. Industry is safe			
17. Many scientists work in industry			
18. Industry is dangerous			
19. Industry causes pollution			
20. Many engineers work in industry			
21. I learn about industry from TV			
22. Young people work in industry			
23. I learn about industry from my teachers			
24. Scientists have important jobs in industry			
25. Our lives would be worse without industry			
26. There are women scientists and engineers			
27. Industry makes things we need			
28. Engineers have important jobs in industry			
29. I could work in industry in the future			

Children's questionnaire post-programme
Children Challenging Industry
Children's questionnaire 2 Code

Please tick the right boxes:

girl boy year 4 year 5 year 6

All of the questions below are about how you feel about science and industry. Try and answer as many as you can with **your ideas**.

2. Please tick the topic you are doing

A Pinch of Salt Exploring Colour & Industry Electricity
 Plastics Playtime Kitchen Concoctions Water for Industry

Tick a box for each question, which says how you feel about science, now you have completed the project:

	Yes	No	I don't know
2. I like science			
3. I'd like to be a scientist			
4. Science is my favourite subject			
5. Science is too difficult			
6. Scientists are important in industry			
7. We do too much writing in science			
8. I like watching science programmes on TV			
9. I like doing science experiments at home			
10. We do too much science in school			
11. School science clubs are a good idea			
12. We have to do too much work in science			
13. I like reading science stories			
14. We have to do a lot of planning in science			

Tick a box for each question, which says how you feel about industry, now you have completed the project.

	Yes	No	I don't know
15. Industry is useful			
16. Industry is safe			
17. Many scientists work in industry			
18. Industry is dangerous			
19. Industry causes pollution			
20. Many engineers work in industry			
21. I learn about industry from TV			
22. Young people work in industry			
23. I learn about industry from my teachers			
24. Scientists have important jobs in industry			
25. Our lives would be worse without industry			
26. There are women scientists and engineers			
27. Industry makes things we need			
28. Engineers have important jobs in industry			
29. I could work in industry in the future			

30. *Have you enjoyed working on this project? Write down...*

The thing that you enjoyed doing the most

The thing that you enjoyed doing the least

31. Answer 'yes', 'no' or 'don't know' to the following questions.

I learned something new _____ I liked learning about industry _____

I enjoyed the challenges _____ I enjoyed doing the investigations _____

I like science more _____ I enjoyed working in a group _____

Please tell us more about your answers (such as why you have enjoyed or not enjoyed certain things.)

Appendix 3

Teachers' questionnaires



Date: _____ Code: _____

Pre-project questionnaire for teachers

The aims of this questionnaire are to gather teachers' views of the manufacturing industry and its links with science, and to evaluate the effectiveness of the *Children Challenging Industry* project. Any information provided here will be used anonymously.

Selected CIEC Resource Pack: _____

Days (approx) spent doing science in-service training in the last 3 years _____

Days spent doing industry links in-service training in the last 3 years _____

School industry links

Does the school have a policy on industry links yes/no

Have you ever organised a visit to industry yes/no

Please tick the industrial companies or link organisations with which the school already has links:

- | | |
|------------------------------------------|--------------------------|
| Education-business partnership | <input type="checkbox"/> |
| Setnet/Setpoint | <input type="checkbox"/> |
| Science & Engineering Ambassadors (SEAs) | <input type="checkbox"/> |
| Local company | <input type="checkbox"/> |

Which science resources sponsored by the chemical and allied industry (e.g. BP, CIBA, Esso, etc.) have you used?

a. _____

b. _____

What are your main objectives of the sessions? Please label the following four (or 5) items in order of priority (i.e. give the most important objective a '1' and the least important a '4')

- | | |
|-----------------------------------------------------------|--------------------------|
| For professional development (ideas for teaching science) | <input type="checkbox"/> |
| To increase the children's knowledge of science | <input type="checkbox"/> |
| To increase the children's knowledge of industry | <input type="checkbox"/> |
| To increase my knowledge of industry | <input type="checkbox"/> |

Other



Please describe 'other' here _____

Please complete the table below:

	Strongly agree	Partly Agree	Don't Know	Partly disagree	Strongly disagree
Industry produces a wide variety of useful products					
Industry causes pollution					
Industry provides many career opportunities					
I feel negative about industry					
Industry improves our quality of life					
A job in industry would be tedious					
Industry creates wealth and boosts our economy					
Industry has a negative impact on the environment					
Industry offers interesting and rewarding jobs					

Thank you for your time and cooperation in completing this questionnaire

Date: _____ Code: _____



Post-project questionnaire for teachers

The aims of this questionnaire are to gather teachers' views of the manufacturing industry and its links with science, and to evaluate the effectiveness of the *Children Challenging Industry* project. Any information provided here will be used anonymously.

I rate the training as: Excellent Good Satisfactory

Please indicate the strengths of the sessions:

Strengths

- Industrial context
- Expert knowledge of science
- Expert knowledge of industry
- Practical science activities
- National curriculum coverage (inc. Sc1)
- Extra/new person in class
- Teaching ideas
- Children's investigative skills
- Group work
- Equipment provision
- Other (please specify)

Please complete the table below:

	Strongly agree	Partly Agree	Don't Know	Partly disagree	Strongly disagree
My knowledge of industry has improved					
My knowledge of teaching science has improved					
My expectations of the project were met.					
I will use the written resources again.					
The classroom sessions offered an effective link with industry.					
The site visit reinforced the classroom sessions.					
The site visit is a valuable part of the project.					
I am now confident to arrange visits to the manufacturing industry.					

Please use the space below to suggest any improvements to the training:

Please complete the table below:

	Strongly agree	Partly Agree	Don't Know	Partly disagree	Strongly disagree
Industry produces a wide variety of useful products					
Industry causes pollution					
Industry provides many career opportunities					
I feel negative about industry					
Industry improves our quality of life					
A job in industry would be tedious					
Industry creates wealth and boosts our economy					
Industry has a negative impact on the environment					
Industry offers interesting and rewarding jobs					

Thank you for completing this questionnaire.

Appendix 4

Statistical analysis

Data cleaning

Following entry, data were checked for completeness. Missing data were checked against questionnaires. Unfeasible answers to questions were checked for error on questionnaires. Impossible values recorded on questionnaires were recorded as missing.

Children's views of science and industry

Questions 2 – 29 on the questionnaire concern the child's positive or negative attitudes towards science and industry. Each individual question was summarised in a table displaying the number of children who responded yes, no and don't know to each question.

For positive questions, such as "I like science", the responses were scored as:

- Yes = 2
- Don't know = 1
- No = 0

For questions that contains negative meanings, such as "Science is too difficult", the responses were scored as:

- Yes = 0
- Don't know = 1
- No = 2

The questions were checked using Cronbach's Alpha to ensure they could be reliably used as a scale. If Cronbach's Alpha is equal to a greater than 0.7, the questions can be combined into a scale. Cronbach's Alpha measures the extent to which item responses obtained at the same time correlate with each other. It determines how consistently the variables measure a construct, in this case, the positive attitude of children towards science.

The analysis was based on non-parametric methods since the data from the questionnaire was mainly ordinal (e.g. yes, no, don't know). A Mann-Whitney U test was performed to compare the responses from the two different unmatched groups of students before and after the project. Significance level was determined by the P-value for the two-tail test.

Teachers views of industry

Nine questions were identical in the pre- and post-participation questionnaires. Questions that contain a positive meaning (such as 'Industry produces a wide variety of useful products') were scored: strongly agree with 5, partly agree with 4, don't know with 2, partly disagree with 2 and strongly disagree with 1. For questions that contain negative meanings (such as 'Industry causes pollution'), the scoring system was reversed.

Scores obtained before the CCI programme were compared with scores after the programme using an unpaired t-test.