Stats and Figures

Statistical Consultancy

Report Title:	**Children Challenging Industry** **Analysis of children's & teachers' data from the Humber region, September 2003 to March 2005.**
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Report Date:	January 2006
Version:	1.2

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1 Executive Summary

Classroom-based training, consisting of three 2½-hour sessions, was delivered to primary school teachers and their year 5 and 6 pupils. The children completed one of four topics on offer, chosen by the teacher. These were, *Water for Industry*, *A Pinch of Salt*, *Plastics Playtime* and *Exploring Colour and Industry*.

The advisory teacher demonstrated how industry could be used as a resource, by providing a real and motivating context in which to teach science. The classroom activities were set within an industrial context, and the children visited an industrial sites. The advisory teacher conducted a 1½-hour training session on science–industry links for the whole staff in each school.

The Children Challenging Industry (CCI) project aims are 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 chemical industry and its relationship with science
- Improve teachers' knowledge and confidence of teaching science
- Improve teachers' perception of the chemical industry and its relationship with science.

1.1 Children's data

Upon completion of the CCI project, 132 children completed questionnaires from the academic years 2003-2005. They were asked questions regarding their awareness of industry and its relationship with science.

Two thirds of the children confirmed that they enjoyed science more, since the CCI project, with practical experiments most frequently cited as the most enjoyable aspect of the project. A tool to measure the children's positive views towards the project found that 80% of children gave the project the maximum score. The most popular reasons provided for enjoying the project were that it was fun and they learned something new.

In addition to their increased enjoyment of science, the children increased their awareness of industry, and were more able to accurately describe modern industry. They were more likely to say that an industrial site was safe and employed fewer people than expected. They were less likely to say that a site was hot, smelly, dirty and dark.

The children drew pictures of their perceptions of industry, which were scored, with a positive score indicating a more informed image of industry. The children's drawings of the internal and external views of an industrial site were more detailed and accurate as a result of the project.

The project also raised the children's awareness of the variety of jobs held in industry. The children learned about the importance of scientists and engineers and their roles on industrial sites. Virtually all the children stated that scientific testing was important. As a result of the project the proportion of children who were aware that scientists and engineers worked in industry increased dramatically with nearly half of the children spontaneously stating that scientists and/or engineers worked in industry.

When asked which job they would choose to do in industry, there was an increase in the proportion of children who chose scientist as a job they would like to do. The reasons for this choice were that it would be enjoyable or fun.

The results demonstrate the extent to which the children learned about science and its links with industry.

1.2 Teachers' data

21 teachers returned questionnaires in the academic years 2003-2005, after carrying out the CCI project. A third of the teachers had not had recent science training and training related to industry was even less common.

Before they had any CCI training, many teachers had not received any information about the chemical industry either through resources developed by industry or through links with the chemical industry. The majority stated they had never seen such resources. The small group of teachers who had used resources were most likely to say that they did so because they were of good educational quality and reasonably priced. Teachers were more likely to teach about industry in the context of history or geography, than science.

The feedback from the training was overwhelmingly positive. The sessions and site visit were of an extremely high standard and were highly rated by the teachers. Aspects of the sessions most often cited as strengths were the practical science activities and the investigative planning. Teachers who rated the visit most highly were significantly more likely to say they would arrange a future visit.

The change in attitudes towards industrial links that occurred during the project was impressive. All the teachers intended to re-use the CCI materials again in the future and three-quarters said they intended to repeat the industrial visit in the future. In addition, All but one of the teachers said they had learned something about industry or teaching science or, very often, both.

This study provides evidence that the CCI training has changed the attitudes of teachers. At the beginning, the teachers were mostly neutral about involving industry to teach primary science. By the end of the training, the majority of teachers were extremely receptive to involving the manufacturing industry to teach science with a more practical approach.

2 Introduction

2.1 Background

In 1988 the Education Reform Act prescribed the curriculum to be taught in state schools in England and Wales. The first set of national guidelines for science were published the following year (DES, 1989). Science was to be taught as a 'core subject' and for the first time primary teachers were being told to teach children a broad science curriculum, covering investigation skills and aspects of physical and life sciences.

However, research carried out in recent years has highlighted teachers' lack of scientific knowledge and confidence to teach science (Parvin 1999). Close links have been found between primary teachers' ability to question children effectively and their understanding of scientific concepts (Whitby, 1993, Jelly, 1985). Productive questions promote science as a way of working, in which a variety of solutions can be sought from first hand experiences (Parvin, 1999). Further evidence of this argument is provided by Jarvis and Bell (2002). They concluded that there was a relationship between teaching behaviour and children's attitudes to science. Children with more positive attitudes towards science are more likely to be found in classrooms which have high levels of involvement, teacher support and use of innovative teaching strategies. Teachers who lack ability, confidence and enthusiasm for the subject tend to use less stimulating, more didactic methods and do not respond effectively to the children's questions making them more likely to have pupils with poor attitudes to science.

For this reason, the Qualifications and Curriculum Authority feel that primary teachers should obtain a minimum of a GCSE in one or more areas of science (biological, chemical or physical) in order to be able to teach the subject (Blackburn, 1997). In addition to qualifications that provide adequate knowledge, successful teaching of science is dependent on a good understanding of scientific concepts and time in which to properly teach these concepts. However, the introduction of the National Literacy Strategy and the Numeracy strategy are having profound effects on science in primary schools, with schools reducing the time spent on science (ASE, 1999). It is therefore important (if not essential) that teachers are given the opportunity to improve their science teaching skills with high quality in-service science training (Parvin,1999).

Using industrial context in primary science teaching leads to an improvement in the quality of the teaching. By setting science activities within an industrial context, the problem of science being an isolated subject with no relevance to everyday life is overcome. The National Curriculum recognises this and states: 'Pupils should be given the opportunities to consider the part science has played in the development of many of the things that they use'. Research has shown that developing children's industrial understanding and providing a purpose and relevant context for their classroom science activities, leads to increased motivation and ownership of their work (Parvin, 1999). Good quality science teaching is extremely important during the primary school years and not just when pupils are making career choices in secondary school. Research by Pell and Jarvis (2001) found that there was a steady decline in children's enthusiasm for science during the primary school years. They also stressed that the way to improve children's enjoyment of science was through in-service training.

The attitudes of primary school children towards science have far reaching consequences. Attitudes towards science at a younger age may influence children's later views of science and scientific occupations as well as their attainment (Pell, Jarvis, 2001). Research from 1975 showed that the ages 8 to 13 are the critical ones for a child's formation of attitudes to science (Pell & Jarvis). Musgrove and

Batcock (1969) found that a third of the science and engineering students they questioned had made the choice to study science by the age of 12. Blatchford (1992) also found that pupils showed awareness of future careers before entering secondary school and children as young as four years old have perceptions about occupations (Parvin, 1999). With little information about industry taught at school many pupils and subsequently adults hold negative views of industry making it unlikely that they would consider this area as a career. The scale of the problem becomes clear When you consider that the UK chemical industry alone, employs more than 200,000 skilled people, contributing a significant amount to the Gross Domestic Product.

MORI polls have shown that the views of industry held by the public (which includes teachers) are often negative or narrow. These views are based on limited knowledge, obtained from the media, which is indifferent at best, even hostile, to the chemical industry or from news reports which cover industry in the role of polluter. The immense contribution to everyday life that the chemical industry makes is often overlooked. The MORI polls showed that the youngest group being surveyed were the most negative towards industry, an indication that these negative perceptions start earlier than adulthood. It is no surprise that concern has been expressed recently at the drop in young people pursuing a scientific career in industry.

To increase the proportion of pupils who enjoy science and may consider a career in industry in the future, children must receive high quality science teaching and demonstrate a positive attitude towards science and industry. In-service training provided by the Chemical Industry Education Centre (CIEC) at the University of York has therefore been designed and delivered to demonstrate to teachers how industry can be used as a resource, providing a real and motivating context in which to teach science.

Project aims

The five main aims are to:

- Provide classroom-based training for teachers in aspects of the National Curriculum for science
- Improve teachers' knowledge and confidence of teaching science
- Improve teachers' attitudes towards the manufacturing industry and its relationship with science
- Increase children's enjoyment of science
- Improve children's attitudes towards the manufacturing industry and its relationship with science.

2.2 Methods

Science in-service training was provided to 29 classes by an advisory teacher between September 2003 and February 2005. The methods are explained in full detail in reports previously published in 2004 and available on the Children Challenging Industry web-site (www.ciec.org.uk).

Questionnaires were returned for analysis from 21 teachers and 132 children from 24 schools. In five schools only teachers or children's questionnaires were returned. In one school 2 classes were involved in the project. In 20 classes, a sample of 6 children was taken but in 3 cases the numbers were 5, 4 and 3 children, most likely due to absence. The data were analysed to measure the impact of the project.

The advisory teacher was able to offer a variety of topics to the teachers and children, to suit their needs and interests, together with company visits. The teachers chose from the following topics, *Water for Industry, Plastics Playtime, A*

Pinch of Salt and *Exploring Colour and Industry.* The proportion of teachers choosing each topic are shown in Table 2-1. This result varies from region to region and from year to year with *Water for Industry* often being the favourite, due to the most promising opportunity for a site visit.

Table 2-1: The Science topics chosen by teachers

Name of topic	Frequency	Percentage
Water for Industry	12	55
A Pinch of Salt	5	20
Plastics Playtime	5	20
Colour for Industry	1	5

58% (76) of the children were in year 6, and 42% (56) were in year 5. This result can vary from region to region and from year to year. In some regions the number of children in year 5 exceeds the number in year 6 taking part in the project. The balance of boys and girls was approximately even with 53% (70) boys and 47% (62) girls. The teachers had been teaching for an average of 21 years. This result is higher than in previous years and reflects the fact that there were very few teachers who had been teaching for fewer than 5 years in this sample. Therefore many of the teachers have been teaching prior to the introduction of the National curriculum.

All but one class that returned questionnaires visited an industrial site. The sites visited by schools in this region are shown in Table 2-2.

Table 2-2: Site visits in the region

Site Visited	Number of pupils sampled	Representing classes	Representing pupils
Novartis	30	5	150
Drax	18	3	90
Ciba	15	3	90
Croda	12	2	60
Unilever Birds Eye	12	2	60
British Sugar	6	1	30
Harborlite UK	6	1	30
Holliday Pigments	6	1	30
Lindsey oil	6	1	30
Linpac	6	1	30
Vencel Recil	6	1	30
Rockware Glass	3	1	30
No visit	6	1	30
Total	**132**	**23**	**690**

The main areas of interest of the project are:

- Evidence of a need for science training
- The reaction of teachers and children to the training
- Teachers' & Children's views of science and industry

These areas are reported and discussed in the following chapters. All the diagrams are displayed as percentages unless otherwise specified.

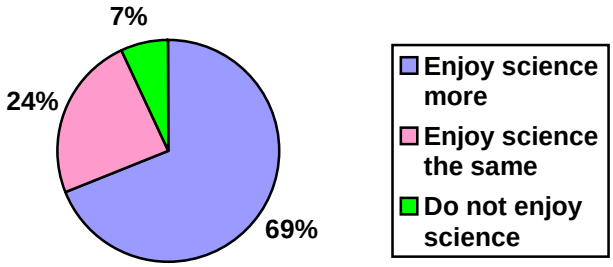
3 Children's views of science

This section discusses the children's views of science and how their positive views of the CCI project have effected their attitudes towards science.

3.1 Enthusiasm for science

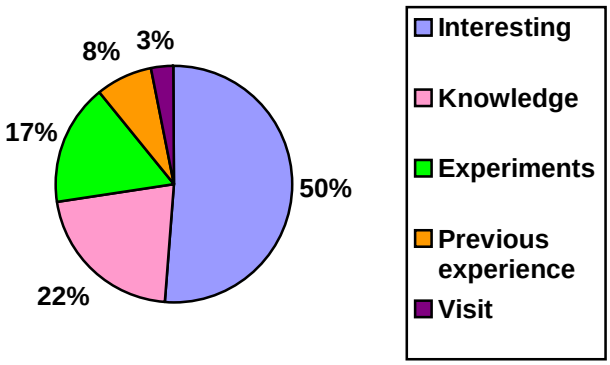
The children were asked if they liked science more, the same, or did not like science since experiencing the CCI project. The children overwhelmingly replied that they liked science more as shown in Figure 3-1.

Figure 3-1: Children's enjoyment of science after CCI



These results demonstrate the projects extraordinarily positive effect on the children's attitudes towards science with two thirds of children saying they enjoyed science more than they did before the project. The children were given the opportunity to go into more detail on their opinion of science. As expected the vast majority (77%) were positive about science and included aspects of science that they enjoyed. Some children were neutral about science (8%) and some described their reasons for not enjoying science (14%). Some of the children who said they enjoyed science the same stated both positive and negative things about science. The positive reasons for liking science have been divided into five categories. These are shown in Figure 3-2.

Figure 3-2: Positive opinions of science



The most common reply was that the children enjoyed science because it was interesting or fun. Many children mentioned that they learned a lot about

science during the CCI lessons and others also mentioned that they enjoyed the practical experiments during the CCI lessons. Some examples of the many positive responses are provided below;

"I didn't like science very much but now I love science and we did experiments." (girl, year 5).

"Because I saw the things happening and its better than just your old science lesson." (boy, year 5)

"Mrs Pook made the programme exciting." (boy, year 6)

"I like it more because the investigations were fun and interesting." (girl, year 6)

"I like science more because we were doing practical things and when we do it in class it was just from textbooks." (girl, year 5)

"I like science more because I've seen how scientists work and I find it more interesting." (girl, year 6)

"I like it more because we don't usually do experiments, we just write about it." (girl, year 5)

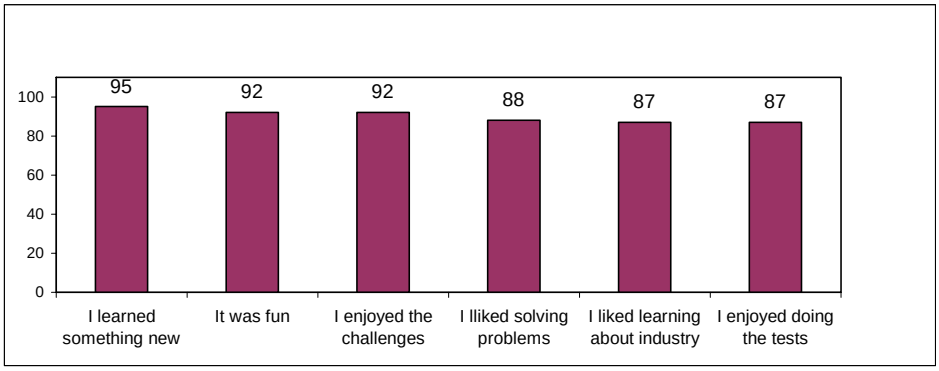
"I like science more because you learn more and I really enjoy it." (girl, year 6)

"I like science more now because I know how industry works. I never understood factories before." (boy, year 5)

3.2 Reaction to the CCI project

The children were asked a series of questions to find out their opinions of the CCI project. The questions were separated into positive and negative aspects of the project and shown with the proportion of children who answered 'yes' to each question in Figure 3-3 and Figure 3-4.

Figure 3-3: Positive attitude towards the CCI project

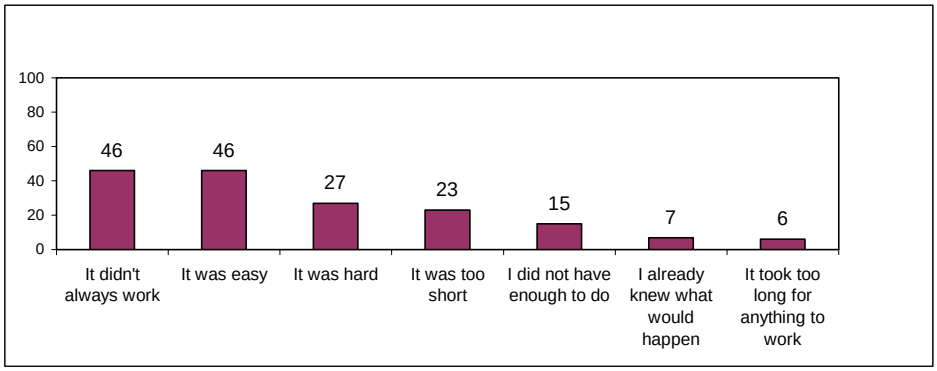


In response to the two remaining questions, 83% of the children stated that 'we all had a job to do' and 83% stated 'I was surprised by what happened.'

The most popular opinions the children held of the CCI project were; they had learned something new, it was fun and they had enjoyed the challenges. More than 9 out of 10 of the children held these very positive views of the project. The CCI project demonstrated that the most successful science lessons involve

and challenge the children and ensure that their learning is taken to the next level.

Figure 3-4: Negative attitude towards the CCI project

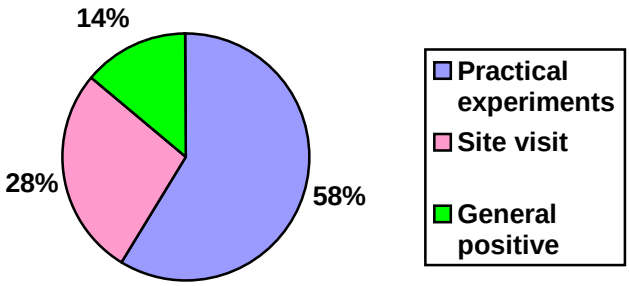


The number of children who gave negative opinions on the CCI project was far smaller. The children were most likely to say that some of the experiments did not always work or that it was easy. Approximately a quarter of the children thought that aspects of the project were too hard or that the project was too short.

Six children (5%), in this case all boys, said the project was boring, and probably felt this way because they were not kept busy at all times. They were more likely to say that they did not have enough to do and that the project was too long. Children vary in the amount of support they need to ensure that they are kept involved at all times.

The children were asked for their opinions on what they enjoyed doing the most during the project. The responses were categorised into three groups which are illustrated in Figure 3-5. Their first answer only was taken into account.

Figure 3-5: Favourite aspects of CCI identified by the children



The majority of the children highlighted the practical science experiments as the most enjoyable part of the CCI project, with nearly two thirds mentioning this as the aspect of science they really liked doing. Many of the children thought that the visit they had to an industrial site was the thing they enjoyed

the most. They are new and interesting to the children as they are often not included in the primary science curriculum. Methods of teaching science that include practical experiments increase the children's involvement and enjoyment of science, which has many benefits for the children. The site visit also involves the children in science in a way that they are not accustomed to in most primary schools. Previous research (5 year on study, Evans & Parvin, 2004) found that a high proportion of children remember the practical aspects of the project and the site visit when surveyed 5 years later, evidence that the enjoyment of CCI makes a lasting impression on children. More evidence is needed to assess whether these positive experiences and memories of CCI and high quality science teaching influence pupils decisions' on pursuing science later in their school life.

Some of the children with responses categorised under 'experiments' simply wrote that they liked 'the experiments' or 'the hands on investigations'. Others went into more detail and specified exactly which experiments they enjoyed. Some of the children gave general positive comments such as 'I liked it all' , 'I liked/enjoyed everything' or 'everything really'.

Some quotes are provided below together with the gender, school year, topic and site visited (if relevant) of the pupil, to illustrate the range of responses.

"I liked doing the experiments and finding out the answer of the experiment." (girl, year 6, salt)

"I liked smashing the block on the Pringles then eating them after." (boy, year 6, plastic)

"I liked the project when we had to make the water clean and make the water cool quicker and seal the pipes together." (girl, year 5, water)

"Doing a test, seeing whether there was a chemical still in the water." (girl, year 6, water)

A small group of children described why they enjoyed the experiments. For example:

"Investigating how to fix the stuff that was wrong." (girl, year 5, 3015/3, water)

"I liked doing all the experiments that we have done because we learned how things worked." (girl, year 5, water)

Many of the children described how much they enjoyed the site visit. The following quotes portray the most popular aspects of a site visit:

"Watching the way things worked and how fast it went." (girl, year 6, colour, Holliday Pigments)

"Seeing the robot work, going to the lab and control room." (boy, year 5, salt, Ciba)

"I liked looking round the cooling towers" (girl, year 5,water, Novartis)

"Looking at the medicine, looking down from a height, checking the medicine." (boy, year 5, water, Novartis)

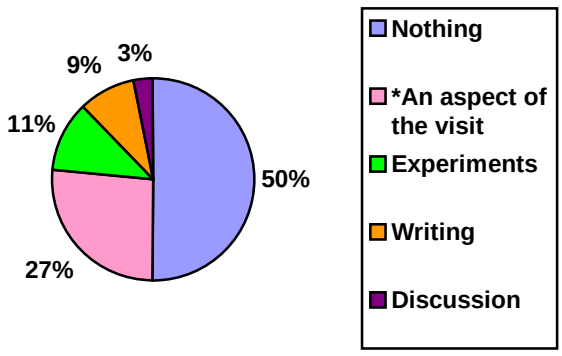
"Going in the freezer, the rice, the carrots." (girl, year 6, water, Unilever Birds eye)

"Looking at chemicals." (boy, year 6, plastic, Lindsey Oil)

"Smell, seeing, bus, people, watching them." (boy, year 6, plastic, Lindsey Oil)

The children were asked if there was anything about the CCI project that they did not enjoy. Half of the children said there was nothing they did not enjoy or they left the question blank. Of the children who said there was something they did not like the majority mentioned an aspect of the site visit such as the smell or the number of stairs they had to climb. The results are shown in Figure 3-6.

Figure 3-6: Least favourite aspects of CCI identified by the children



*e.g. not enjoying climbing up the stairs

If the children had not enjoyed a part of the project it was most likely to be an aspect of the site visit. Many of the children gave positive and negative comments regarding the visit, often citing other aspects of the visit as their favourite part of the CCI project. The four aspects of a site visit enjoyed the

least were the stairs (if the site was particularly large), the waiting around particularly at the beginning and end of the visit, the noise of certain machines and the smell of particular areas. Unilever Birds Eye that makes fish fingers and Croda that makes soap do have areas that contain strong smells. However, despite these issues these site visits were very popular as the children thoroughly enjoyed watching the process of the products being made, as shown by the number of children who cited the site visit as their favourite part of the project. Some children need more priming before the visit than others to ensure that they are thoroughly prepared. This reduces the risk of this anxious group being scared or unnerved by what they experience. Some examples of the views of the children are expressed here.

"Going up the stairs, wearing glasses and hats." (girl, year 5, water)

"When we had to wait a while." (girl, year 5, salt)

"Walking past the machines made me feel a bit scared, especially past the grinder." (girl, year 6, colour)

"The fish factory because it was smelly." (girl, year 6, water)

"I did not like doing the walking all round the site." (boy, year 5, water)

A few children said they did not like a particular experiment. Examples of this type of response are provided below.

"I didn't like the water getting stuck in the pipes." (girl, year 5, water)

"Waiting for water to go through the filter." (girl, year 6, salt)

"I did not really like the heat exchange." (boy, year 6, water)

A small number of children provided more details and described what aspect of the practical work they did not like. Some children find it particularly hard working in a group and need extra support to ensure they feel included.

"I didn't like being bossed about by other children." (boy, year 5)

"I did not like doing the experiment and being left out." (girl, year 5)

Apart from certain practical work, it was the writing up of experiments that children liked the least, with nearly 1 in 10 children citing this as their least favourite part of the project. Less often other aspects of the project were mentioned that have been grouped under the category 'discussion'. Examples are provided below.

"Just talking about it, I prefer doing the experiments rather than talking about them." (girl, year 6, plastic)

"I did not like doing the charts on the board." (girl, year 5, salt)

Half of the children had nothing negative to say about the project at all implying that they enjoyed everything the project had to offer. Most of the remaining half mentioned very specific aspects of the project such as a specific experiment or a specific part of the site visit that they had not enjoyed. The children's enthusiasm for the project is obvious. This is an extremely successful project in terms of the children's enjoyment of the project and

consequently, their increased enjoyment of science. More analysis was carried out to see whether a scale could be developed to measure the children's enjoyment of the CCI project.

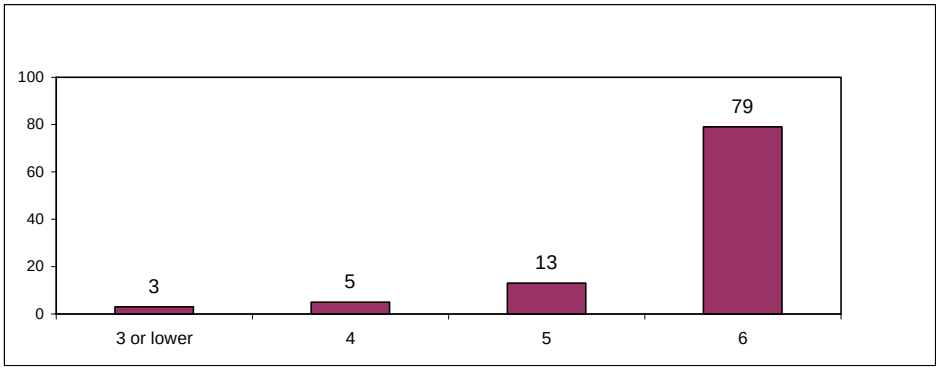
3.3 Measure of attitudes towards CCI project

It is possible to design an attitude scale for measuring the children's attitude towards the CCI project by identifying a group of questions that are related and thereby provide a scale with high internal reliability (the ability of a scale to accurately measure whatever it is measuring). This is measured using Cronbach's alpha, which, if over 0.7 is considered reliable enough to use as a scale. Upon closer inspection there were six questions (five of them positive and one negative) that were related and seemed to be measuring the positive attitude of children towards the CCI project. The most positive children with the highest score of 6 out of 6, said yes to the first five questions and no to the last question:

1. It was fun
2. I liked solving problems
3. I liked learning about industry
4. I enjoyed doing the tests
5. I enjoyed the challenges
6. It was boring

The Cronbach alpha value for these six items was 0.82, evidence of good reliability. The number of children with each of the resulting scores between 0 and 6 are displayed in Figure 3-7.

Figure 3-7: Score of children's attitude towards the CCI project



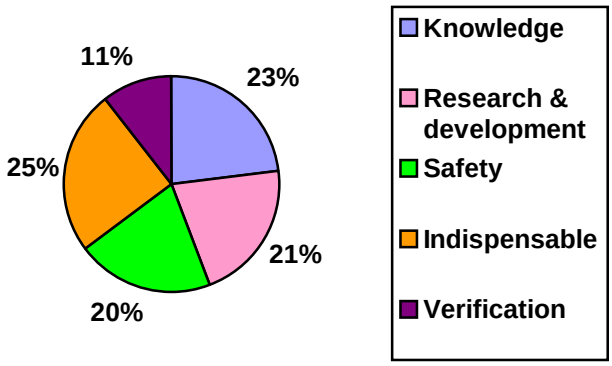
More than three quarters of the children scored the maximum of 6 points on the attitude scale and more than 9 out of 10 children scored a 5 or a 6, indicating that the pupils were extremely positive about the CCI project. The children enjoyed the project and the challenges of the practical experiments while at the same time learning about industry. These positive results provide evidence of the utility of using real life industrial examples when teaching science to make it more interesting and relevant for children.

3.4 Importance of scientists

The children were asked whether they thought scientists were important in industry and 98% of them agreed that they were important. This is similar to the figure seen in previous years (96%). There are many reasons why the children thought

scientists were important, the most common ones being that scientists are indispensable and increase our knowledge. The results are shown in Figure 3-8.

Figure 3-8: Why scientists are important



During the project the children increased their awareness of the roles of scientists in industry. They learned that scientists have a range of roles that include creating or designing products such as medicines, and discovering new ideas or methods that add to our existing knowledge. Some quotes are provided to illustrate the range of children's responses.

The following two children felt that scientists were indispensable:

"Because there are a lot of things we wouldn't have without them." (girl, year 6, water)

"Because if we didn't have scientists there would be no technology and things to make things like machinery." (girl, year 6, water)

The following two children thought that scientists increased our knowledge:

"Scientists find out interesting facts." (boy, year 6, plastic)

The following two children thought scientists were important because of safety:

"Because they look at ingredients to see if they are safe and stable." (boy, year 6, plastic)

"They are important because if germs got in the medicine, they work out how to take it out." (girl, year 5,water)

The following quotes are from two children who's responses were categorised under 'verification':

"To make sure that the right things are in everything." (girl, year6, plastic)

"So they can test different things for the product." (boy, year 6, plastic)

The following quotes are from children who's responses were categorised under 'research and development':

"They are important because they develop new ideas for the future." (boy, year 5, water)

"Because they invent really good stuff that we need." (girl, year 6, water)

"Because they research all of the medicines and design them." (boy, year 5, water)

3.5 Chapter summary: Children's views of science

- 69% of the children stated that they enjoyed science more as a result of their positive experience of the CCI project.
- The most common reason was because the project made science interesting and fun.

  "I didn't like science very much but now I love science - we did experiments."

- The most common opinions of the CCI project were; they had learned something new, it was fun and they had enjoyed the challenges. More than 90% of the children cited these three opinions of the project.
- The aspects of the project enjoyed the most were the practical experiments and the site visit.

  "I liked doing all the experiments that we have done because we learned how things worked."

- Using a scale to measure the children's positive attitude towards the project, 4 out of 5 children gave the project the highest possible score for positive feedback, an indication of how highly thought of the project was.
- Nearly all (98%) of the children felt that scientific testing was important and relevant for a number of reasons such as scientists add to our knowledge, they create new things and they are indispensable in our society.

  "Because if we didn't have scientists there would be no technology and things to make things, like machinery."

- Attitudes towards science and scientists were extremely positive by the end of the project as demonstrated by the positive feedback collected from the children.

4 Children's views of industry

This section explores the children's views of industry in three parts.

- Children's descriptions of industrial sites
- children's drawings of the inside and outside of industrial sites
- children's views of jobs in industry.

4.1 Industrial environment

As part of the questionnaire the children received at the end of the project, they were asked to draw the inside and outside of a place where things are made, an analysis of which is covered in the next section of this chapter. The question immediately after the drawings presented the children with eighteen words that describe industry and asked them to choose the six words that they thought most accurately described the place they had drawn. The words were:

safe	dirty	clean	smoke	
dark	small	computers	smells	men
cold	hot	light	dangerous	women
machines	large	people	noisy	

The proportion of children who circled each word is summarised in Figure 4-1 and Figure 4-2.

Figure 4-1: Children's descriptions of industry

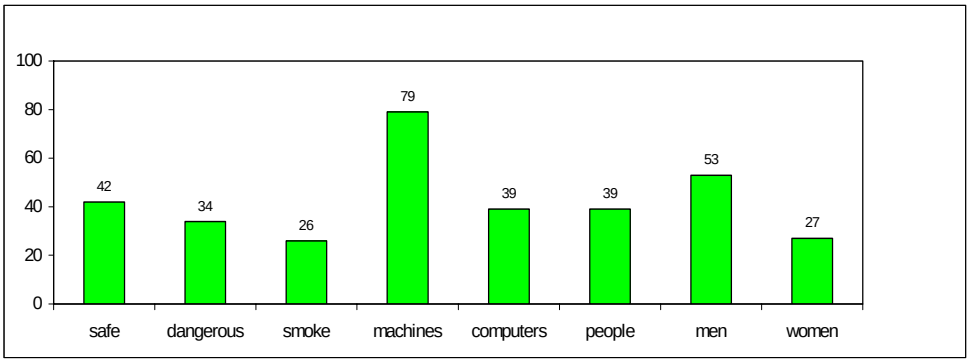
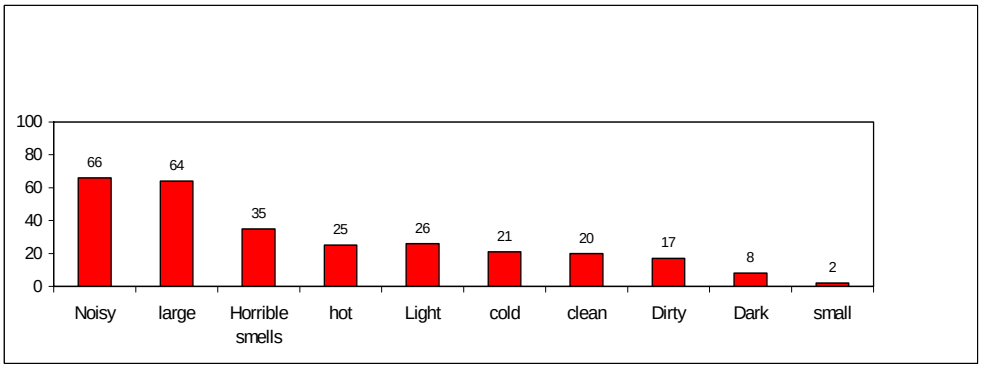


Figure 4-2: Children's descriptions of industry



Before the project, the predominant view held by the children was that the manufacturing industry was dangerous. Data collected from more than a thousand children between 2000 to 2003, before taking part in the project, were used as baseline data. Three quarters of these children thought that industry was dangerous and only a quarter thought that it was safe. However by the end of the project in this study twice as many children believed industry to be safe. The lessons and site visit increased the children's awareness of safety practices in the manufacturing industry and showed them first hand how important safety issues are in the work place.

Another aspect of the manufacturing industry that was explored was the relationship between the presence of machines, computers and people in an industrial work place. Previous data found that children overwhelmingly viewed industry as predominantly machinery worked by many people, with four out of five children mentioning that both people and machines were associated with industrial sites. The effect of the training was to reduce the number of children associating large numbers of people with industry, however machinery was still strongly related to an industrial site. Women were mentioned as being associated with industry only half as often as men, however this is a new question so impossible to compare with the previous data.

Many of the children viewed industrial sites as large and noisy places and this is very often true. However the number of children reporting that they thought industrial sites were hot, smelly, dirty and dark greatly reduced compared with previous data. In this study the number of children reporting that sites were hot was virtually the same as the number who thought sites were cold, whereas before, nearly twice as many thought that they were hot places as opposed to cold.

The views of many of the children are largely accurate by the end of the project. They were aware that many industrial sites were large and contained noisy machinery. However, there was a heightened awareness that much of the machinery was automated and involved fewer people, with computers also taking on an important role. In addition, the children were aware that many practices are in place to ensure everyone's safety on site.

Further exploratory analysis known as cluster analysis was performed in order to identify groups of children who gave particular combinations of answers. Initial analysis on children's data from all the regions involved in the CCI project suggested that the children fell into three groups and analysis on this region confirmed these findings. Roughly equal numbers of children were in each group. The first group were overwhelmingly positive about the industrial environment. These children were more likely to describe a site as safe, clean and light. The second group were characterised as having quite negative feelings about industry. These children were more likely to describe industrial sites as dangerous, dirty, noisy and smoky with machinery playing a significant role. The final group were quite neutral. The children in this group were more likely to circle both 'safe' and 'dangerous' or both 'hot' and 'cold'. The most consistent markers of all three groups were 'safe' and 'dangerous'. The three groups were identified as the group who think industry is safe, the group who think industry is dangerous and the group who think industry is a combination of both safe and dangerous.

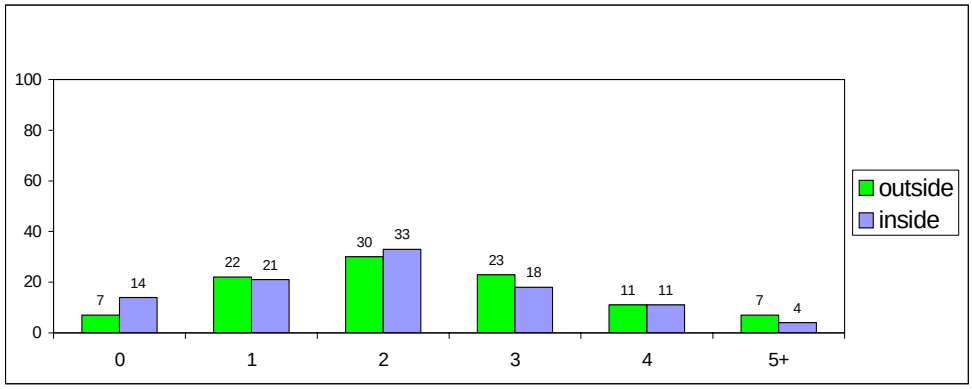
The first group of children appeared to have positively changed their views of industry. Although this group will also include the children who initially held positive views of industry, analysis of previous data found that the vast majority of children viewed industry as dangerous before embarking on the CCI project. The children in the third group had also made improvements in their views of industry having some positive and negative or neutral views of industrial sites. A minority of children were predominantly negative about industry and had not appeared to have changed their views of industry as a result of the project.

4.2 Drawings analysis

At the end of the project, the children were asked to draw pictures of their impressions of an industrial site (inside and out). The pictures were coded according to the criteria in Appendix 1 and given a score. A high score demonstrated good knowledge of an industrial site and a score of zero demonstrated no knowledge gained as a result of the project.

The range of scores obtained from the children of their external and internal pictures are shown in Figure 4-3.

Figure 4-3: Scores for external and internal drawings of industrial sites



By scoring the children's drawings, a measure of how much the children had learned about industrial sites during the project was obtained. The higher the score the more a child appeared to have learned about the appearance of modern industrial sites and the modern processes involved in industry. All the children except for three, obtained a score of more than zero for at least one of their drawings of an industrial site indicating that virtually all the children had learned about industry. The mean score was 2.3 for the external drawings and 2.0 for the internal drawings, significantly greater than zero for both groups. The children drew more detailed pictures than would have been expected if they had not had the CCI training.

In the next section, examples of drawings are provided to illustrate the differences between a high score of 4 or more, a medium score of 2 or 3 and a zero score. Drawings of the outside are displayed first, followed by drawings of the inside of industrial sites.

DRAWINGS OF THE EXTERNAL IMAGE OF INDUSTRY

The children were asked to draw what they thought the outside of an industrial site would look like. Pictures drawn at the start of the project in previous years typically depicted a 'historical' and old fashioned image of industry that included dark and sombre buildings with huge smoking chimneys and many small windows. Children rarely included a lot of detail in their drawing, such as pipes connecting different parts of the site. Many of the children who carried out the topic on salt drew pictures of the sea or buildings beside the sea as they thought that salt came from salt water. This was because very few children knew about 'solution mining' or salt quarrying before the project started.

The pictures drawn by children after the project tended to be more modern images of industry, and included more detail.

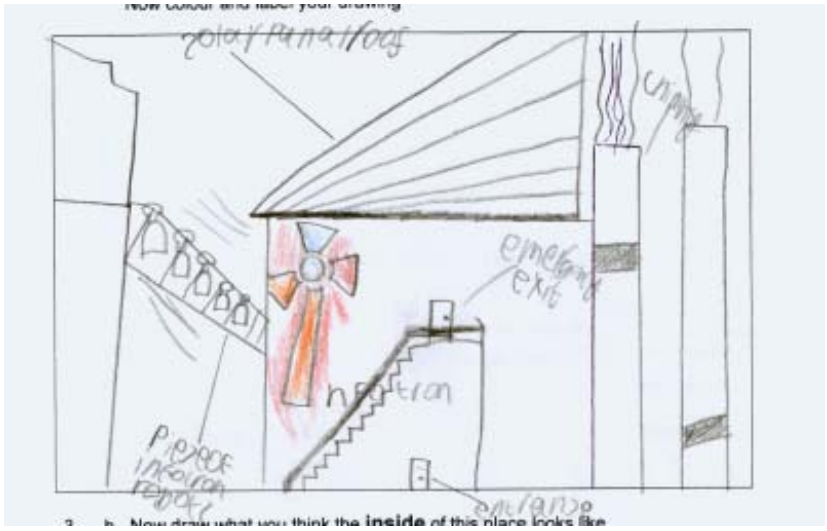
The following picture is an example of a high positive score obtained by a child who carried out the topic *Water for Industry*. In addition, this child had an industrial visit to Croda.

Figure 4-4: Child 1, external picture of industry after the CCI project

This child's drawing is very detailed. There are several areas included that depict storage containers and a loading bay. There is closed pipe-work originating from a tank on the left and liquid being disposed into a cubic storage container. There is also evidence of stairs and ladders and signs on the wall. One employee is included rather than a large number of workers. Furthermore, all the main elements of the drawing have been clearly labelled. In summary, this child has significantly added to her knowledge of modern industry as a result of the project.

The following picture is an example of a high positive score obtained by a child who was involved in the topic *Water for Industry*. This child had an industrial visit to Drax Power Station.

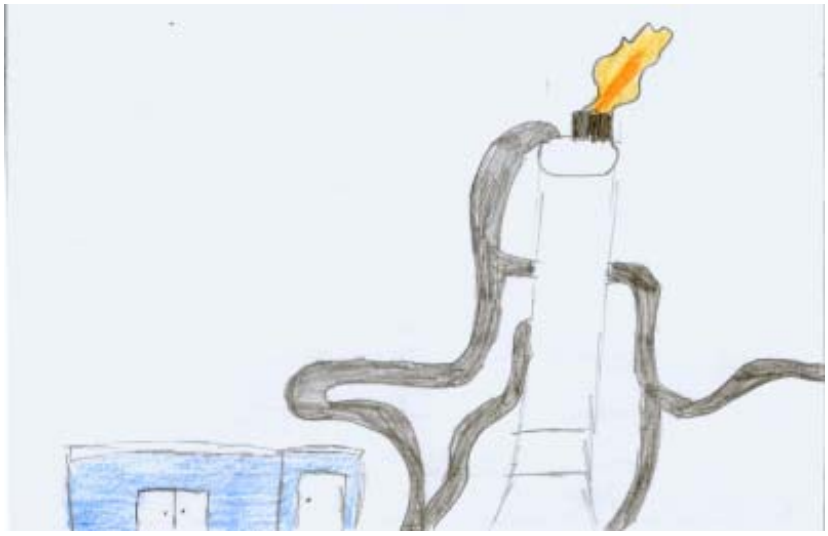
Figure 4-5: Child 2, external picture of industry after the CCI project



This child has drawn a modern building and included storage containers and enclosed pipe work, connecting different parts of the site. The drawing is far more detailed and various parts of the site have been labelled.

The following picture is an example of a medium positive score obtained by a child who completed *Plastics Playtime*. This child visited Lindsey Oil refinery.

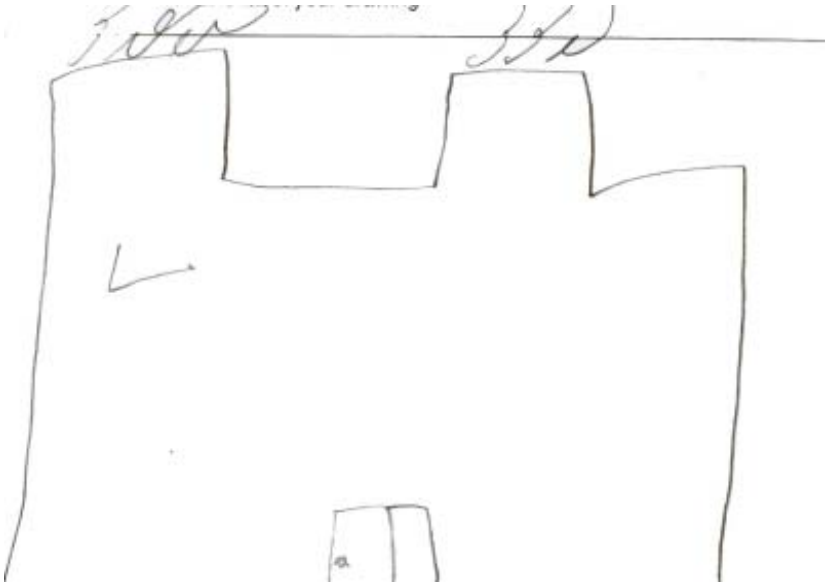
Figure 4-6: Child 3, external picture of industry after the CCI project



The drawing contains some modern elements of the manufacturing industry such as low level buildings and enclosed pipe work. However, the roaring chimney is the largest aspect of the picture whereas in actual fact this is not the case. The child has, none the less, improved their knowledge of the external image of industry as a result of the project.

The following picture is an example of a zero score obtained by a child who did the topic *Plastics Playtime*. This child did not have a site visit.

Figure 4-7: Child 4, external picture of industry after the CCI project



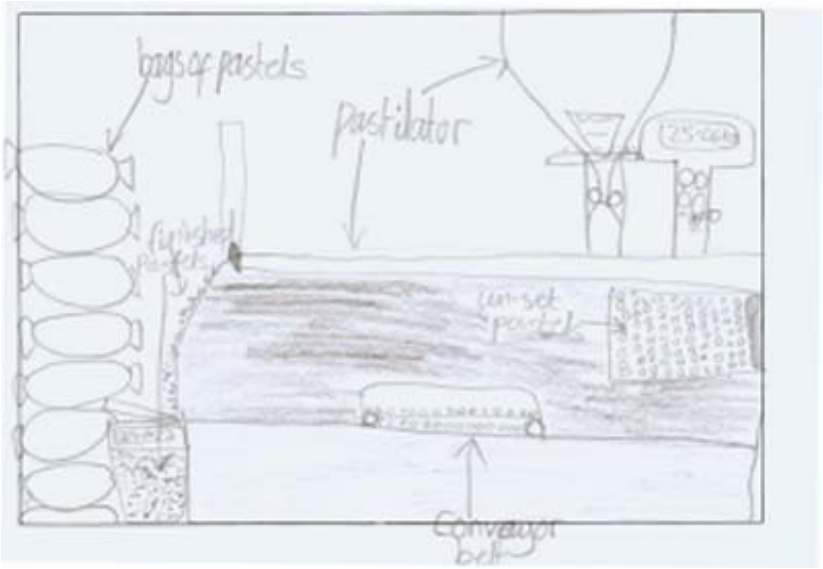
This child's views on industry are fundamentally the same as would be expected before the project. The child has drawn a simple building with a door and two smoking chimneys. The child may not have drawn a more detailed depiction of industry because the time was short and this was all the child could complete or perhaps they did not feel able to add any more detail. This child's drawing of the inside of the same place was similarly sparse.

DRAWINGS OF THE INTERNAL IMAGE OF INDUSTRY

The children were then asked to draw what they thought the inside of an industrial site would look like. Before the project, many of the children drew pictures depicting an 'old fashioned' view of industrial processes, with dangerous substances being poured into huge vats, and conveyer belts containing lines of people. The pictures drawn after the project tended to be images that were more modern which contained more pipes and closed vessels, as well as fewer people.

The following before and after pictures are an example of a high positive score obtained by child 1 who had an industrial visit to Croda.

Figure 4-8: Child 1, internal picture of industry after the CCI project



The picture portrays an accurate image with a range of machines and equipment including an enclosed conveyer with side viewing windows. They have drawn the process of 'unset pastels'. The waxy material is dropped as a liquid onto the conveyer and changed to a solid as it cools.

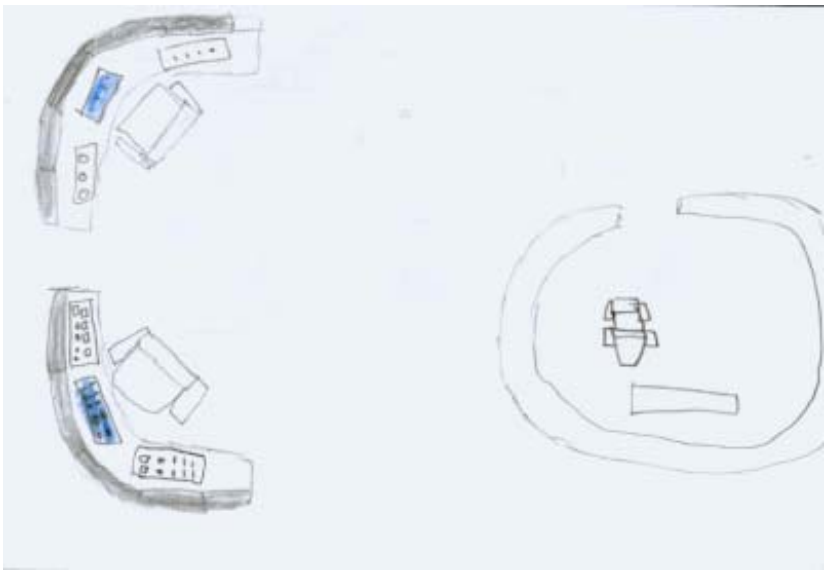
The following picture is an example of a high positive score obtained by child 2 who had an industrial visit to Drax Power Station.

Figure 4-9: Child 2, internal picture of industry after the CCI project

The child has depicted a more modern environment. There is a fork lift truck and a small number of employees included. Although there is a conveyer belt labelled it is fully automated and does not include a production line of workers.

The following picture is an example of a medium positive score obtained by child 3 who had an industrial visit to Lindsey oil refinery.

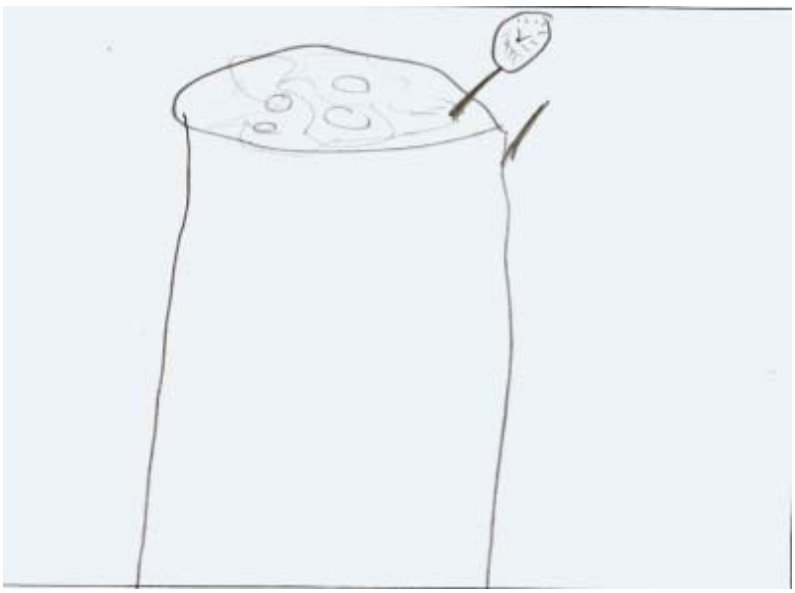
Figure 4-10: Child 3, internal picture of industry after the CCI project



This child has drawn a modern image of the internal aspect of an industrial work place. She has included 2 work-stations that include modern automated equipment and computers which is the control room. The space is accurate as the room is huge compared to the work stations.

The following picture is from child 4 who obtained a zero score.

Figure 4-11: Child 4, internal picture of industry after the CCI project



This child's views of industry are fundamentally the same as would be expected before the project. What looks like an open vessel has been depicted. There were only a minority of children who drew pictures as simplistic as this one.

After the project, the children were more likely to draw detailed external and internal images of industry. This indicated that they were more aware of the appearance and processes involved in industry after the project. Parvin concluded that the best way to improve children's knowledge of industry is via classroom activities followed by a well-planned visit to an appropriate company and these results confirm this view.

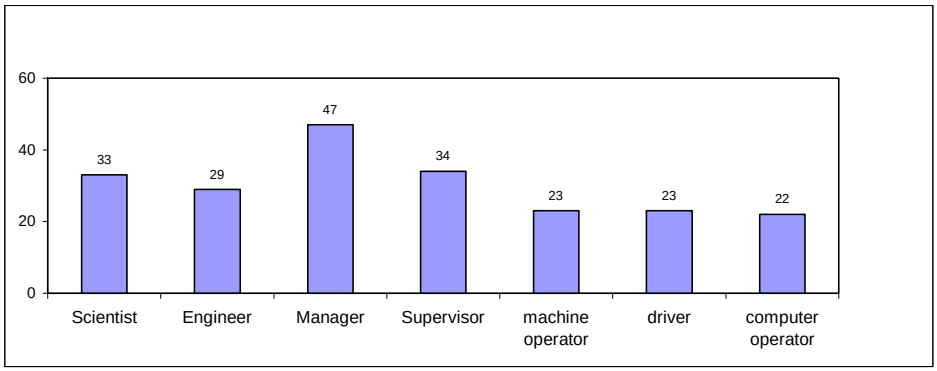
4.3 Industrial careers

This section deals with children's perceptions of jobs occurring in the industrial workplace. It is divided into two sections:

- Industrial jobs that children were aware of as a result of the project
- the industrial job children would choose as a result of the project.

The children were asked to draw a picture of a person who works on an industrial site and list other jobs that they thought existed in industry. The seven jobs most frequently mentioned are shown in Figure 4-12.

Figure 4-12: Industrial jobs that children were aware of in industry



Other jobs mentioned less often included materials handler, packer, office worker, tour guide, security guard, cook and safety officer.

Our baseline data show that before the project many of the jobs of people drawn or listed were categorised as 'materials handler', where children quoted jobs relating to processes such as mixing, heating and moulding. They were less able to suggest specific jobs and usually described their drawing by describing what the person was doing rather than giving a job title. The number of children drawing or listing a materials handler or machine operator has decreased dramatically.

Before the project took place, the children were very unlikely to say that they had drawn a scientist or an engineer, as shown by the baseline data. In her original study (Parvin, 1999), Parvin found that children do not associate scientists with industry and are more likely to associate them with a research environment. They are unsure of scientists' and engineers' roles in industry and therefore feel more comfortable with jobs involving products, machines (including computers) or offices.

The situation after the project has dramatically improved. The proportion of children drawing or listing scientist or engineer was 33% and 29% respectively by the end of the project. Nearly half of the children (44%) mentioned either scientist or engineer and nearly 20% mentioned both scientist and engineer. These positive results provide strong evidence that the children's awareness of the importance of scientists and engineers, and their roles on industrial sites, significantly increases as a result of the CCI project.

The only job listed more frequently than scientist was manager. The children were more specific about job titles and manager was often expanded to give personnel

manager, control manager or warehouse manager, which rarely happened before the project. This is likely to be due to the role-play included in classroom sessions, as well as the site visit.

4.4 Jobs in industry chosen by children

The increased awareness of scientists and engineers working in industry is the first step to improving the children's attitudes towards science and industry careers. To take this one step further the children were asked which job they would like to do in industry, to identify what proportion of children would choose scientist or engineer. The children were also asked for the reason why they chose that job. The most common jobs chosen are shown in Table 4-1 together with the results from the baseline data of children surveyed between 2000 to 2003.

Table 4-1: Industrial jobs chosen by children

Which job would you choose	Percent before CCI	Percent after CCI
Scientist	4	11
Engineer	3	6
Materials handler	27	5
Manager	13	15
Supervisor	4	8
Computer	1	12

Before the project, by far the most popular job chosen by children was 'materials handler'. By the end of the project the profile of chosen jobs looked very different. The jobs that children were most likely to choose after the CCI project were manager, computer operator and scientist. These are all careers which for the most part need further education involving scientific or technical expertise. The proportion of children saying they would like to be a scientist increased nearly three fold while the proportion of children saying they would like to be an engineer doubled.

These results are similar to those seen by Parvin (1999). She too found a dramatic decrease in the number who chose 'materials handler' and a rise in the number of children who chose 'scientist' after the project.

The results are extremely positive. The classroom sessions were designed specifically to link the science carried out in the classroom with that done by professional scientists on site. The classroom sessions and the site visits clearly increased the children's knowledge of the role of scientists in industry.

The reasons why scientist and engineer were their chosen jobs were investigated in more detail. When the children were asked why they had chosen 'scientist' or 'engineer' as their preferred job in industry, their response was usually that being a scientist or engineer would be fun or interesting, or that they would enjoy it.

Quotes from some of the 14 children who said they would choose to be a scientist are provided below;

"Scientist, It would be fun to experiment with different chemicals and make new concoctions." (girl, year 5, visit to Novartis).

"Scientist, because I like science and I think I'm good at it." (boy, year 6, visit to Linpac).

"Scientist, because I would like to help make medicines in Novartis and work in a laboratory." (girl, year 5, visit to Novartis)

"Scientist, because I would like to use chemicals." (girl, year 6, visit to Ciba).

Quotes from some of the 8 children who said they would choose to be an engineer are provided below:

"Engineer, because it's fun." (boy, year 5, visit to Novartis).

"Engineer, because I think it would be interesting and fun." (girl, year 5, visit to Novartis).

The children were far more likely to say that a scientist or an engineer was their chosen job if they were aware that these jobs existed in industry. If the children had listed scientist as a job carried out in industry they were 9 times more likely to say they would choose to be a scientist (26% compared with 3%). The same results were seen with engineers. If children had listed engineer as a job carried out in industry then 18% said they would choose to be an engineer, compared with 1% if they had not listed engineer as an industrial job.

These results are similar to those seen in previous data from 2000-2003, both from pre-project and post-project data. When questioned, approximately 1 in 3 children who know that scientists work in industry will say that given the choice they would work as a scientist in industry. In addition, approximately 1 in 5 children who know that engineers work in industry will say that given the choice they would work as an engineer in industry. The higher the proportion of children who know that scientists and engineers work in industry, the higher the number of children who will say that they would choose to be a scientist or an engineer. Children who are not aware that scientists or engineers work in industry do not explicitly say that they would be a scientist or engineer but have a small chance of describing a job that scientists or engineers do in industry without knowing the job title.

If all children of primary school age knew that scientists and engineers worked in industry rather than only 1 in 20 children as seen in previous studies before CCI, the number of children considering a career as a scientist or engineer may well increase.

4.5 Chapter summary: Children's views of industry

- By the end of the project nearly half of the children thought that industry was safe and only a third thought it was dangerous.
- Many of the children had more positive views of industry as a result of the project.
- The CCI project reduced the number of children associating industrial sites as places where many people work, for example on production lines and places that were hot, smelly, dirty and dark.
- The children demonstrated from their detailed drawings of the exterior and interior of industrial sites that they had learned about aspects of modern industry.
- The project raised the children's awareness of the variety of jobs held in industry.
- The children learned about the importance of scientists and engineers and their roles on industrial sites.
- By the end of the CCI project the proportion of children who were aware that scientists and engineers worked in industry increased to 44%.
- Nearly half of all the children who mentioned that scientists or engineers worked in industry then went on to say that they would choose to be a scientist or engineer if they worked in industry themselves.

“I would like to be a scientist, It would be fun to experiment with different chemicals and make new concoctions.”

- If all children of primary school age knew that scientists and engineers worked in industry rather than only 1 in 20 children as seen in previous studies where the CCI project has not taken place, the number of children considering a career as a scientist or engineer may well increase.

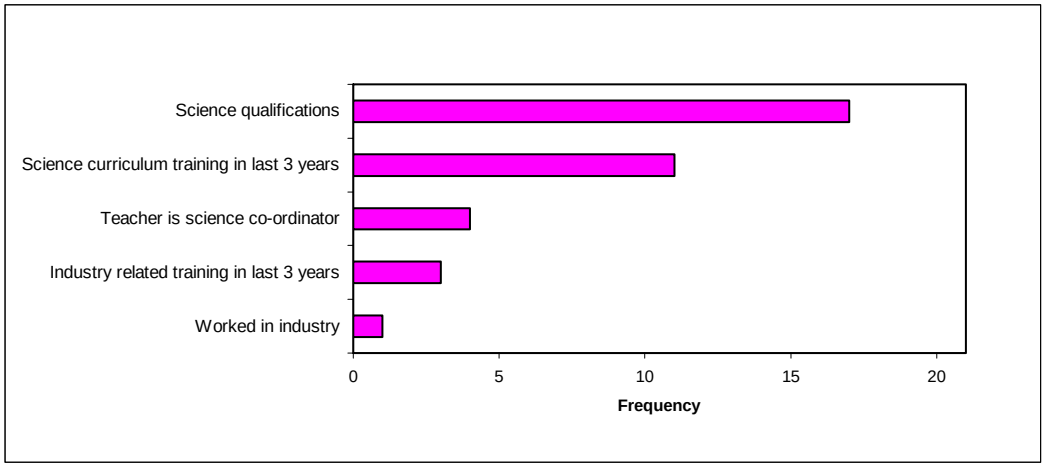
5 Evidence to support the provision of training

This section discusses the reasons why this type of training is needed by teachers.

5.1 Training and qualifications

The 21 teachers surveyed were asked about their science qualifications and training they had undergone in the past three years. The graph below summarises the results.

Figure 5-1: Training and qualifications



Qualifications

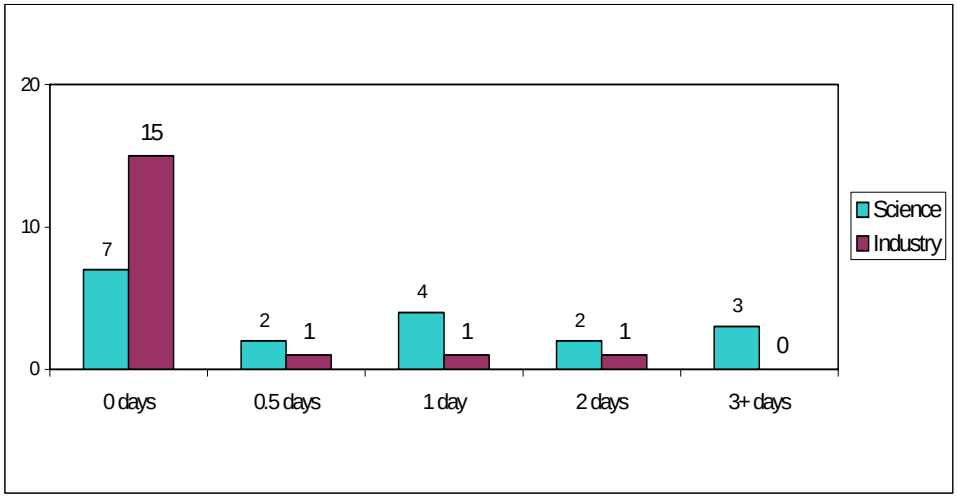
All but one of the 18 teachers who responded to the question on qualifications had at least a GCSE in science. This is good news and quite different to previous studies, as a science GCSE is viewed as the minimum requirement to teach primary science. This survey did not distinguish between the different branches of science, i.e. biology, chemistry and physics. However this has been changed on the questionnaire for the future to provide more detail about teachers' science qualifications. Previous research from Parvin has shown that biology, as a subject, is far more popular than chemistry or physics. Half the teachers said that they had more than a GCSE in science. They either said they had a science A level (3 teachers), a science degree (3 teachers) or another qualification such as a diploma (3 teachers). It appears that science qualifications have improved over the last 10 years with more teachers obtaining at least a science GCSE and many achieving more than this.

In addition to science qualifications, the teachers were asked if they had worked in industry to ascertain whether they had any industrial experience. Only one out of eighteen teachers stated that they had worked in industry. Very few teachers have the experience to teach science with industrial context without additional training.

Training

The teachers were asked how many days of science and industrial training they had undergone in the last 3 years. The results are shown in Figure 5-2.

Figure 5-2: Number of days of science & industry training



Approximately two thirds of the teachers had undergone some science training in the last three years. This was significantly more than in previous studies where nearly half of the teachers had not had any science training. Industry training is even less common than science training. Only three teachers had any experience of industrial training.

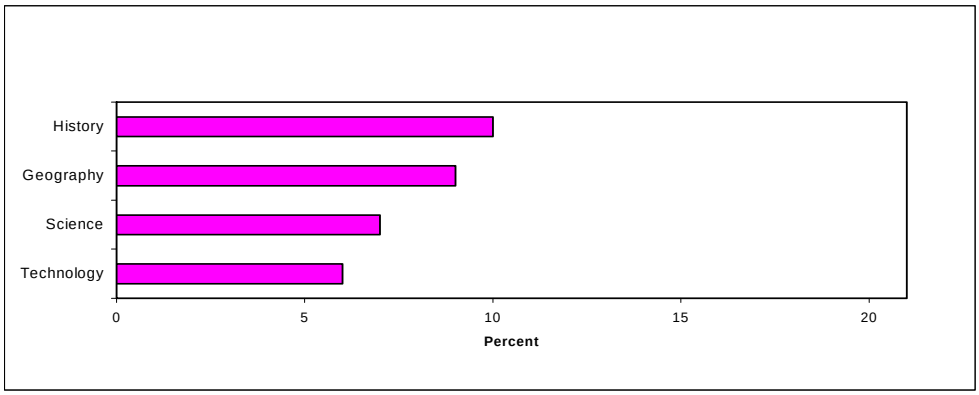
All teachers have five training days per year where they must cover all aspects of the primary curriculum. It may seem surprising that many schools are still not using any of these days to cover science. However, Numeracy, Literacy and ICT have taken a high priority in primary education since the mid-1990s which may explain why training is more likely to be in these curriculum areas.

Science co-ordinators may be more likely to have science training experience but the sample size was too small here to verify this. Only 4 teachers stated they were a science co-ordinator and the number of years they had been a co-ordinator were 1, 2, 9 and 14 years. They were slightly more likely to have more than 1 or 2 days of science training.

5.2 Teaching of industry within the curriculum

Teachers were asked where they taught about industry in the primary curriculum.

Figure 5-3: Subjects covering industry in the curriculum



Slightly less than half of the teachers (7 out of 16) covered industry in the science curriculum. Although this is an increase on the 12% obtained from the original study it is similar to the previous baseline data collected where half of teachers covered industry in the science curriculum. Topics given were varied, although two teachers gave no details about the topic. Two teachers mentioned that they

covered industry under the 'materials' topic, one mentioned electricity, one said that they covered industry under various topics.

The most common place to cover industry was in History, and the Victorian era was the most commonly cited historical topic. This gives a view of industry as it was a hundred years ago if not balanced with more modern views, taught in science and technology as in the last study.

Many teachers covered industry in Geography which is a wide-ranging subject with many topics. Five of the teachers listed settlements as the topic where they covered industry and three mentioned 'water' or the environment. Pollution is most likely to be covered as part of the Geography curriculum although it was not mentioned explicitly by any of the teachers in this study.

One of the main aims of this training was to encourage teachers to teach about industry in the science curriculum. This would enable children to learn about industry as it is today and to learn about its relevance to the science curriculum taught in schools now.

5.3 Industrial links

Teachers were asked about their links with industry including whether they had a school policy on industrial links.

Industrial links

A minority of the teachers replied that they had industrial links. Only one teacher thought their school had a relevant policy. Schools have the option of being involved with a number of organisations such as Education Business Partnership (EBP) and Setnet that promote links with industry. Of the links available, links with EBP were the most common, with four teachers stating they had links of this type. Three teachers described links with local companies, two of which could be categorised as manufacturing industries. They were BP, Linpac and Tesco. Two teachers said they had links with Setpoint.

One of the aims of the training was to encourage teachers to forge links with manufacturing companies and learn about the benefits to the school of having these useful links. How effective the training is in achieving these goals is explored later on in the report.

Use of resources

The teachers were asked whether they had used any resources from industrial sources. Only a small proportion of teachers had previously used these types of learning materials. One teacher had used the British Soft Drinks materials – 'Liquids mean life' together with materials from Soda Stream – 'Bubbles'. Another teacher had used information from Rockware Glass factory and Drax Power station. One teacher wrote that they had used posters but did not go into any further details. The fourth and final teacher said that they had used the CCI materials and therefore was involved in the project for the second time. The remaining 14 teachers who answered the question replied that they had not used any of this type of learning materials. This result is very similar to that found in previous studies where three quarters of teachers had not used industrial resources sponsored by or developed by the chemical and allied industries.

The most likely reasons for using industrial resources were that they were good educational quality or they were inexpensive or free. A number of teachers also said that they were at an appropriate level of for the children or they provided good

ideas. Two teachers said that they chose them because they fitted the national curriculum.

The teachers were asked why they had not used them and the most common reason given was that they did not know about them. None of the teachers who had not used industrial resources said it was because of company propaganda.

Teachers seemed to be more likely to know about resources if they had any industrial links. If they had no links, only 21% of teachers used resources, compared with 40% if they had any of the links mentioned. This was not statistically significant as the numbers are too small but provides interesting information.

5.4 Chapter summary: Evidence to support the provision of training.

- Many teachers appeared not to be aware of the importance of teaching the science curriculum with an industrial context which has the potential to make the subject more interesting and relevant.
- Teachers were more likely to teach about industry in the context of history or geography than science or technology.
- Many teachers may not have the required skills to teach science with industrial context as industrial training and experience of working in industry was rare.
- In addition, a third of all teachers had not had any recent science training.
- Few of the teachers had links with industry and three-quarters of all the teachers had not used any resources developed by industry.
- This training was very much needed by primary teachers to increase their confidence, knowledge and motivation of teaching science using industrial contexts.

6 Teachers' reaction to the CCI project

This section examines the teachers' reaction to the CCI project

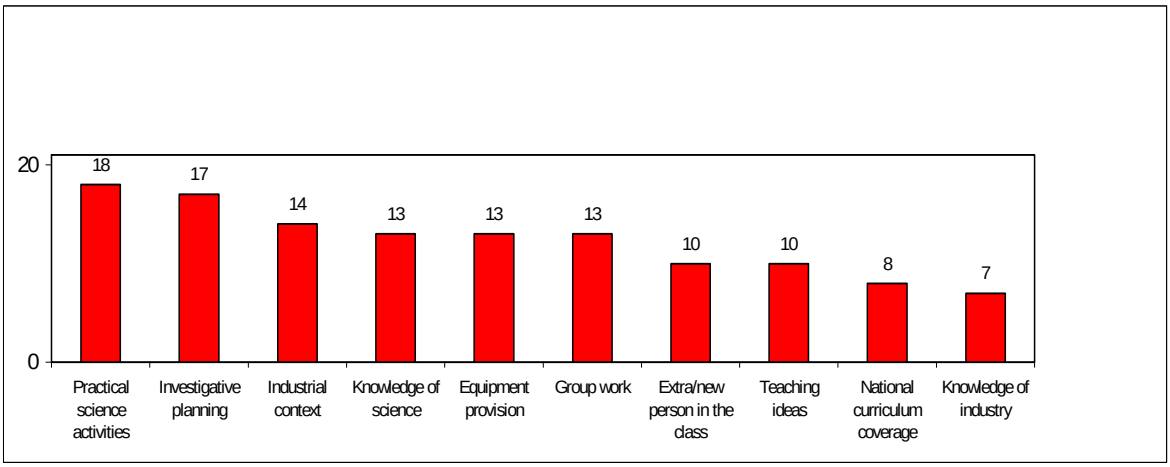
6.1 Strengths

The teachers were asked to evaluate the CCI training. All the teachers rated the CCI project as very good (8 teachers) or good (6 teachers). Furthermore, all the teachers felt their expectations of the project had been met. One teacher summed it up perfectly.

*"Well organised, well resourced, very relevant to national curriculum and **very** enjoyable."*

Further information was collected from teachers on their views of the classroom activities and the industrial visit. Additional evidence that the CCI project was highly rated was obtained when teachers were asked to indicate which of ten possible categories were strengths of the classroom sessions. The results are shown in Figure 6-1.

Figure 6-1: Strengths of the CCI project



Virtually all the teachers indicated that the 'practical science activities' and the 'investigative planning' were strengths of the sessions, followed by 'industrial context'. These are wonderful results as the main aims of the project were to improve the teachers confidence and abilities in these three areas

The categories least likely to be indicated as strengths of the project, were knowledge of industry and national curriculum coverage. Despite the fact that investigate planning is right at the heart of the primary science curriculum many teachers continue to view it as a useful optional extra to their science lessons. Perhaps the advisory teachers need to place even more emphasis on the relationship between the CCI training and the primary science curriculum as laid out by the QCA.

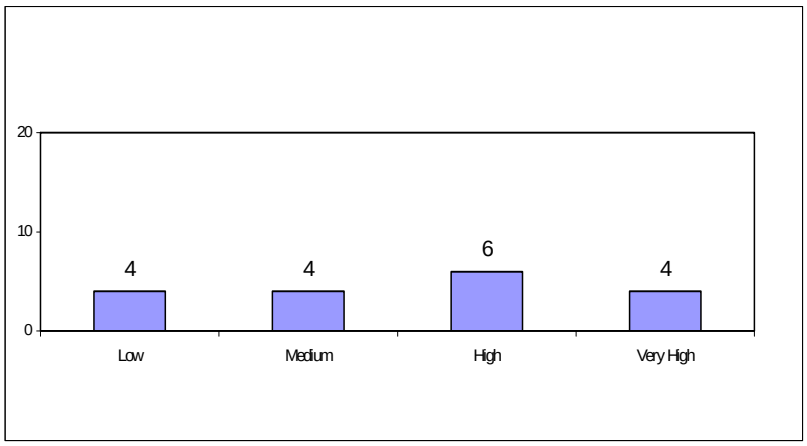
The teachers slightly contradicted themselves by not selecting 'knowledge of industry' as a strength. Later on in the questionnaire they were asked whether they thought the classroom sessions offered an effective link with industry and all the teachers agreed that they had been an effective link. Knowledge of industry was rated as a strength less often than knowledge of science maybe because many saw the visit as the industry side of the training, and the classroom activities as the science side of the training. Yet 'industry context' is very high in the classroom and

the advisory teacher's knowledge of industry has an impact on the success and use of industry context.

These results are similar to those gathered previously. The two main strengths in the previous study were that CCI training provided information on practical science activities as well as the provision of science equipment.

It is possible to develop a scale to measure the teachers reaction to the CCI project using the items that are related if they produce a high enough Cronbach alpha. Using all ten items the Cronbach alpha=0.7 which is acceptable. The mean number of strengths selected by teachers was 7 out of 10. The teachers' were categorised into four groups based on their rating of the CCI project. The group labelled 'Very High' was comprised of teachers who ticked 9 or 10 items on the scale. The group labelled 'High' ticked 7 or 8 items, the group labelled 'Medium' ticked 5 or 6 items and the group labelled 'Low' ticked 3 or 4 items. None of the teachers ticked fewer than 3 items. Figure 6-2 displays the results.

Figure 6-2: Teachers' rating of the CCI project



More than half of the teachers gave the CCI project a high or very high positive rating. This is a strong indication of how highly the training was regarded by teachers. They were extremely enthusiastic about the project and clearly felt it had been a valuable use of their time.

Quotes are included below as examples of how the teachers felt about the sessions:

"A great project. Pupils really enjoyed the science experience."

"Can we have more of it please!"

"Industry visit very useful as it brought together on a large scale the things the children had been learning about in the classroom."

"The children really enjoyed this hands-on approach."

One school had disseminated information about the project to an amazingly large audience.

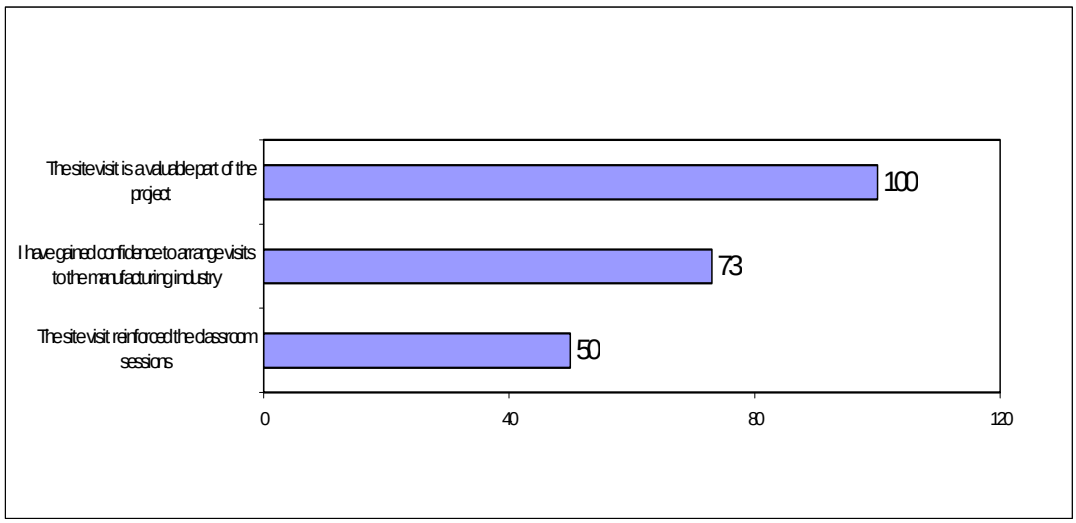
"(We had) an open evening where parents, governors and staff from other schools were invited to hear more about 'Children Challenging Industry', see photographs and samples of work and observe children carrying out some of the investigations."

The teachers were also asked three questions regarding the importance of site visits.

1. The site visit reinforced the classroom sessions
2. I have gained confidence to arrange visits to the manufacturing industry
3. The site visit is a valuable part of the project

Some of the teachers did not answer all the questions and the results are therefore displayed as percentages in Figure 6-3.

Figure 6-3: Teachers' views of the CCI project

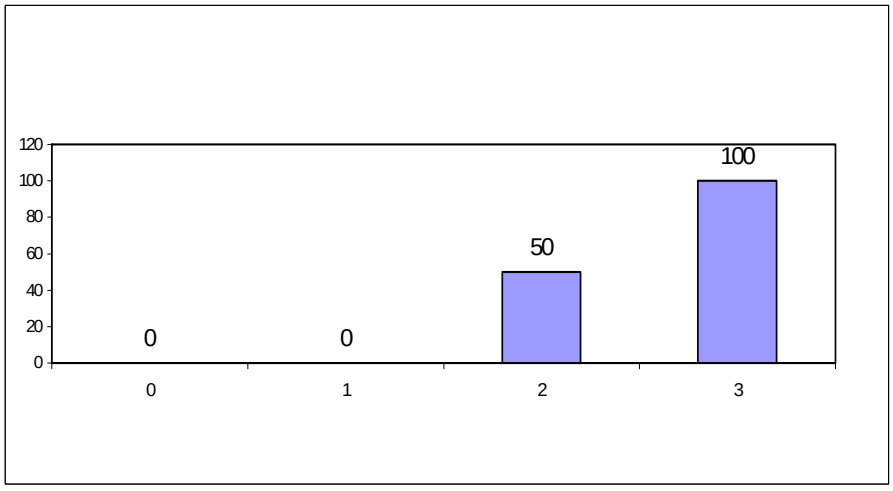


All of the teachers thought the site visit was a valuable part of the project. Many of the teachers also thought that the project gave them more confidence to arrange visits.

A scale was developed to measure the strength of the teachers attitudes towards the site visit. All three of the above questions were strongly related and produced a Cronbach alpha=0.76. Teachers who answered yes to all three questions obtained a score of 3 whereas teachers who answered no to all three questions obtained a score of 0.

Teachers who were more positive towards the site visit may be expected to be more likely to arrange a visit the next year and there was evidence that this was indeed the case. Teachers with a maximum score of 3 were more likely to say they intended to visit industry in the future. All the teachers who said yes to all three questions and obtained a score of 3 said they intended to visit industry compared with only half of the teachers who answered yes to 2 out of the 3 questions See Figure 6-4 for the results presented as percentages.

Figure 6-4: Teachers' intentions of visiting industry in the future



The higher the score for attitude towards the site visit the higher the proportion of teachers who said they intended to visit industry again. None of the teachers who

had a score of 0 or 1 said they would re-visit industry. This is further evidence that if teachers are to repeat the CCI project with a site visit it is extremely important that the site visit is a positive and relevant experience which supports the material covered in the classroom sessions.

6.2 Weaknesses

The teachers were asked whether they thought there were any weaknesses to the sessions. Very few of the teachers highlighted any weaknesses. One teacher said there was too much to cover and one said there were difficult concepts involved. A further two teachers said there were some issues with the timing. When asked whether there were any improvements that could be made to the CCI project three teachers provided information which is provided here.

"Increasing the number of classroom sessions with more practical science activities would be nice! The children really enjoyed this hands on approach."

"Noise made understanding explanations difficult in factory."

"p.m. sessions were not as effective as the am sessions – children's responses were not as good."

6.3 Chapter summary: Teachers' reaction to the CCI project.

- The feedback from the training was overwhelmingly positive. A quote from a teacher is provided below.

  *"Well organised, well resourced, very relevant to national curriculum and **very** enjoyable."*

- The sessions were of an extremely high standard that was highly rated by teachers.
- Aspects of the sessions most often cited as strengths were the practical science activities and the investigative planning.

  "The children really enjoyed this hands-on approach."

- The site visit was highly rated by many of the teachers.

  "Industry visit was very useful as it brought together on a large scale the things the children had been learning about in the classroom."

- All the teachers who highly rated the site visit said they would arrange a visit to industry in the future.
- Very few teachers highlighted any weaknesses of the project

7 Knowledge and attitudes of teachers

one of the main goals of the training was to increase the teachers' knowledge of industry, and how it relates to primary school science. The aim was to achieve this via class-based training, together with a visit to industry to give them an opportunity to experience the chemical industry first hand.

7.1 Knowledge of industry and science

Industrial knowledge

Teachers were asked whether they had learned anything about industry, and what they had learned. 87% (13 out of 15) of teachers who answered the question stated that they learned something new about industry during the project. The most common response was that they had increased their knowledge of the processes of industry as a result of the visit to industry. The quotes below provide examples of how teachers felt their knowledge of industry had been improved in this way:

"The immensity of production and functions/values of a particular product."

"The spacious and airy (even if noisy) working conditions were a revelation."

"(I had) no real understanding of a computer based factory. (I was) astounded that only 48 people work on whole 6 acre site."

"How the power industry uses water in many different ways."

"What the inside of a modern factory looks like. Made me much more aware of everyday links with school science."

"CRODA is on our doorstep but the children know very little about its activities, although it's a major local employer. Children became more aware of the variety of jobs available in the chemical industry."

Some teachers mentioned classroom activities that had improved their knowledge of industry:

"Everything about expanded polystyrene."

"The video and advisory teacher's comments gave me a better insight into how salt was extracted."

It was not possible in this study to quantify how much the teachers learned about industry. They may have learned one part of an industrial process or completely changed their knowledge of industry through an increased awareness of the whole process. In future more detailed questions are to be included in the questionnaire that attempt to grade the teachers' knowledge.

Knowledge of teaching science

Teachers were also asked what they had learned about teaching science. 88% (14 out of 16) of teachers stated that they learned something new about teaching science. Many of the teachers said that they learned new teaching ideas. Some teachers said it helped them with the science curriculum. Quotes are included below to illustrate these points.

"I learned a lot. As a teacher who is new to year 6 since the NC began, the ideas and organisation of AT1 Science was an invaluable help."

"Experiment ideas."

"To give real-life context to science modules."

"Using vocabulary – setting up a fair test. Putting the concept over to children in a simple way for them to understand."

"Liked the management of tasks (different jobs for each group member). Ideas for AT1 that work."

"…because I have a year 3-6 class I tend to give groups different investigations. In future I will give them all the same investigation as this obviously worked very well."

"Interesting ways of allocating jobs within the group – organisation."

"The organisation of a large class for AT1 science made me think about the everyday relevance of the science we teach."

"Importance of open ended questions."

"Putting the science into an industrial context made the practical activities more relevant to the children. They understand the reason for learning science in school! All staff were grateful for the practical investigations sheets that were made available."

In future, the wording of the question is to be changed in order to help measure the extent to which they have learned about teaching science. Only one teacher said that they had not learned about industry or teaching science.

7.2 Attitudes towards links with industry

At the start of the project only four teachers said that they had recently used resources developed by industry. The teachers had positive reasons for using these resources such as they were of good educational quality and good sources of ideas. Many teachers had not used resources developed by industry because they had not seen any, rather than because they were against using this type of educational material.

Before the project only four teachers had links with industry such as EBP. Previous studies have shown that prior to being involved in the CCI project very few teachers are able to suggest specific links with industry that they would like to experience. Half of teachers left the answer blank and many of the remainder said they would welcome ideas but were unable to provide specific details, although site visits were mentioned by about 15% of teachers.

The teachers attitudes towards industrial resources and links could therefore be summarised as broadly neutral at the beginning of the project.

After the training sessions and visit to industry, teachers were asked about their views on using the CCI resources and visiting industry in the future. The response of teachers after they had experienced the training sessions was extremely positive. All the teachers stated that they would like to use the written materials again and 70% said they would be interested in visiting industry again in the future. The teachers were much more aware of the benefits of teaching science with industrial context. They realised how much children appreciated learning about science with real world context, and planned on permanently changing their science teaching methods.

More than two thirds of teachers also intended on visiting industry but when teachers involved in Parvin's original study were revisited very few of the teachers had visited industry again although they had said they were keen to do this. This was because they felt they did not have the time to organise it. It is a hard problem to overcome as it is rare for companies to make the first move to invite schools to visit, which is the one thing that would make the job easier for teachers. CCI advisory teachers or another organisation need to keep acting as brokers in this process. Teachers only make time to forge these kinds of links with industry if they are very motivated to do so, such as if there is a very strong link with the national curriculum.

7.3 Chapter summary: Knowledge and attitude of teachers.

- Virtually all the teachers said they had learned something about industry as a result of the CCI project.
- The most common response was that they had increased their knowledge of the processes of industry as a result of the visit to industry. See an example of a quote below.

  "The immensity of production and functions/values of a particular product."
- Virtually all of the teachers said they had learned something about teaching science as a result of the project.
- Many of the teachers said that they learned new teaching ideas. See the example of a quote below.

  "The organisation of a large class for AT1 science made me think about the everyday relevance of the science we teach."
- Before they had any CCI training, many teachers had not received any information about the chemical industry either through resources developed by industry or through links with the chemical industry. The majority stated they had never seen such resources.
- The small group of teachers who had used resources produced by industry were most likely to say that they did so because they were of good educational quality and reasonably priced.
- The change in attitudes towards industrial resources that occurred during the training was significant.
- All the teachers intended to reuse the Children Challenging Industry materials.
- 70% of the teachers intended to visit an industrial site again in the future.
- The training had changed the attitudes of teachers. At the beginning, the teachers were mostly neutral about involving industry to teach primary science. By the end of the training, the majority of teachers were extremely receptive in involving the manufacturing industry to teach primary science.

8 Conclusions

8.1 Summary of conclusions

The CCI project involved approximately 850 children attending 29 schools from primary years 5 and 6. The advisory teacher was able to offer a variety of topics to the teachers and children, to suit their needs and interests. The topic *Water for Industry* was the most popular choice of topic, and there was a wide choice of industrial sites for the children to visit in this region.

The CCI project clearly achieved its main goals. The children and teachers were more knowledgeable about industry and the role of scientists after the project. Children were able to depict industrial sites and industrial processes more accurately. Teachers felt they had learned about teaching science and were more likely to use the CCI materials and visit industry in the future. Teachers and children's perceptions of industry, including safety, improved. More children were aware of the roles of scientists and engineers, and aspired to working in these professions in the future. Teachers and children had become much more aware of the link between science in the classroom and industrial processes, and had enjoyed the project immensely.

8.2 Children's data

The project increased the children's enjoyment and attainment of science by demonstrating how science can be taught successfully using industrial context. Children who enjoy science and are good at science are more likely to pursue science subjects at GCSE and A level. Levels of uptake of Chemistry and Physics are particularly low, and decreasing, which are the areas of science that primary teachers are often least knowledgeable about. The children's enjoyment of science was extremely high with two thirds of children saying they enjoyed science more as a result of the project. The feedback from the children indicated how effective they found the practical work and investigations, when learning primary science.

Many children choose their career before they start secondary school and therefore it is important to increase primary children's awareness of the manufacturing industry, a major employer of scientists and engineers in this country. This project dramatically raised the children's awareness of modern industry, and present day scientists employed there. After participation in the CCI project, many of the children were able to depict detailed drawings, demonstrating their acquired knowledge of industry. Furthermore, far more children perceived industrial sites as safe, and with fewer employees, a more accurate reflection of modern industry. The children were more aware of the need for scientists and scientific testing and, when given the choice, many children expressed a desire to be a scientist or an engineer.

The combination of increased enjoyment of science and improved attitude towards science and the manufacturing industry, provided by this training, is a potent one. Research has indicated that a perception of the importance of science does not necessarily translate into a positive attitude towards science (Jarvis & Pell, 2002). It is important, therefore, that teaching science with context does not solely include teaching about the importance of science in society, but also teaches children to enjoy science at a more involved level as the CCI project does very successfully.

The classroom and site visits clearly provided the ideal environments to experience, first hand, investigative planning and learning about the important roles of scientists and engineers in modern industry.

8.3 Teachers' data

Evidence presented here identified why this type of training is crucial for teachers of primary science. Many of the teachers had not had recent science training and training related to industry was even less common. It was also found that teachers were more likely to teach about industry as part of the history or geography curriculum, than the science curriculum. Previous research has emphasised that primary teachers are more confident in teaching English than Science and Technology. Furthermore in terms of the science curriculum, teachers are often more confident when working with 'life processes', and less confident when conducting 'guided discovery' investigations.

Before they had CCI training, many teachers had not received any industry related information, either through resources developed by the manufacturing industry or through industrial links. The reason they gave for this was they had not seen any. It was clear that many teachers were not aware of the relevance of teaching science with industrial context to make the subject interesting and relevant.

The reaction to the training was extremely positive. Many of the teachers had nothing but praise for the training received, and rated it highly. Virtually all the teachers said they had learned about teaching science and about the manufacturing industry.

A significant change in attitudes towards teaching science with industrial context occurred as a result of the training. All the teachers intended to re-use the CCI materials with future classes. Three quarters of teachers intended to visit industry again. By the end of the project, the majority of teachers were positive towards using the manufacturing industry as a tool for teaching primary science with industrial context.

The classroom and site visits clearly provided the ideal environments to experience, first hand, how to teach primary science through investigative planning and practical work with industrial context.

9 Appendix 1: Points system for analysing drawings

One point is accrued for each condition met. The list of criteria for outside drawings are listed first followed by the criteria for inside drawings.

Outside drawings

- Chimneys
- Cooling towers
- Number of buildings including specific buildings e.g. wharehouse
- Approximate number of levels that buildings contain
- Signs and logos
- Other features such as fencing or security barrier
- Production area such as pipes, vessels, storage drums
- Appropriate vehicles such as forklift truck or road tankers
- Other

Inside drawings

- Few people depicted (doing specific job such as scientist or computer operator or forklift truck driver)
- Closed pipes or vessels (no open vats or open furnaces)
- Automated system
- Machinery such as production equipment
- Computers
- Lab equipment
- Lab work depicted from classroom activities
- Other

10 References

Association for Science (1999) Science and the Literacy hour, Executive Summary (Hatfield: ASE).

Blackburn, I. (1997), Primary sector's gravity problem, (10 January 1997). *In The Times Educational Supplement, London*: The Times Supplements Ltd.

Blatchford, P. (1992) Children's attitudes to work at 11 years. Educational Studies, 18, 107-118.

Department of Education and Science (DES) (1989), Aspects of Primary Education: the teaching and learning of science. London: HMSO.

Evans, C.E.L., Hogarth, S. & Parvin, J. (2004), Children Challenging Industry, Analysis of CCI project data five years on. *Chemical Industry Education Centre*: University of York.

Jarvis, T. & Pell, A. (2002), Changes in primary boys' and girls' attitudes to school and science during a two-year science in-service programme, *The Curriculum Journal*, 13 (1), 43-69.

Jarvis, T. & Pell, A. (2002), Effect of the Challenger Experience on Elementary Children's Attitudes to Science, *Journal of Research in Science Teaching*, 39 (10), 979-1000.

Jelly, S. (1985), Helping children raise questions – and answer them. *In Harlen, W. (ed.) Taking the plunge*, London: Heinemann.

Musgrove, F. and Batcock, A. (1969) Aspects of the swing from science. *British Educational Psychology*, 39, 320-325.

Myers, R. and Fouts, J (1992) A cluster analysis of high school science classroom environments and attitudes to science. *Journal of Research in Science Teaching*, 29(9), 929-937.

Osborne, J. and Simon, S. (1996) Primary science:past and future directions. *Studies in Science Education* 29, 99-147.

Parvin, J. (1999), Children Challenging Industry: the Research Report. *Chemical Industry Education Centre*: University of York.

Pell, T & Jarvis, T. (2001), Developing attitude to science scales for use with children of ages from five to eleven years, *International Journal of Science Education,* 23 (8), 847-862.

Whitby, V. (1993), The relationship between teachers' own scientific knowledge and their ability to ask high level cognitive questions, in order to teach the National Curriculum for science. *Paper presented at the BERA Conference*. England.