Children Challenging Industry: the research report

A study of the effects of industry-based science activities on the views of primary school children and their teachers of industry and science.

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Abstract

The aim of this study was to evaluate the implementation of a model for teaching industry-based science activities and its effects on children's and teachers' views of science and industry. The model was implemented in 38 primary schools in County Durham, with 44 teachers and over 1300 children. The model consisted of three half-day sessions of science activities, over three weeks in each school. These were taught by the project officer in collaboration with the class teacher. In over half of the cases, children visited an industrial site after the final classroom session.

A combination of research tools were used: audio-taped and transcribed interviews with children in half of the schools and with all of the teachers before and immediately after the intervention, telephone interviews with half of the teachers one year after the intervention, and questionnaires with children in half of the schools.

The main findings are that the profile of the chemical industry was raised in both the children's and teachers' minds during the project. Children had a greater awareness of what happened in the industry, who worked there, and how science fitted into the industrial workplace. Teachers extended the project by incorporating the industry-focused science activities in their classroom teaching with other groups of children. Suggestions are made, in the light of the findings, for extending the project to other regions in the UK, for providing additional support for the teaching of science in primary schools, and for future research.

Chapter 1   Introduction

Tom Swan, Chief Executive of Thomas Swan & Company Ltd, like many leaders of the chemical industry, has been increasingly worried about the adverse perceptions of the chemical industry in the minds of the public. These worries are amply confirmed by a number of MORI polls. Firmly believing that this perception can only be combatted effectively through education, Tom Swan decided to initiate a new programme for supporting the teaching of science in primary schools.

Tom Swan discussed his idea with Miranda Stephenson, Manager of the Chemical Industry Education Centre (CIEC) at the University of York, who shares his aspirations to enthuse young people about chemistry, and its place within the chemical industry.

The project was designed in such a way as to build upon the experience of the Centre, with a particular focus on the primary school sector. This experience includes the production of written materials that:

- set science activities within the framework of the National Curriculum
- make use of industrial contexts
- form the basis of in-service training for teachers.

The project design therefore consisted of a refined model of in-service training with intensive support for science inspired by industry. It was also designed to maximise the opportunity to carry out detailed research into children's and teachers' views of science and industry and into the impact of the classroom-based training and activities.

Although the project was localised in County Durham, the home of Thomas Swan & Company, Ltd., the long-term aim was for its expansion into other regions.

The project officer was both the advisory teacher in the classroom and the researcher. She has experience in primary school teaching, knowledge of the chemical industry, and has written many of the Centre's primary school resources. This enabled her to plan and carry out hands-on science activities and investigations which demonstrated a range of industrial processes whilst covering aspects of the National Curriculum for science.

Therefore the main aims of the project were to:

- improve primary school children's perception of the chemical industry and its relationship with science
- increase children's enjoyment of science
- provide classroom-based training for teachers in aspects of the National Curriculum for science.

Thus the project has three dimensions: the use of chemical industry-related activities for primary age children, support for science teaching, and research which seeks to establish the effects on children and teachers of using such resources.

The background against which the Children Challenging Industry project is set is described in **chapter two**. This background includes:

- the introduction of the National Curriculum
- knowledge and confidence of teachers to teach science
- training that is available to support the teaching of science
- teachers', children's and the public perceptions of industry
- education-industry initiatives.

The project model, devised against this background, was piloted in four schools. Following the pilot, minor changes were made to the research methodology, and to the choice of classroom

activities. A more important change to the project design was the inclusion of industrial visits, where possible, following the sequence of classroom activities. The refined model was then used with 40 classes of children in 34 schools in the main phase of the project.

The research methodology included the use of semi-structured interviews with teachers and children, and questionnaires for children to complete. Details of this methodology, the data analysis, and the project model are provided in **chapter three**.

In **chapters four and five** the data are presented and discussed. The chapters divide the data into two main areas; **chapter four** focuses on the views held my teachers and children of the chemical industry, whilst **chapter five** looks at their views of the science curriculum and how it links with industry.

Chapter six concludes the report, by drawing together the main findings of the study. These findings are linked to action points to improve the development of the project model for future implementation, to offer additional support to teachers, and to highlight further research opportunities.

Chapter 2   Primary school science and its links with industry

2.1   Introduction

This research is set within the context of the National Curriculum, which was introduced as part of the Education Reform Act in 1988, and has undergone many changes since. During this period of implementation, teachers' perceptions of the National Curriculum have changed, as research described in this chapter shows. There is still a long way to go before primary teachers feel wholly comfortable with teaching the science curriculum. Therefore, the kind of support that the *Children Challenging Industry* project offers is invaluable.

Research carried out in recent years, and described in this chapter, has highlighted teachers' lack of scientific knowledge and confidence to teach science. One of the aims of the project was to support primary teachers in their teaching of science. Teachers were encouraged to work collaboratively with the project officer. The majority chose to observe the officer whilst she led aspects of each session, and then work with groups of children during practical activities.

The project had a strong classroom-based, in-service training component. In-service training provides a very important method by which teachers can be supported in addressing their concerns. This chapter would therefore not be complete without a discussion of the research carried out into the effectiveness of such training, both here and in the US. The training has been designed to improve teachers' knowledge and confidence, as well as cover pedagogical issues faced by primary teachers.

Views of industry held by the public are often negative or narrow, as the research discussed in section 2.5 reveals. These views are often based on limited knowledge, usually obtained from the media, which is indifferent at best, even hostile, to the chemical industry. The project aimed to develop understanding and thus a more balanced view of the industry, by working with teachers and their classes on curriculum-linked activities.

Industrial links in schools have been encouraged for many years, and developments in such initiatives are traced in section 2.6, though many schools still need encouragement to participate in such activities. The project aimed to show teachers 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 many children also visited industry. During the project, several chemical and allied companies were offered training on effective site visits for primary children. A large component of this training was communication skills, as this is often an area of difficulty for those involved in scientific fields, as section 2.6 explains.

2.2   National Curriculum

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', along with English and mathematics. For the first time, primary teachers were being told to teach children a broad science curriculum, covering investigational skills and aspects of both physical and life sciences. Since 1988, the science curriculum has undergone many changes, but to allow for period of stability, the most recent set of guidelines (DES, 1995) was to remain unchanged for five years.

However, changes have taken place, with the introduction of a daily Literacy Hour in September 1998, and a Numeracy Hour to follow in September 1999. Science remains a core subject, alongside English, mathematics, and information and communications technology. The foundation subjects are no longer compulsory, though the guidelines remain in use in schools.

2.3 Teacher knowledge and confidence

Since the 1970s, great attention has been given to researching primary teachers' scientific knowledge, both in the United States (Smith & Neale, 1989) and in the UK (Kruger, Summers & Palatio, 1992); and their confidence to teach science (Bennett, Wragg, Carré & Carter, 1991; Littledyke, 1994; Harlen, Holroyd & Byrne, 1995). In the UK this has been linked to the content of the National Curriculum. The Qualifications and Curriculum Authority feel that primary teachers should obtain a minimum of a GCSE in science in order to be able to teach the subject (Blackburne, 1997).

Summers et al (1989-92) in their Primary School Teachers and Science (PSTS) project, interviewed 20 primary teachers and sent questionnaires to 450 more, to find out about their scientific knowledge of materials, forces and energy. They found that:

> . . . there is a severe mismatch between primary teachers' understanding of science concepts and the demands made by the programmes of study and the attainment targets . . .

> (p.348)

The areas of knowledge covered in the PSTS project were not those traditionally studied (i.e. prior to the National Curriculum) in the primary classroom. Primary science has, in the past, often been associated with 'the nature table' and the biological sciences. Although curriculum materials, including those discussed above, promoted coverage of physical and biological sciences, research (Platten, 1990) has shown a bias towards biology - especially amongst infant teachers and female junior teachers.

The link between primary teachers' lack of scientific knowledge and their lack of confidence was acknowledged prior to the National Curriculum, in the National Primary Survey (NPS) of 1978 and HMSO surveys of the 1980s (DES, 1989). This lack of knowledge was felt to be a major obstacle to primary teachers choosing subject matter that met the interests and abilities of the children they taught. In the 1980s there was improvement in this area, enabling teachers to offer a 'broad and balanced' curriculum, rather than the depth required to achieve progression.

Several years on from the introduction of the National Curriculum, teacher confidence does seem to have shown some improvement. In a longitudinal study, carried out between 1988 and 1991, Bennett *et al* (1991) evaluated teachers' attitudes to and perceptions of the science curriculum. The study used a combination of classroom observations (pilot phase), interviews and questionnaires. The main source of data was questionnaire responses. The study found that teachers felt more confident in their own ability to teach science and also to deliver science than they had prior to the introduction of the National Curriculum. Although the study's statistics show significant improvement, they also show that there is still a long way to go before teachers feel 'very confident' to teach science.

Limited classroom observation was carried out during the study, and only in the early stages of the project (to inform the questionnaire design). Therefore the study does not show whether teachers:

- were actually more confident in the classroom
- had a better understanding of scientific concept
- were competent to teach science.

Recent research by Harlen, Holroyd and Byrne (1995) shows that confident teachers are not always competent ones. Questionnaires sent to 119 primary schools in Scotland (with an 83% return) focused on background information about the teachers (teaching experience, qualifications, in-service training, etc.), teachers' perceived confidence, and knowledge of the broad primary curriculum, with particular reference to science and technology. Interviews, with 57 teachers selected from the 119 schools, used Osborne's interview-by¬events techniques

to discover the extent of teachers' understanding of science and technology. Finally, reflective diaries from these 57 teachers were used as the basis for telephone interviews, in which difficulties faced in teaching science and technology were discussed. One interesting piece of information that these data yielded is tabulated below.

Table 2.1   Numbers of teachers with different combinations of confidence and understanding (n=36) (Harlen & Holroyd, 1995)

confidence about teaching science/technology	high	low	high	low	mixed
understanding of science	high	low	low	high	low
number of teachers	8	12	6	4	4

Note: Confidence was self-perceived, rather than measured via observation.

Over a third of teachers who perceived themselves to be confident (6 of 14 teachers) had a low level of understanding of scientific concepts. A quarter of teachers with low confidence (4 of 16 teachers) had a high level of understanding. The researchers felt that the combination of high confidence and low understanding arose for one of two reasons:

- some teachers carried their confidence as primary practitioners into all curriculum areas
- other teachers regarded the secondary school science they were taught to be sufficient to teach science at the primary level.

On the other hand, the researchers also suggest that perhaps those with low confidence and a high level of understanding had done a great deal of personal reading, study and discussion to rectify their perceived low level of understanding.

A study by Whitby (1993) found close links between primary teachers' ability to question children effectively and their understanding of scientific concepts. Teachers need this skill of phrasing questions appropriately in order to develop children's understanding of science. When asked to grade questions on a scale of 1-5, according to how productive they were perceived to be, Whitby discovered that teachers perceived questions as productive only when they understood the scientific concept themselves, and could therefore see ways of developing ideas with the children.

Feasey (1998) suggests that teachers all too often forget to incorporate the second component of her 'effective questioning' equation, and need to do their own science homework in order to do move on the children's understanding.

Question stem [why, what, when] + science learning outcome = effective question

(p.157)

Jelly (1985) defines unproductive questions as those which promote science as information that can be found in secondary sources and lead to 'correct answers'. Productive questions, on the other hand, promote science as a way of working, in which a variety of solutions can be sought from first hand experiences.

This highlights the importance of offering teachers examples of productive questions, and the information necessary to answer them. Chemical Industry Education Centre resources offer such questions and information to support the teacher's own understanding of the concept. The *Children Challenging Industry* project offers practical examples as the project officer leads classroom discussions on, for example, children's ideas or evidence from their investigations.

2.4   In-service training

In-service training to improve primary school teachers' scientific knowledge and their ability to teach science effectively is still called for (Griffiths, 1991; John, 1992; Tresman & Fox, 1994; Harlen *et al*, 1995). The methods by which these two aims can be achieved are varied. Many of them include the use of distance learning material in some way, and researchers (Summers & Kruger, 1994) are now developing such resources to be used as part of either school-based, in-service training or courses offered by institutes of higher education.

Tresman & Fox (1994) evaluated one of their Open University courses for primary teachers, which was aimed at improving the teachers' subject knowledge. This course made use of distance learning 'study commentaries' and a series of 20 training days. Their own conclusions suggested that this method of training is not the most appropriate. They state that primary teachers find science difficult, but that the course helped teachers feel more comfortable with their difficulties. However, although teachers found learning science concepts valuable, they were unable to apply the concepts in their teaching. Tresman & Fox did not describe the approach to improving teachers' knowledge, but perhaps a constructivist approach to the teachers' own learning (i.e. building upon previous knowledge, as advocated by Summers & Kruger, 1994; and Smith & Neale, 1989) would have provided that necessary link between the science concepts and 'classroom situations'.

Many 20-day science courses (GEST[1] -funded) were successful primarily in improving the confidence of teachers in their subject knowledge of science (Harland & Kinder, 1992). However, the desired dissemination of the teachers' knowledge on returning to school rarely occurred. This was thought to be due to those courses which did not cover the necessary skills, or where intended follow-up advisory teacher visits to schools did not take place. Courses often emphasised the improvement of subject knowledge over the other two aims of the courses - to develop pedagogy and dissemination skills.

Smith and Neale (1989), in their study based in the United States, aimed to improve teachers' knowledge of science using an intensive summer school approach. Teachers attended the four-week course, which used constructivist strategies to improve their knowledge. The study suggests that improvements were made in the teachers' own knowledge and, in some circumstances, their ability to create appropriate learning activities for children. However, the study was based on only ten teachers, and data were often analysed for only 4-5 of them. Therefore, this method of improving teachers' knowledge would need studying on a larger scale, and would also rely on teachers' willingness to devote a substantial part of their summer break to the course.

It does appear that specific aspects of the training outlined above were successful. Perhaps the best way forward, therefore, would be to combine several approaches to training and offer a 'package' to teachers. John (1992) eloquently argues the case for a 'multi-layered' approach which combines distance learning, school-based support and study time. Teachers often have no or little non-contact time in school (Kinder & Harland, 1991), so study would take up leisure time, which some teachers may be reluctant to use in this way. It may also be considered insensitive to place additional strain on teachers already feeling the pressures of the National Curriculum (Newton & Newton, 1992). The *Children Challenging Industry* project would therefore seem to offer an approach similar to that suggested by John, but with little time outside their class teaching required for the training.

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[1]GEST = Grants for Education Support and Training

2.5 Perceptions of industry

The motivation for the *Children Challenging Industry* project stemmed from the MORI polls, which revealed that the public perception of the chemical industry was poor, and not showing any signs of improvement. These perceptions are particularly poor amongst young people. The youngest being surveyed were 15 years old. But how early in life do children's perceptions of industry begin to form?

Research carried out with primary school children shows that children as young as 4 years of age have ideas about occupations (Hutchings, 1996). The research focused on children's occupational preferences and, even though the numbers of children involved in the study were low, engineers were mentioned by some children by the age of 7 years. However, these were the only occupational preferences that might be considered industry-based, and children may have been thinking of car mechanics, electricians, etc.

The sources of the information upon which they based their choices were predominantly from models presented either in the family or community, or from those presented on the television. As community or television models rarely include industrial ones, children are only likely to aspire to such occupations if they have a family model. Even then, it relies on parents communicating the nature of their work to the children. Some may argue that it is not important for children to have occupational knowledge at 10 years of age, but Hutchings points to research by Lea et al (1987):

> There is evidence that occupational foreclosure takes place; that is, that at an early age children begin to restrict the range of occupations they might aspire to. If, as this survey indicates, children aged ten and eleven have only limited information about the possibilities, this is surely a matter of concern.
>
> *(p.29)*

Adding to the lack of industrial occupational models represented on the television, is the image of industry portrayed in news reports. These often cover industry in the role of polluter, rather than as providing benefits to society or playing an important role in scientific research.

Environmental issues are of great concern to the public, and are given much media coverage. Therefore, a chemical spill might be one of the few instances of industrial coverage by the media. Dunwoody & Griffin (1993) describe two major patterns found in research studies on the coverage of risk stories. The first is that the coverage does not result from observation or measurement but by inference; and the second pattern in these stories is that they contain very little risk information. These images are seen by children, but the main audience for such news stories is the adult population, which of course includes teachers. The MORI poll (1994) shows that media coverage is a more common source of information on industry than any other (Table 2.2). Environmental groups were a much more common and credible source of information than the industry itself, which was penultimate on the list. Interestingly, formal education was only marginally ahead of industry as a source of information. This is a trend that the Chemical Industry Education Centre aims to change, through projects such as *Children Challenging Industry*. Without such changes, the information obtained by the public will continue to present a biased picture of industry. The *Children Challenging Industry* project aims to present a broader picture, by presenting the benefits of industry, and its part in scientific research and science-related work.

Table 2.2   Sources of information about the chemical industry and the credibility given to them by the public

	source of information %	Credibility %
TV documentaries	70	58
TV news	68	37
national newspapers	64	21
pressure groups or environmental organisations	27	19
family or friends who work in the industry	13	16
schools, colleges, other education	13	10
the chemical industry itself	8	3
chemical companies	7	3
politicians and ministers	7	2

Source: MORI, 1994, p.17

2.6   Science in an industrial context

Industry-education partnerships can be traced back to the early 1950s. These partnerships were ad hoc and aimed at secondary school and university students, and tended to focus on the industry rather than the curriculum (Key, Mapletoft and Parvin, 1996). A key event which sparked interest in the purposes of industry links was James Callaghan's Ruskin College speech (Callaghan, 1976). This led to national debate about the nature of the school curricula in preparing pupils for adult life and work. A strand of the debate was the provision of science for all, as Waddington (1995) points out, which would:

> *. . . not only empower all students to live in an increasingly scientific and technological society but alo enable and encourage intellectually able students to pursue careers based in these subject areas.*

> *(p.4)*

The re-thinking of the curriculum which followed led eventually to the National Curriculum, with science having a high profile. It also resulted in the setting up or enhancing of various government inspired and funded education-industry liaison agencies.

Therefore, since the 1970s there have been many more developments, both in the number and purpose of link organisations, and the industry's re-focusing on curriculum-related partnership. Today, there are over 100 organisations in the UK that bring together industry and education. These include organisations such as Schools Curriculum Industry Partnership (SCIP), Understanding British Industry (UBI), regional Education Business Partnerships (EBPs) and Science and Technology Regional Organisations (SATROs). Industry's role in liaison is no longer purely as provider of industrial information, but as a collaborator in educational programmes. Each liaison organisation provides collaborative projects of differing natures.

Specific references to industry had been in the National Curriculum for science (1991), as this statement for Key Stage 2 pupils shows:

> *Science in everyday life: …. Pupils should be given the opportunity to develop further an awareness of the role and importance of science in everyday life …. Industrial contexts should be introduced, alongside those of domestic and environmental contexts, as starting points for pupils' work in science.*

> *(p.7)*

However, with the revised version of the curriculum guidance (1995), this statement had been reduced to:

> *Science in everyday life: . . . Pupils should be given the opportunities to consider the part science has played in the development of many of the things that they use.*

> *(p.7)*

Similarly, non-statutory guidance produced by the National Curriculum Council (1990) covered industry as one of its five cross-curricular themes (1990), under the heading *Economic and Industrial Understanding* (EIU). The intention was that each theme permeated all the main curriculum subjects. However, since their inception, these themes have met with varying success in UK primary schools, with little lasting impact in most schools, in part because their emphasis in the curriculum has been reduced. In one research study, primary teachers were asked to rank all the curriculum subjects, themes, and religious education. They ranked EIU as the least important aspect of the curriculum they had to teach (Littledyke, 1997). Even prior to the National Curriculum and the additional workload it brought, a study of secondary school science teachers found that the main reason given for not being involved in industry links was 'the shortage of time, as in competition with other activities' (Paterson, 1990).

Teacher trainees in a study undertaken by Ross (1992) ranked EIU as the least important cross-curricular theme. The main foci of his research were to look at the students' understanding of and attitude towards teaching EIU. He suggested several factors that affected trainee teachers' economic and industrial understanding, with previous full-time employment being the most significant. He did not, however, state whether the students had a sound understanding of the subject, or relate this understanding to their confidence.

However, teachers' lack of industrial understanding may provide a reason for not rating the subject highly, or incorporating it in to the curriculum. Ross cited this as being the case for elementary teachers' understanding of economics in the US (Walstad, 1979). This might provide an area of further research in the UK.

Alongside the introduction of the revision of the National Curriculum, in September 2000, the government intend to introduce 'Key Skills' across the curriculum in primary schools. There is potential for industry to be linked to the teaching of these skills (Feasey & Siraj¬Blatchford, 1999), in terms of them providing an audience for the children's work in communication, including information and communication technology, and to help children work more effectively with others. The *Children Challenging Industry* project has these aims within its framework.

As with the teaching of science; teachers with little industrial understanding could lack the confidence to include industry in their teaching. Unlike the science curriculum, there is no statutory compunction that might motivate these teachers to include industry.

Therefore, as long as 'industry' does not feature in the National Curriculum, companies and link organisations need to take a proactive role to:

- initiate links with schools
- develop teachers' understanding of industry
- identify benefits of developing children's understanding of industry - identify industry's links with the school curriculum.

Without this kind of proactive role, only a limited number of teachers with a personal interest will offer industry-related activities to their classes.

One project aimed to promote the work-related curriculum as an area of study in its own right: Pathways toward Adult and Working Life (Harris, 1996). The teachers involved in this project did make some links with curriculum subjects, but the main focus was on the use of a work-related curriculum. Harris acknowledges the difficulties faced by those wanting to promote such a curriculum:

> *Given that the existence of the work-related curriculum is dependent on it having a secure place in curriculum provision, the current position looks far from promising   Given the twin pressures of parental choice through open*
>
> *enrollment and the government's desire to encourage comparisons of school performance via league tables, it is not surprising that the work-related curriculum has not been given a high priority in schools.*

> *(p.7 & 8)*

It remains to be seen whether the project will be extended beyond the boundaries of the three education authorities in which it was piloted, as it does rely heavily on EIU gaining curriculum status.

A key feature of the way in which the Chemical Industry Education Centre develops its projects is to focus the industrial activities on the science curriculum, a core subject in schools today. This addresses one of the main concerns that arose from the Great Debate, and which is still relevant to those engaged in industry-education liaison work today. This was the need to address:

> *The lack of relevance and motivation for some pupils which is based on the idea that much of the content of school work is too academic and remote from the interests and needs of most pupils.*

> *(p.12)*

By setting science activities within an industrial context, the Chemical Industry Education Centre aims to overcome this problem of science being an isolated subject with no relevance to everyday life. At the same time, the Centre aims to show teachers that by using such a relevant context, children are more motivated, and engage in science activities in an enthusiastic and focused manner. Children are provided with an audience beyond the classroom and have a purpose for carrying out their investigations; thus they take ownership of their work.

Placing scientific enquiry within an appropriate context is important to 'bridge the gap between children and their science and the wider world' (Feasey, 1998). Fleer (1992) points out the importance of context when trying to develop children's understanding of science. She focused her research on the ability of teachers to develop 'shared meanings' with 5-8 year old children. Her findings divided teachers into those who could and those who could not develop these shared meanings (those who could not, used procedural talk for the basis of all their discussions). Her definition of 'context' is close to that which forms the basis of the *Children Challenging Industry* project's science activities, relevance to the lives of the children. Fleer writes:

All interactions and experiences are made meaningful, since they occur in a social context based on shared understandings of that context. Classrooms are more artificial, topics are introduced by the teacher, usually devoid of a social context and hence can be introduced as something meaningless, since their social relevance is not obvious. ... When something is introduced ... within a meaningful social context, children are better able to conceptualise the learning task and to make use of the learning experience in other social contexts.

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(p.389)

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Research in the US supports this belief (Nagel, 1996), and her primary school case studies emphasise the importance of children owning their work in terms of increasing their motivation and development of independent learning.

Thus several research studies point to the importance of two of the aims of the *Children Challenging Industry* project: to develop children's industrial understanding, and to provide a purpose and relevant context for their classroom science activities, leading to increased motivation and ownership of their work.

Another feature of the *Children Challenging Industry* project, which gained importance as the project developed, was to arrange industrial visits for as many classes as possible. Effective site visits have long been an aim of the Chemical Industry Education Centre, with several publications encouraging good practice (Parvin, 1995; Mapletoft, 1995). Recent research carried out at the Chemical Industry Education Centre (Stephenson & Wingfield, 1998) showed that almost 50% of companies within the chemical and allied sector are willing to accommodate visits from primary school children. Many of these companies do so in a reactive rather than proactive manner.

Since its inception the Chemical Industry Education Centre has provided training for chemical companies on effective site visits. Amongst others, a key component of this training is communication. Many of the people children meet during a site visit are engaged in science-related work, and are used to talking at a highly technical level. These people need to develop skills of communicating with young people. This is not dissimilar to the scientific community at large talking with the public. Training for scientists working in research institutions, before communicating with the public, has been recently called for (Pringle, 1997). This training related particularly to those engaged in initiatives for the Public Understanding of Science campaign. Scientists working in the chemical industry sector are increasingly involved in similar events, often initiated through their involvement in Responsible Care (1992), in which they develop links with their local communities, including school children and their teachers.

Miller (1996) points out, in a discussion on the public understanding of science, that many of those involved in chemistry-related activities are behind their contemporaries in the physical or biological disciplines at communicating their work, and readily slip into jargon. This is magnified with young children, when jargon includes talking about 'chemists' rather than 'scientists'. Miller goes on to suggest that this reluctance to promote their work in the public domain may be due to chemists' lack of training to communicate with non-specialists. The training offered to company staff during the *Children Challenging Industry* project attempts to combat such a situation, and encourages staff to find out about their audience and their requirements, and Miller emphasises this point:

To motivate an audience, you have to know who they are. This element is often ignored when scientists discuss the public understanding of science.

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(p.40)

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This applies equally to liaison with primary school teachers and their children. It is important that a company knows the level at which the children are operating, and something about the work they are doing at school which has led to the site visit. One survey involving a limited number of

businesses in two counties (Creighton -Griffiths, 1996) highlighted the concern on industry's part about their lack of knowledge of the school curriculum. They remembered their own secondary school experience of science:

> *Many expressed doubt about what aspect of their business would be relevant to the children, and the ability of their staff to communicate relevant information.*
>
> *(p.12)*

The *Children Challenging Industry* training aims to provide appropriate information on the primary school curriculum, and offers advice on which aspects of each site's operations that would be relevant to the children.

Chapter 3 Methodology

3.1 Introduction

The research was carried out in two phases:

- a short pilot phase
- the main study.

In the pilot phase, interview schedules and classroom activities were tested in four schools and, where necessary, refined for the main study. The methods of data collection used in the main study thus built upon those used during the pilot. This chapter describes both phases of the study. The range of data collection methods are shown in Table 3.1.

Table 3.1 Data collection methods

method	with whom	purpose
questionnaires	class teachers	to obtain information about the school and the teachers' background
interviews[2]	class teachers children industrialists	to ascertain views of industry and of science
questionnaires	children	to ascertain views of industry and science
interviews	class teachers (one year after the intervention)	to determine any long-lasting impact

These methods enabled a comparison to be made between the views of all the parties involved in the industry-focused science lessons.

3.2 Pilot phase

The intention of the pilot phase was to test the evaluation tools and classroom activities, thus providing an opportunity to refine them for the main study.

The research questions were established at the beginning of the pilot phase, and these were:

- what are children's views of science and of industry?
- what are primary teachers' views of science and of industry?
- does the use of industry-focused science lessons alter these teachers' or children's views?

The pilot phase took place in four schools during the spring term of 1996. The sequence of events for the main study is outlined in Figure 3.2. The pilot phase followed this sequence with three differences:

[2] The interviews with teachers and children were conducted both before and after the classroom intervention. Using the data collected in the first 21 schools (including the pilot schools), a questionnaire was devised which replaced the interviews with children.

- the pilot schools were contacted by telephone, following recommendations made by colleagues with local knowledge of County Durham schools
- interview schedules were not sent to teachers in advance, as time did not allow this
- schools were offered the choice of 1, 2, or 3 classroom sessions.

The schools in the pilot scheme had the choice of five different activity packs. These packs had been selected with the following criteria in mind

- they were aimed at the 9-11 year age range
- they had clear links between science and its industrial applications
- they offered a wide range of classroom activities.

The packs chosen were *A Pinch of Salt* (Parvin, 1994), *Noise busters!* (Jones, Powell & Stead, 1993), *Plastics Playtime* (Parvin, 1993), *Water for Industry* (Parvin, 1993), and *Farming Tales* (Parvin et al, 1991). A summary of each of these activity packs is provided in Appendix One. All are published by the Chemical Industry Education Centre at the University of York.

Noise busters! was removed from this list for the main study, as this pack offered activities suitable for only one session, and all teachers opted for three sessions. *Noise busters!* was combined with another activity pack during the pilot phase, but this was not satisfactory, as the focus of the classroom activities became too divergent.

It also became clear in the pilot study that teachers wanted support for investigative work. This aspect of the science curriculum is not supported in depth in *Farming Tales*. Thus it was decided that it would only be offered to teachers during the main study if the other three packs did not fit with their term's science planning.

Only minor alterations were made to the interview schedules and background information questionnaires as a result of the pilot.

The interviews with groups of six children were frequently over an hour, and often children repeated points of view offered by others. It was decided that the number of children interviewed would be reduced from six to four for the main study. Groups were chosen rather than individuals as, at this age, the presence of peers encourages children to contribute to the discussion.

One of the pilot schools was situated near a polymer company. As the class activities focused on plastics, a visit was arranged to the site. This raised a research question to add to those stated above, namely:

Do site visits alter the children's and teachers' views in any way that differs from changes noted after the classroom sessions?

3.3   Main research phase

The study was intended to be a formative evaluation for similar, future projects around the country. It was also intended to be illuminative, as the large amount of data collected represented:

- teachers' views of industry
- children's views of industry,
- how science relates to the world of work.

As very little work has been done in this field, the resulting bank of data would provide new and detailed information on these views.

Durham Local Education Authority agreed to mail all 241 primary or junior schools in the county, inviting them to participate in the project. Responses were received from 54 schools, a 22% response rate. It was encouraging to find that almost a quarter of the schools showed interest in this industry-linked project. Thirty six of these schools were able to take part in the project over 2 years (from the summer term of 1996 to the summer term of 1998). The sequence of events followed by each school is described in Figure 3.1. Each school was involved in the project for a half-term period, with one planning visit being made to the school in the previous half-term.

It was decided that the project officer would work with a small number of schools again in the second year of the main phase of the project. The purpose of the second intervention was to find out whether the project could be extended to other members of staff and children in a school. All schools interested in a second involvement were asked to submit proposals suggesting how the project would be extended in their school. Initially, teachers were given guidance rather than a formal structure for their proposals.

However, responses were low (6 of the first 16 schools), as teachers were not confident to submit their ideas. A proposal form was therefore devised for teachers to complete (Appendix Two), which offered teachers a range of suggestions to select from, and the option of providing their own ideas. Of the remaining 7 schools, 6 responded. All six teachers chose from the suggestions provided rather than offer their own. Six of the twelve schools responding received a second classroom input, two of which had been pilot schools.

3.3.1   The classroom activities

Schools were given the option of working from one of three activity packs. With one exception, all schools were happy with this selection, this one school preferring to use *Farming Tales*, due to the focus of their planned science work. Table 3.2 shows that the pack about plastics was the most popular, as this offered practical investigative work on plastics. Teachers felt they knew little about plastics, and expressed a desire for support with investigative work. In mixed age classes of 8-11 or even 7-11 year olds, *Plastics Playtime* was the most appropriate choice, due to the style of the activities. Plastics are also a material which children have a limited view of (Gray *et al* (1994). *Water for Industry* is most suitable for children over 10 years old. The pack *A Pinch of Salt* tended to be chosen by schools participating during the winter months, as the context looks at the use of salt as a de-icer on winter roads.

Figure 3.1 Sequence of events

A letter was sent to all primary schools in County Durham, inviting them to particpate in the project.
34 schools were selected on the basis of specific criteria (page 6).
The sequence of events outlined below followed for each participating school.
participation in the project.

Meeting with the head teacher and class teacher to discuss the nature of involvement in more detail.

Teacher selects an activity pack, and completes a background information questionnaire.

3-4 weeks later

Interview schedules, activity pack and children's questionnaires sent to the teacher.

A schedule of dates is agreed for the interviews, classroom sessions, and potential site visit.

1-2 weeks later

Interview with class teacher and interview or questionnaire with 4-6 children.

Discussion with teacher about the classroom sessions.

1 week later

Three classroom sessions are conducted by the project officer, whilst the class teacher observes and supports group work where appropriate.

Before and after each session, the teacher and project officer discuss the aims, outcomes and any modifications which can be made.

3 weeks later

Where possible, the class visit an industrial site. The visit focuses on aspects of the site's activity which relates to the children's work in class.

1 week later

Interview with class teacher and interview or questionnaire with 4-6 children.

The teacher keeps the activity pack and is offered a second pack.

The teacher is offered the opportunity to submit a proposal for further involvement one year later.

1 year later

Interview with class teacher, post project evaluation.

Six schools selected for further participation in the project.

Table 3.2 Choice of activity packs made by the project schools

Title of pack	Number of schools, n=44*
A Pinch of Salt	9
Farming Tales	1
Noisebusters!	2
Plastics Playtime	23
Water for Industry	10

* Six schools participated in the project twice, two of which had been pilot schools. 'Noisebusters' was used only in the pilot phase.

After initial planning meetings and data collection, the project officer carried out three activity sessions with the class of children (see Figure 3.2 for an example of a series of activities). These sessions were approximately 2 1/2 hours each. To enhance the industrial storyline in the pack, the project officer provided additional activities, such as a demonstration, video extracts, or discussion of industrial photographs or equipment.

Although a variety of teaching methods was used, the majority of the activities were practical in nature, with classes being divided into groups of four children for these activities.

Teachers were given the opportunity to lead sessions with support from the project officer, but with the exception of two teachers, they chose to observe the project officer.

Figure 3.2 Example of a series of classroom activities

Feely bag activity
to develop language related to properties of plastics
(flexible, rigid, hard, soft, rough, smooth)

Classification
children identify PVC, polyethylene, polystyrene and
expanded polystyrene using (a) crease test and (b) floating test

Expansion of polystyrene
demonstration and video, in which children see
polystyrene being expanded and moulded

Plastics for packaging
children investigate a range of materials for
their shock absorption properties.

Mini-enterprise
children design and make a package for crisps,
buying materials with a limited budget.

3.3.2 The site visit

During the pilot phase of the project, it became apparent that children and their teachers were keen to visit industry, with teachers saying it would be a valuable way to conclude the children's work. The project officer therefore contacted companies in County Durham who may have been able to offer a visit. Gradually, contact was made with six willing companies, and these were:

Bonar Polymers   Newton Aycliffe
Glaxo Wellcome   Barnard Castle
Hydro Polymers   Newton Aycliffe
ICI   Wilton, Teesside
Mono Containers   Durham
Thomas Swan   Consett.

A short training session was given to site staff who acted as tour guides at Bonar Polymers, Glaxo Wellcome, and Thomas Swan. This was to ensure that site visits were tailored, where possible, to the needs to the schools, and that the visits followed up the classroom science in which children had been engaged. Mono Containers offered one visit, which was organised through the Durham Business Education Executive.

57% of the children participating in the main phase of the project visited one of the sites listed above - with one school having a visit by Durham County Council's gritter, driver & environmental scientist. The majority of schools would have liked a visit, if it had been possible to arrange. However, it took several months to build up links with all of the companies, and as organising visits depended upon the location of schools in relation to these companies, and on the availability of staff to receive the children, not all of the classes could be accommodated.

3.3.3 The schools and the teachers

The 36 schools involved in the main phase of the project were located throughout County Durham (as were the pilot schools), as shown in Appendix Three. The schools were selected using three main criteria:

-       the preferred term for involvement (schools were offered all six choices) - location of the school
-       number of children on roll.

Thus the sample included:

-       a wide range of abilities and experiences amongst both children and staff - children living in rural areas and attending small village schools
-       children attending large schools in towns
-       children in areas of high unemployment (due to the closing of coal mines).

A detailed list of each school's number on roll, and age range of children in the chosen class is provided in Appendix Four. Table 3.3 summarises this information, showing the wide range of school locations and sizes achieved. To give three examples of differing schools, the project officer worked in:

-       a small remote rural school with all 16 Key Stage 2 children in one class
-       a large class of 37 year six children in a thriving market town with Glaxo Wellcome as a major employer
-       a large school of 560 children in a small town which once relied heavily on the local colliery for employment.

Table 3.3 Information about the schools and classes

feature		no. of schools*
location in the county:	town or city	16
	village	22
no. of children on roll:	<100	8
	100-200	17
	201-560	13
no. of teachers:	<5	10
	5-10	22
	11-25	6
year group(s) in project class:	Y5	11
	Y6	9
Y3 = 7-8 year olds	Y5, Y6	16
Y4 = 8-9 year olds	Y4, Y5	2
Y5 = 9-10 year olds	Y4, Y5, Y6	1
Y6 = 10-11 year olds	Y4, Y5, Y6	4
no. of children in project class:	<25	8
	25-30	20
	31-37	15

* total number of schools = 38, total number of classes = 43

Data in this and subsequent chapters include the two pilot schools that did not receive a second input. As this pilot data supported the main phase, it was decided that it was important to reflect as many teachers' and children's views in the study as possible. The only exceptions to this inclusion were the data that had become redundant due to minor changes in the collection methods.

It is interesting to note that the class size varied quite considerably, with 35% having over 30 children. Also, 55% of the children in these large classes are taught in mixed age ranges, thus encompassing a wide range of abilities. These factors, amongst others, can contribute to the lack of practical science taught in primary school classrooms. See chapter five for further discussion of science teaching.

Primary science has only been taught formally in primary schools for the last decade, and much support for primary science is still sought. Teachers were therefore asked to provide information on their own science qualifications and recent in-service training in science.

Table 3.4 Teachers' qualifications and training in science

qualification/training		no. of teachers *
years in teaching:	<10 yrs	13
	10-20 yrs	16
	21-30 yrs	14
years in industry:	1-11 yrs	6
years in admin:	1-7 yrs	8
science qualifications:	none	24
	1-3 O-levels	7
	1 A-level	4
	Degree[3]	5
	HNC	1
	OU foundation	1
science INSET in	none	18
previous 3 years:	1-3 days	8
	4-6 days	7
	7-24 days (all incl. DfEE INSET)	7
DfEE INSET course	8-20 days	13
INSET on industrial	none	38
links:	1-3 days	3

* n=43 and includes teachers from 38 schools, plus 5 new teachers receiving their school's second input. A small number of teachers did not complete all sections of the questionnaire, thus not all of the totals are 43.

The support for science teaching and industry links was welcomed by all the teachers regardless of the number of years they had been teaching - be it 3 months or 30 years. 12% of the teachers had a science degree, whilst 59% had no science qualifications.

One third of the teachers had completed a DfEE science course, lasting 8, 10 or 20 days. These courses combined scientific knowledge with knowledge of teaching science. The DfEE training course provided one third of the in-service training that teachers had attended prior to the time they participated in the project. Nearly half the teachers had received no in-service training at all in the same three year period, as the main priorities often related to school inspections or preparing for the literacy hour. Also, school budgets only allow teachers from each school to attend a limited amount of training courses. However, the combination of teachers with few science qualifications and little recent training suggests a continuous, rather than diminishing, need for in-service training in science.

Although the cross-curricular themes[4] that accompanied the introduction of the National Curriculum still officially exist, very few schools use them in their current practice. With school priorities shifting, it is not surprising to see that only 8% of these teachers had received in-service training on economic and industrial understanding in 3 years. Those who had received training had done so via the Durham Business Education Enterprise (DBEE), an active local education-business partnership, rather than through the Local Education Authority. However, it was encouraging to find a sizeable minority of teachers with previous industrial experience (15%), including civil engineering, software engineering, and working in a research laboratory on a chemical plant.

[3] One teacher had a biology degree, one teacher had a combined biology and geology degree, one teacher had a combined geography, geology and astronomy degree, and two teachers did not specify their degree subject.

[4] The cross-curricular themes were intended to be taught across curriculum subjects and included documents on economic and industrial understanding, citizenship, careers, health education and the environment.

3.3.4   Data collection methods

The majority of data were collected by interview, with a substantial number of children's views being collected via questionnaire, as can be seen in Table 3.5. Each teacher first completed a background information questionnaire, the data of which were presented in the previous section.

Table 3.5 Data collected by different methods

with whom	method of data collection	when collected (pre- or post- intervention)	number collected
teacher	questionnaire	pre/background	43
teacher	interview	pre	41
teacher	interview	post	40
teacher	interview	post - one year later	23
children	interview	post	21
children	interview	pre	21
children	questionnaire	post	120
children	questionnaire	pre	78
industrialist	interview	post	3

3.3.5   The interviews

All teachers were interviewed before and after their participation in the project. Children were interviewed in the first 21 schools, both before and after participation, and these data were used to inform the design of questionnaires for use in the remaining schools. Teachers in 23 schools were also interviewed one year after their project involvement, to determine whether any lasting change in their views and practices had occurred. In order to compare the views of all parties in the project, three industrialists were also interviewed.

All interviews were semi-structured, with a series of open-ended questions and prompts. This format was chosen in order to provide a focus, the opportunity to probe some responses, and for teachers to talk freely. As Bell (1993) states:

> *Freedom to allow the respondent to talk about what is of central significance to him or her rather than to the interviewer is clearly important, but some loose structure to ensure all the topics which are considered crucial to the study are covered does eliminate some of the problems of entirely unstructured interviews.*
>
> *(p.94)*

The interview schedules are given in Appendices 5-6. The interviews were audio-taped, fully transcribed for analysis and coded in order to retain the anonymity of participants.

In each school, the class teacher and four children were interviewed before and after the classroom intervention. The teacher was interviewed alone, and the children were interviewed in a group. Each group of children consisted of two boys and two girls who represented the class's ability range in science, and whom were confident speakers. Group interviews with the children were chosen, as it was felt that individual interviews would prevent them from providing detailed answers to questions (Hopkins, 1993; Heath, 1999). As Hopkins states:

> *. . . I increasingly find group interviews with three or four students the most productive. Far from inhibiting each other, the individuals 'spark' themselves into sensitive and perceptive discussion.*

<div align="right">

(p.124)

</div>

Teachers' interviews were typically 20-30 minutes' duration, whereas the interviews with children lasted up to an hour.

Any changes in the teachers' views could be sought by comparing the two interviews, whereas individual children were not identified during the interviews, so it is only possible to compare group data before and after intervention.

Children were asked questions about how and where 2-3 products were made (see the schedules in Appendix Six). The selection of products used during the interviews depended upon which series of activities the class were about to do and which site they were hoping to visit. For example, a school visiting Hydro Polymers would be asked about a plastic product such as a yogurt pot, whilst a school visiting Thomas Swan might be asked about a Mars bar wrapper, as Swan contribute to the adhesive used to seal the chocolate bar. The products used during children's interviews are shown in Table 3.6. Other products were selected to gather data on a wide range of products related to the chemical industry.

Table 3.6 Products used during children's pre-intervention interview

product	no. of interviews	no. of questionnaires
plastic container	16	72
bleach	10	0
washing up liquid	8	12
indigestio/headache tablets	6	0
Mars bar wrappers[5]	5	12
salt	5	24
plant food (Baby Bio)	2	0
TOTAL	52	120

N.B. 65 questionnaires were used for analysis, see section 3.3.6 for details.

The first few interviews which took place with teachers one year after participation were in person. However, it soon became apparent that the quantity of information gleaned was not sufficient to merit the time required. As the project officer had already built a rapport with the teachers, it was decided that telephone interviews would be a suitable approach. Appendix Five shows the telephone schedule that was sent to teachers 1-2 weeks prior to the telephone interview, the timing of which was arranged to suit the convenience of each teacher.

3.3.6   The questionnaires

After carrying out an initial analysis on the children's data from 21 schools, it was possible to draft a pre- and a post-intervention questionnaire for children to complete (see Appendix Seven). Teachers were asked to administer the questionnaire to a group of three girls and three boys who were mixed ability in science, and whose literacy skills were good (the questionnaire were still designed to require minimal reading and writing).   The questionnaires combined closed questions with a small number of open response questions. The closed questions required a limited response, by offering children selections of the most common responses occurring in the interviews. Open questions gave children the opportunity to elaborate on these responses.

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[5] Discussions of this product included the plastic wrapper, inks and adhesive.

In addition, they were asked to draw images of industry - both the envisaged workplace and workforce. This was hoped to enrich the oral descriptions offered during interview. Thus, the advantages of the questionnaire data are two-fold. Firstly, the drawings provide additional data to enrich the oral data. Secondly, the views of individuals can be compared before and after the intervention, as each child was identified.

The questionnaires, like the interviews, focused on the manufacture of products related to the chemical industry. As the questionnaire focused on only one product, the range used was reduced.

The post-intervention questionnaires were collected or posted back to the Chemical Industry Education Centre. This resulted in a returns rate of 70%. Two classes involved in the project were year four children. These children did not meet the research criteria as they were too young. The teachers of these children were very keen, so it was agreed that they could participate in the project. One school did not administer the questionnaire correctly, thus they could not be used for analysis. Therefore, of the 120 questionnaires administered, 55% were used for comparative analysis with the post-intervention interviews.

3.4 Method of analysis

3.4.1 The interviews

The data which were audio taped were duly transcribed in full. These data were coded, as shown in Figure 3.3, to retain the anonymity of the participants, and to aid analysis. Each code represents a comment made by a child, teacher or industrialist. The code also indicates the school that the teacher or child attends.

Figure 3.3 Coding the data
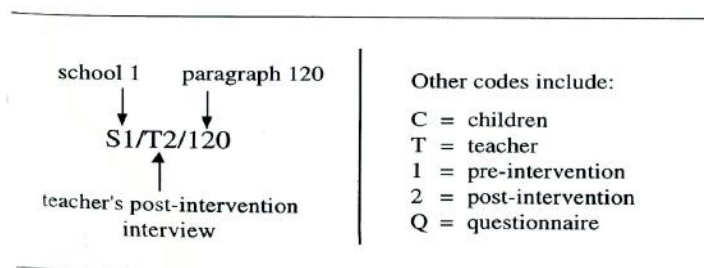
The same method of analysis was used for all the interviews. Each group of interviews was analysed separately, the groups being defined by each row of Table 3.5. Each group of transcripts was read and re-read for points of interest relevant to the research questions. Similar comments were highlighted and grouped. Figure 3.4 shows how the data analysis progressed, using the technique of 'progressive focusing', as defined by Parlett and Hamilton (1976):

> *"Beginning with an extensive database, the researchers systematically reduce the breadth of their enquiry to give more concentrated attention to the emerging issues. This 'progressive focusing' permits unique and unpredicted phenomena to be given due weight. It reduces the problem of data overload, and prevents the accumulation of a mass of unanalysed data."*

> *(p93)*

The validation techniques suggested by Hopkins (1993) were applied during the analysis. These involved 'triangulation' of methods (i.e. collecting several viewpoints of the same event) to ensure the range of data collected determined each category's justification. The project officer also looked for any contradictory evidence which might negate a category. Finally, other researchers

were asked to apply the categories to the data, and any discrepancies were discussed and dealt with. This validation is particularly important in attempting to achieve the highest level of objectivity possible, in circumstances when the researcher is also the curriculum developer, as Harlen (1975) points out:

> *"When the evaluator puts himself so much inside the materials or method being tried, there must be empathy between him and those taking part in the experiment, and his attitude must be positive or he would be in danger of undermining the confidence of the participants. Then judgement may become less objective than is desirable."*

> *(p.48)*

The researcher/project officer attempted to maintain constant awareness of her position, using systematic analysis techniques, as described below.

Initial categories were defined as patterns in the data began to emerge. These categories at first grew in number, but as patterns became more comprehensive, categories could be re¬grouped and given tight definitions.

For each group of data, analysis grids were devised. For example, for the children's pre-intervention interviews, the (gradually modified) emergent categories formed the rows; and the products used during interview forming the columns. The coded data were transferred to this grid. Re-reading was done to look for contradictory evidence to each category, as a validation procedure, and to ensure all data had been correctly positioned on the grid.

Three colleagues, engaged in science education and research, used the analysis grids to categorise data from two transcripts per group of data. This was done after the project officer had analysed 7-8 transcripts. Any differences between our positioning of data were then discussed. The categories were felt to be clear and justified, and comments made during discussion helped formulate a few new categories emerging from the data. For example, the link between risks in the chemical industry and legislation was beginning to arise in some of the teachers' post intervention transcripts, so this category was added to the analysis grid. Some data were re-categorised, using tighter definitions and new categories and sub¬categories were introduced. The project officer then continued to analyse the remaining transcripts. As the analysis progressed it was possible to see new themes emerging, and categories were created to record these themes.

Figure 3.4 Method of analysing the interviews

Fully transcribe and code taped interviews for one group of data.

Read each group of transcripts and highlight features of interest that are relevant to research questions.

Define the emergent categories, and assign coded data to them.

Refine categories, as data from additional transcripts necessitates.

Develop analysis grids, based on emergent categories.

Look for contradictory evidence to validate categories.

Colleagues validate categories using data from transcripts from each group in conjunction with analysis grid.

In light of feedback, tighten category definitions.

Re-read transcripts and, where necessary, add data to modified grid.

Transfer data to a data base, in order to manipulate and analyse the data more readily.

Repeat the procedure for the next group of data.

3.4.2 The questionnaires

It was possible to use a database immediately to analyse the children's questionnaire data, as the questions offered choices taken from the analysis grids. For the closed response questions, it was simply a matter of recording the number of each type of response. Response to the open questions could also be transferred to the appropriate categories in the database.

Analysis of the drawings required a new system of analysis. As with 'draw-a-scientist' research carried out by Newton & Newton (1992 and 1997), it was decided that common features would be identified and categorised. For example, the drawings of the place of manufacture contained people, chimneys, furnaces, and conveyor belts. The people who worked there were drawn wearing hats, glasses, overalls, boots, suits or laboratory coats. Each of these items was assigned a category in a database, and data from each transcript were duly categorised. Features in drawings that were not clear were discussed with colleagues. Either a consensus was reached on the feature, or it was assigned to the 'unidentified' category.

Criticisms have been levelled at the draw-a-scientist methodology, first used by Chambers in 1983 (Symington & Spurling, 1990). These criticisms referred to the situation in which children were asked to draw the scientists. Children were given no purpose for drawing the scientist, and were therefore given no context in which to set the person (unless they chose to do so). Symington and Spurling suggest that this situation will result in children communicating stereotypical images of scientists, even when they may hold others.

The questionnaire designed for the *Children Challenging Industry* study attempted to prevent this occurrence, by placing the drawing after a series of questions about the industrial workplace; thus setting the scene for the children's drawings.

The same process was conducted for post-intervention drawings. As a precedent could not be found in other studies for comparing these drawings (Newton & Newton used a different cohort of children in their comparative study), the project officer decided to award points for drawings that showed a more accurate representation of industry than those done pre-intervention. For example, with the drawing of the outside of the manufacturing site, one point was awarded to a drawing for each of the following:

- move from one to more buildings
- reduction to one or no chimneys
- addition of pipes
- addition of vessels/tanks
- addition of storage drums
- addition of road tankers
- addition of fork lift trucks
- addition of safety signs
- addition of specific areas/buildings (e.g. laboratory, warehouse, control room)
- addition of the company name
- significant move from many or no windows.

In a similar way, points were deducted for opposite occurrences. Therefore, a high positive score indicates better knowledge of the place of manufacture, and a high negative score indicates poorer knowledge.

A colleague, engaged in science education research, validated the categories, by allocating points in the same way as the project officer. Agreement between the two was high (84%), with the definition of one category being tightened and a few modifications made. These modifications related to whether one or two isolated features indicated a more accurate representation of industry. For example, it was agreed that the change in words one child used to label a chimney indicated greater accuracy. The first chimney was said to 'burn pollution fire' and the second chimney burned 'fumes and gases'.

The drawings depicting inside the place of manufacture were analysed using a similar points system (validated, with 95% agreement), but it was not possible to analyse the drawings of people in this way. The drawings of people often depicted a workman in overalls, wearing a hat or helmet and other safety wear, and these images are frequently seen on chemical sites. Therefore, rather than comparing each child's pre- and post-intervention people drawings, overall changes in the sample drawings was made.

Chapter 4 Children's and teachers' views of industry

4.1 Introduction

The bulk of this chapter is dedicated to discussion of children's views of industry, as their views were sought in depth. Section 4.5 deals with the teachers' views of industry, with their views of industry-education links being dealt with in chapter five.

The data from the interviews with children fall into four main categories, which form four areas of discussion in this chapter:

- children describe how they think various products are made, and the raw materials ('ingredients') used
- places of manufacture are portrayed, both orally and in drawings
- the jobs done by people employed in making the different products are listed and the people drawn, and the children discuss their views on these jobs
- children try to define the origins of their views about these industries (children's views of the links between science and industry are described in chapter five).

The majority of the data presented relate to children's views prior to the intervention. As little research appears to have been carried out into young children's views of industry, it was decided to build a large bank of data in this area. The design of both the interviews and questionnaires allowed comparison between pre- and post-intervention data in areas where children expressed a new opinion or felt they had learned something new.

Throughout this chapter, data from interviews and questionnaires have been collated. The numbers of children quoted refer to:

- individual responses from 65 questionnaires, and
- group responses made during each of 21 interviews.

N.B. These data include 41[6] responses from children visiting industry.

Individuals were not identified during interview. Therefore, where one or more children in an interview group made statements which fell into the same data category, these have been entered as one 'group response'.

4.2 Children's views of chemical manufacture

4.2.1 The raw materials used to make industrial products

Before being asked how a product might be made, children were asked from what the product was made. The number of children asked about each product varied substantially (see Table 4.1), making it difficult to compare directly the children's responses to this question. For example, 58 children were asked to describe a plastic container, and 10 children described bleach. Comparison is thus simplified by using the percentage of responses, as presented in Figure 4.1. The graph indicates the percentage of children who cited each 'ingredient' used in the four products which yielded the majority of the data.

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[6] One school received incomplete questionnaires. As a result, the analysis of children's factory drawings does not include the data from these six children.

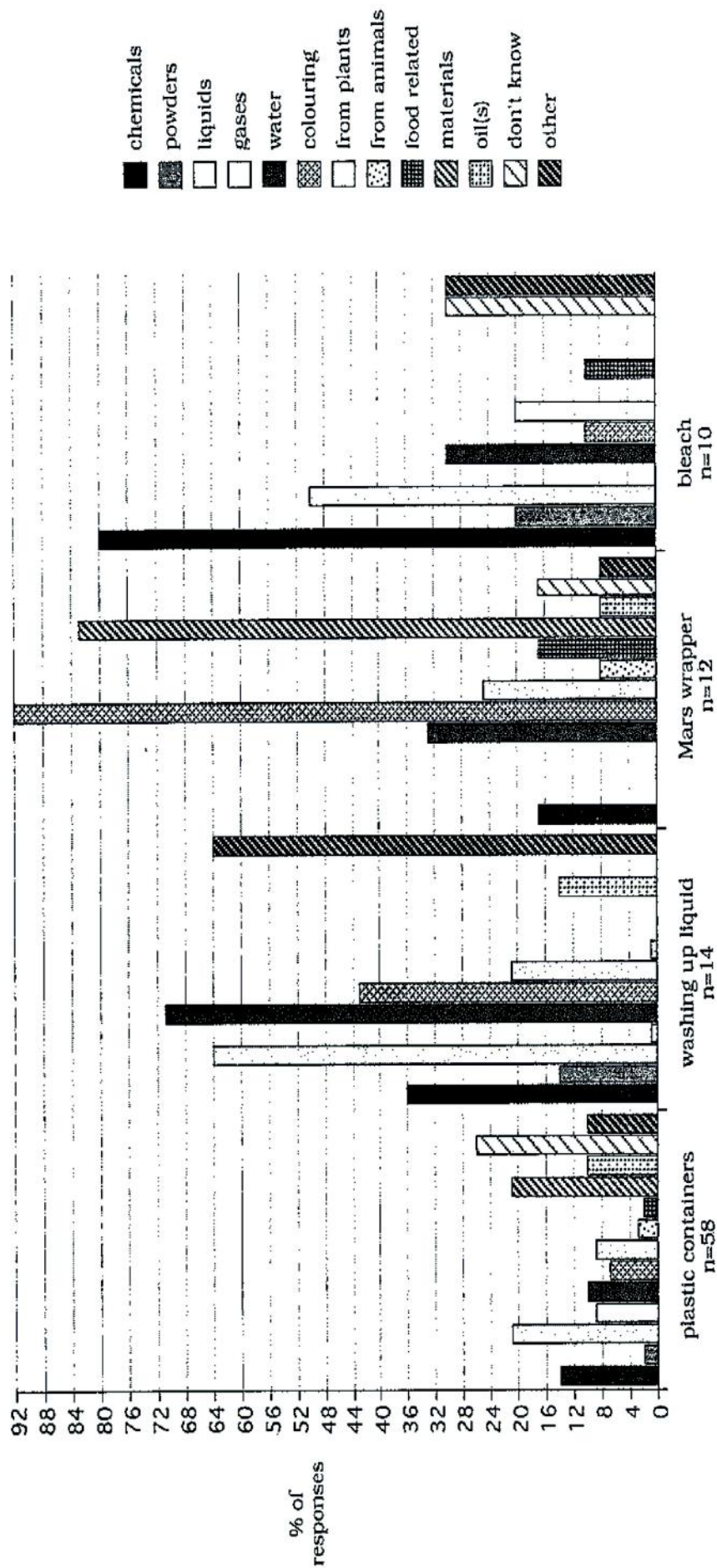**Figure 4.1 Children's ideas about the composition of products**

Table **4.1 Numbe**r of children asked about each product

Product	Number of children or groups asked (n=86)
plastic container	58
washing up liquid	14
Mars bar wrapper (incl. glue & inks)	12
bleach	10
salt[7]	16
indigestion powders/headache tablets	6
plant food (Baby Bio)	2

As can be seen in Figure 4.1, some specific raw materials were mentioned, such as water, colouring (including dyes) and oils. In addition, the category 'materials' includes specific references to paper, wood, metal, plastics, etc. The collective term 'materials' has been used, as children of this age are learning about the properties of materials such as these in their science lessons. Sand and glass are examples of materials they felt would be in plastics (and a small number felt plastic was a naturally occurring material). Card and paper are examples of 'materials' in a Mars bar wrapper.

Children spoke in general terms about many of the raw materials used to make products, using broad categories such as liquids, powders (only once was the word 'solid' used) and gases. This may seem at first to be vague, but when compared with the areas of the science National Curriculum which 9-11 year olds are learning about, this is not surprising. One of the main learning outcomes sought at Key Stage 2 which relate to 'materials and their properties' (DES, 1995) which broadly speaking covers chemistry, is:

> *"Pupils should be taught to recognise differences between solids, liquids and gases, in terms of ease of flow and maintenance of shape and volume."*

> *(p.11)*

Another set of raw materials cited by the children, and common to all of the products, is 'chemicals'. This would seem to be in a similar vein to the groups solids, liquids and gases, and perhaps encouraging, as the research focus is on the chemical industry. However, in the primary science National Curriculum, no mention is made of chemicals. Therefore, what are children thinking of when they refer to chemicals? Children using the term 'chemical' during interview were asked to explain what they meant, and children writing 'chemical' on their questionnaires were given a supplementary sheet (Appendix Eight) to draw and write about chemicals. In 18 of the 21 schools in which interviews were conducted, children referred to chemicals on at least one occasion. 19 children completed the supplementary questions after citing chemicals on the questionnaire. However, in one school, it was clear that all six children had given identical responses on their questionnaires. As it was suspected that the teacher had helped the children complete the questionnaire, these were counted as one response.

The most common responses shown in Figure 4.2 appear to reflect the 'popular' view of chemicals predominantly as liquids in bottles that are dangerous and poisonous, rather than the scientific view that chemicals are the elements and compounds from which all things derive. Chemicals are most commonly cited as a raw material for bleach - a liquid that children are warned to stay away from, as it can be harmful. One child in interview offered the following description:

[7] Children were asked where salt came from, rather than what was in it. Consensus was reached by a small number of children (7), that it came from stones or rocks, most commonly found in the sea. Only one or two children referred to other possibilities, including plants, animals and chemicals.

"[chemicals look] liquidy, and they can be different colours, and sometimes if you mix two together and they are the wrong ones, they could blow up or something"

(S3/C1/216)

Other research carried out in the United States (Nicoll, 1997) shows that many college students studying chemistry maintain the view that chemicals are unhealthy substances and that 'chemical-free' products are best, rather than, or sometimes in conjunction with, the scientific view.

Figure 4.2 Children's descriptions of chemicals[8]
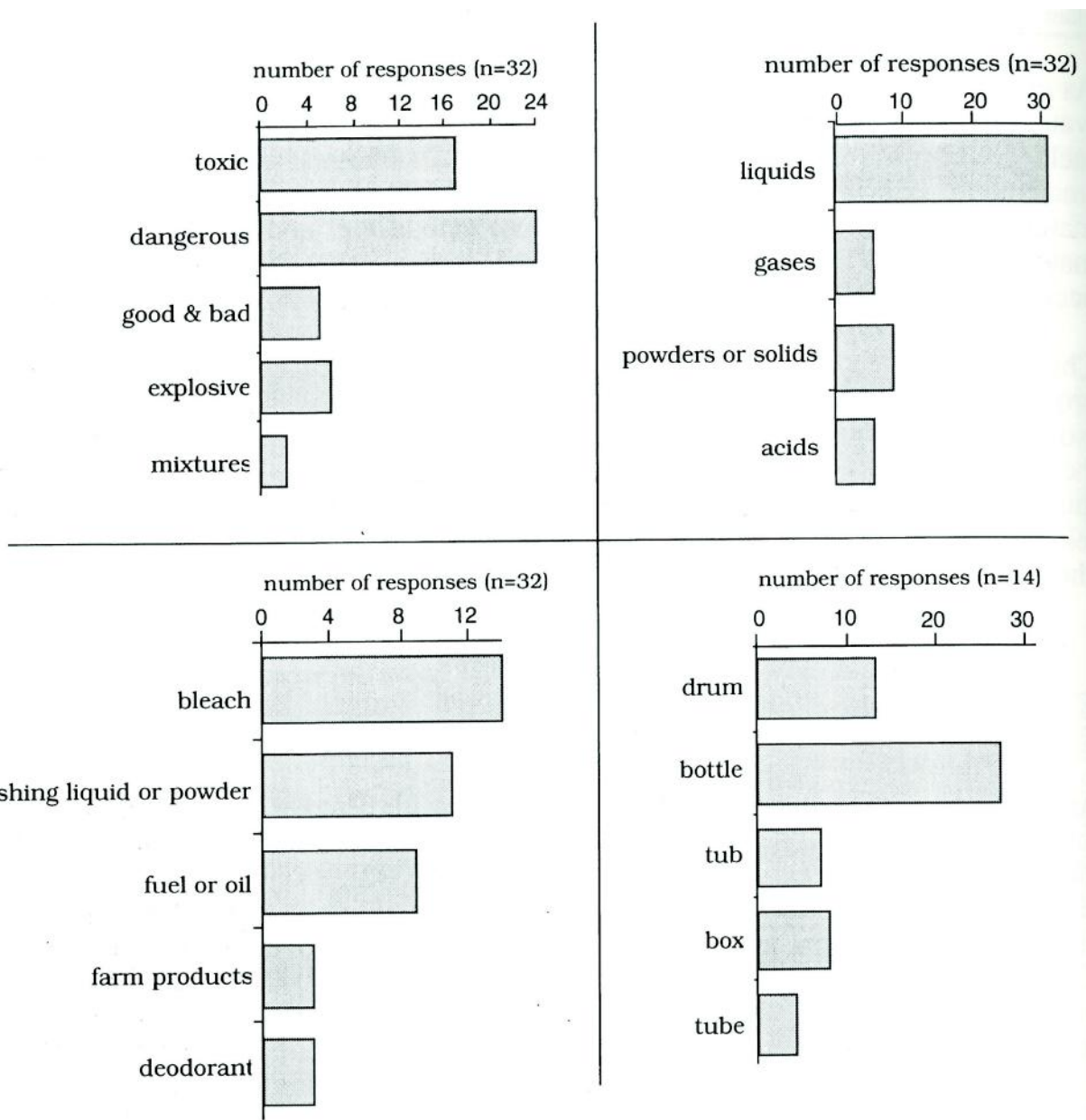
It is possible the children also recognise hazard warning labels, and associate these with dangerous substances and chemicals. On some occasions children did use warning labels to denote 'toxic' substances in their drawings.

One study of university students found that containers marked with several hazard warning

[8] These data are from 32 children or groups of children, except for the final table, which are from 14 children (questionnaire data only). The numbers in this final table are greater than 14 as each child drew several containers, as shown in Figure 4.3.

labels were deemed to be very dangerous, whilst those that were not labelled were perceived to be relatively safe (Safe, 1995). Combining this notion of warning labels with young children's perceptions of chemicals; one might conclude that children think that bottles with warning labels contain chemicals, whilst those without do not.

The project officer used the word 'ingredient' rather than 'chemical' during the classroom intervention, and advised chemical companies to do the same when children were visiting the site. This is not to suggest that it is unimportant to educate young people about chemicals in relation to the industry and everyday life, rather that the age at which this is tackled is best when children are introduced to chemicals in the National Curriculum (e.g. Key Stage 3, 11- 14 year olds).

Children who did mention gases in interview, did so after prompting from the project officer, who asked 'are all chemicals liquids?'. This perhaps led children to the conclusion that they were not, and some then cited solids or gases.

There were a small number of children who held a more balanced view of chemicals, citing both 'good' and 'bad' chemicals. One or two had a scientific view and referred to chemicals as mixtures, showing a link with their science lessons in school.

Figure 4.3 Example of the chemicals one child drew
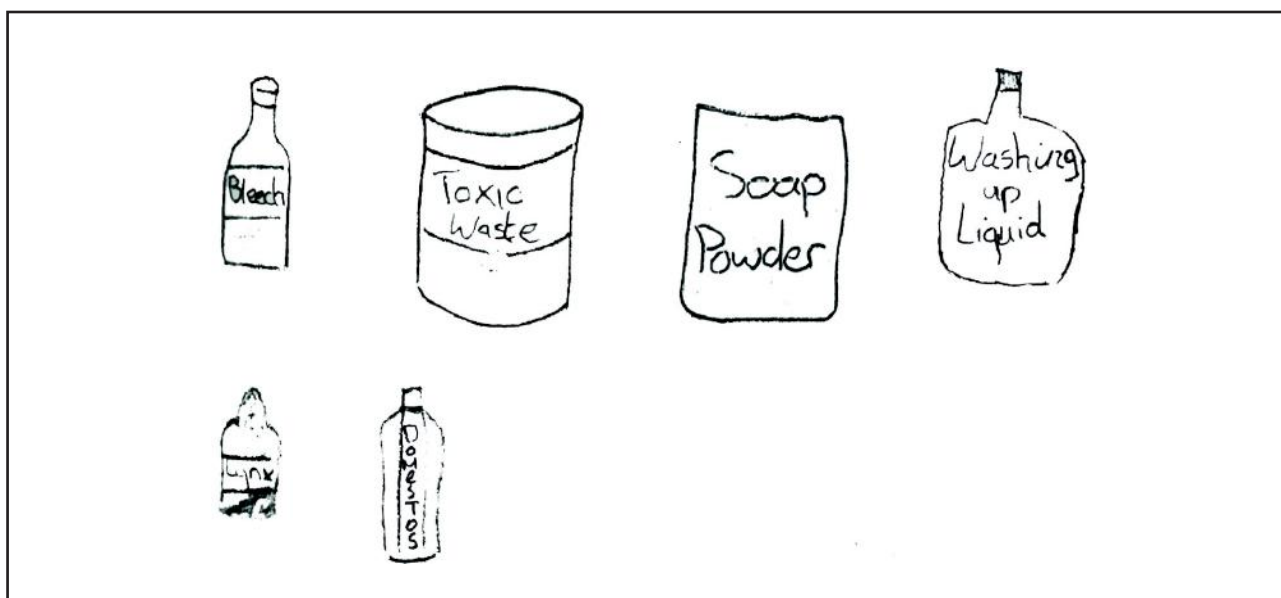
(22/4)

4.2.2   Processes involved in making products

The open ended question used in interview resulted in the following processes being most frequently cited:

- mixing
- draining
- cleaning
- sieving.

- heating
- moulding
- dissolving

- squashing
- cooling
- grinding

The findings for the four most commonly used products are summarised in Figure 4.4. Data pertaining to all products can be found in Appendix Eight.

The questionnaire asked an additional question, and that was to put the processes used to make the products in sequence. Over 50% of the children put the processes in the following order:

- plastics: mixing - heating - moulding - cooling

- washing up liquid: mixing - cooling

- mars bar wrapper: heating - mixing - cooling

- salt: cleaning - draining - heating*

* with mixing, grinding, cooling and dissolving occurring at varying times in the process.

Children referred frequently to mixing, heating and cooling - processes they are familiar with when cooking, and several children commented on this, saying it was like cooking. For example:

> *"You mix them [raw materials] together. Its a giant food blender that they have in factories, and then pour all the ingredients in, and anything solid they'd crush to turn into a liquid."*

> *(S1/C1/73)*

> *"They boil it [bleach], really boil it hot so if any germs have sneaked in there, the heat will kill them. After that they'll freeze it again, because when it cools off, when its warm, germs are quite attracted to warm things, so they'll freeze it."*

> *(S7/C1/152)*

This analogy with cooking is used by some in the chemical industry to explain how various products are made. This research suggests that this level of language is the most suitable to help children understand the chemical industry. Although the National Curriculum covers reversible and non-reversible change at Key Stage 2, an in-depth coverage of chemical change is not introduced until Key Stage 3.

Moulding was also thought to be an important part of making plastics, as children envisaged factories taking the raw materials and making a finished product of a bottle or similar:

> *"I think its a sort of liquid, and then you put it into a sort of mould and put it in a heating place, and then take the mould off and you've made a plastic bottle."*

> *(S10/C1/433)*

Figure 4.4 Processes involved in product manufacture cited by children
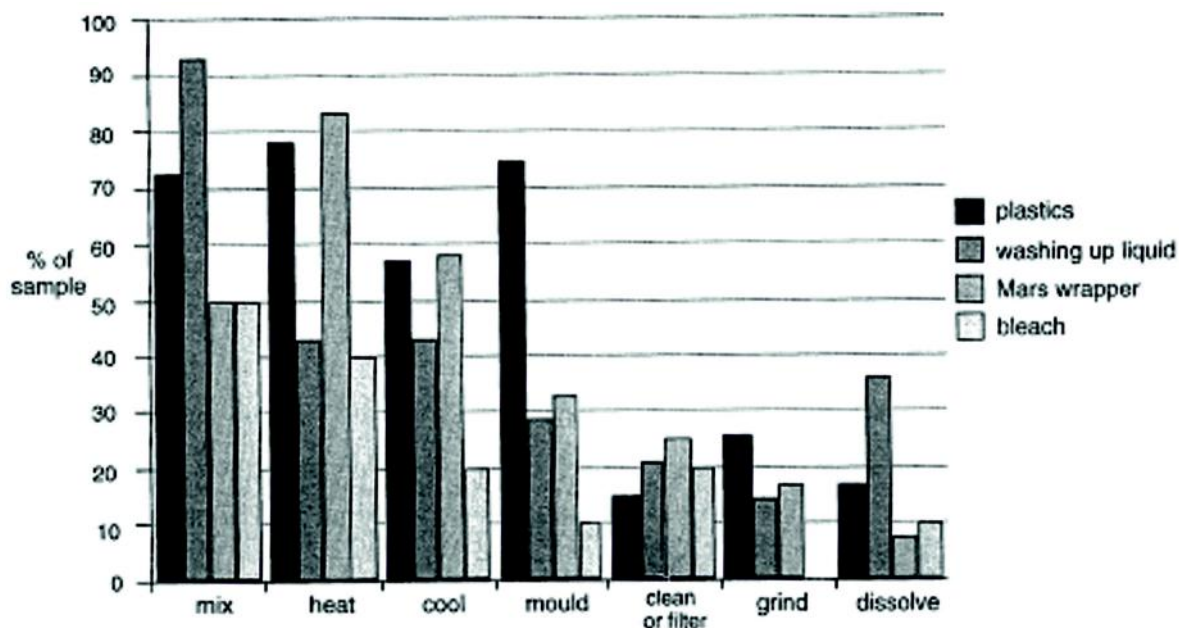
4.2.3 The place of manufacture - general views

This section describes ideas held by groups of children, not individuals. Data used has been collated from interviews and questionnaires, and includes aspects of open and closed questions and data from children's drawings.

Children from all schools referred to the place of manufacture as a 'factory', with a small number describing other places, as shown in Table 4.2. Three children referred to a 'plant' rather than a factory, and two (of the 82) children referred to a 'chemical' factory. Those who said that products were made in the laboratory were speaking specifically about headache tablets, and they felt that doctors would be involved in the production.

Table 4.2 Stated places of manufacture

location	number of children or groups (n=86)
factory	82
laboratory	7
chemical or plastics plant	3
don't know/no response	5
other (warehouse, seaside[9], farm, mill, warehouse)	11

Children offered images of this place of manufacture, describing both the working environment and the physical surroundings. Data pertaining to children's initial impressions of the working environment are given in Figure 4.5. Data for each product have not been shown separately, as there were few significant differences between the manufacturing sites described. The only two exceptions were:

-5 out of 6 children completing questionnaires on the Mars bar wrappers factory felt the factory would be clean. This reflected the fact that they also thought the wrappers would be made on the same site as the chocolate.

- 3 of the 6 children completing questionnaires on the washing up liquid factory thought it would be cold. This could be linked to the fact that heating was not thought to be a process which occurred in the making of this product.

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[9] The sea-side was commonly cited as the location for salt production.

Figure 4.5 Environment in the place of manufacture, pre-intervention[10]

number of responses (n=86)

large place
small place

many people
few people

many machines
few machines

dark
light

noisy
quiet

dirty
clean

horrible smells
nice smells

dangerous
safe

hot
cold
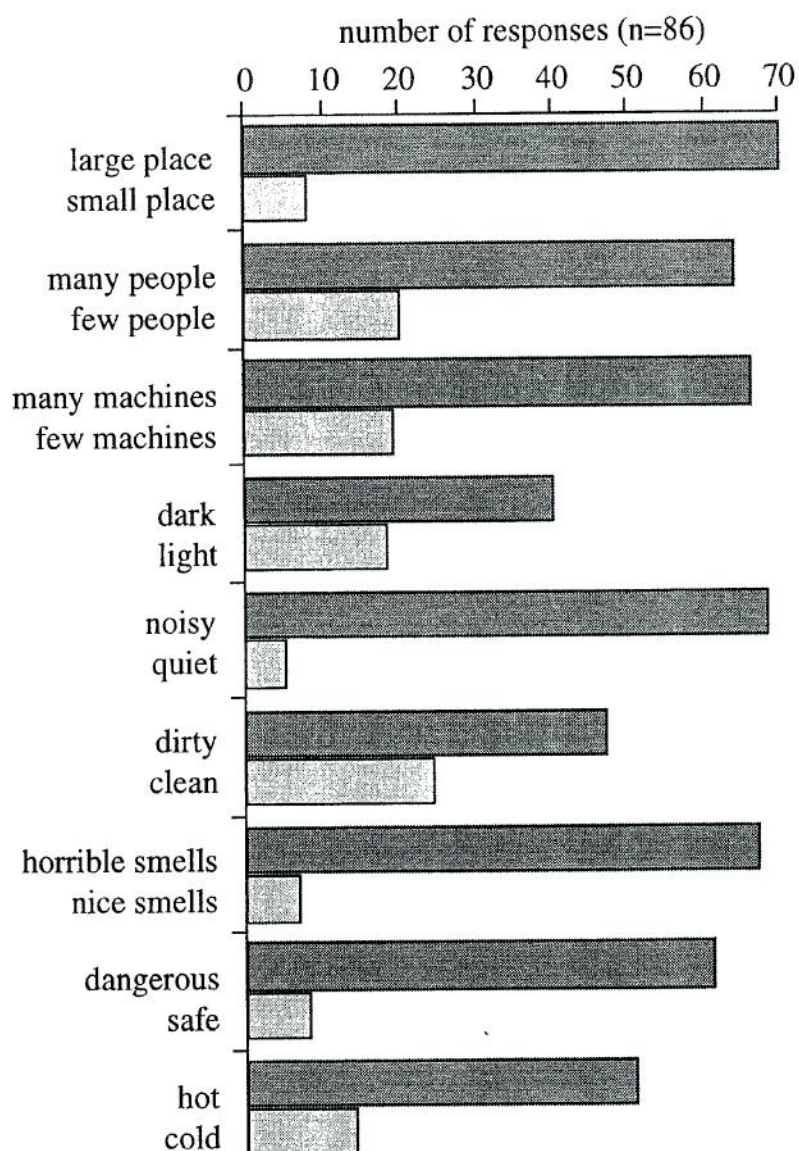
The overall picture of the manufacturing site is one of a large, dirty, hot and smelly factory, involving lots of people and noisy machines. This image is further reinforced when the physical description of the factory is analysed (Figure 4.6). The picture then broadens to become predominantly one of a busy production line, involving lots of people and noisy machines; where people fill the machines with raw materials which can spill all over the floor and the people. This potential spillage of raw materials or products is linked with the children's ideas of the process equipment used. This equipment is of a simple nature, varying from small manual mixing bowls to automatic machines which are predominantly open vessels into which people pour raw materials. Two children exemplify this view:

> *"I would say its a very big building with lots of pipes and smoke, and there'll be double glazed windows. Inside there's lots of machines and there's one that goes straight in the air and it looks like a drill and its working. There's another one that looks like a tractor and its pumping up and down and there's lots of smoke coming out of it. And if you go down a pathway there's a table with lots of people there and they're boxing the plastic bottles and things like that."*

> *(S3/C1/222)*

[10] For each pair of responses shown (e.g. noisy/quiet) the data have been presented with the most frequent response first. This does not reflect the presentation of the questions on the questionnaire, which was specifically designed to avoid children selecting responses from one column.

"[There would be] churning, like when it was churning around to mix it [bleach] all in. The machines might make noises, like the conveyor belt sometimes makes a buzzing noise when it goes across. And there'd probably be quite a lot of talking and shouting to other people."

(S9/C1/348)

Due to the children's perception that heating of the raw materials is important, there are fires, furnaces or ovens, and consequently plenty of chimneys and smoke in the images. Few children represented in their pre-intervention drawings site equipment or utilities that might exist on a chemical site, with the exception of cooling towers. During classroom discussion of cooling towers, many children thought that it was smoke rather than steam that was being emitted from the towers. Therefore, children may have thought they had drawn chimneys.

Figures 4.6 and 4.7 show changes in children's perception of industry.

Figure 4.6 Physical description of the factory
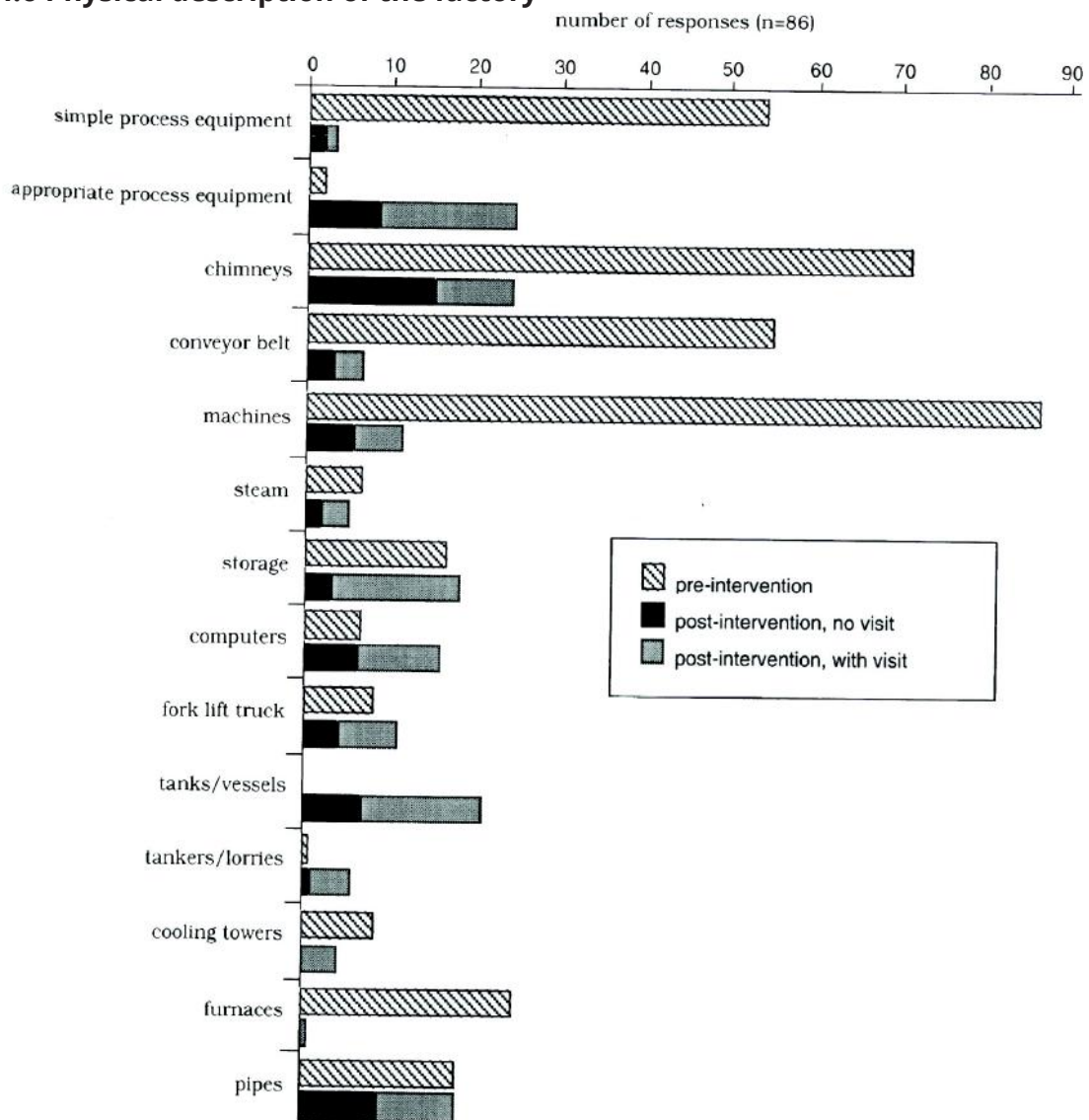
One of the first points to note is the reduced number of responses, compared with the pre-intervention data. This is partially due to the nature of the questions asked. In the pre-intervention questionnaire, responses were required to a range of closed questions. For example, each child chose one of each pair of options (e.g. noisy or quiet) in Figure 4.5. The post-intervention questions asked were open, with children also having the option of not responding at all.

In addition, where many children shared an initial image of a production site, this image was replaced with a range of images, depending on what had captured each child's interest on a site visit, or when watching a video depicting a site. For example, the high number of machines forming part of most children's initial image may be replaced by a fork-lift truck driver, a scientist in a research laboratory, or the control room.

Where the vast majority of children had described or drawn one building initially, many realised that there were large outdoor working areas (see section 4.2.2 for further discussion), and that the sites were far bigger than they had imagined. One child described the site as an 'outdoor factory' (S3/C2/104), whilst others said:

> *"The place in my imagination was like a normal factory, not very big, but when I saw it on the video, it was massive."*

> *(S7/C2/177)*

> *"The buildings are mainly made up of like big tankers and massive tubes and barrels."*

> *(S8/C2/124)*

Figure 4.7 Children's changed ideas about the place of manufacture
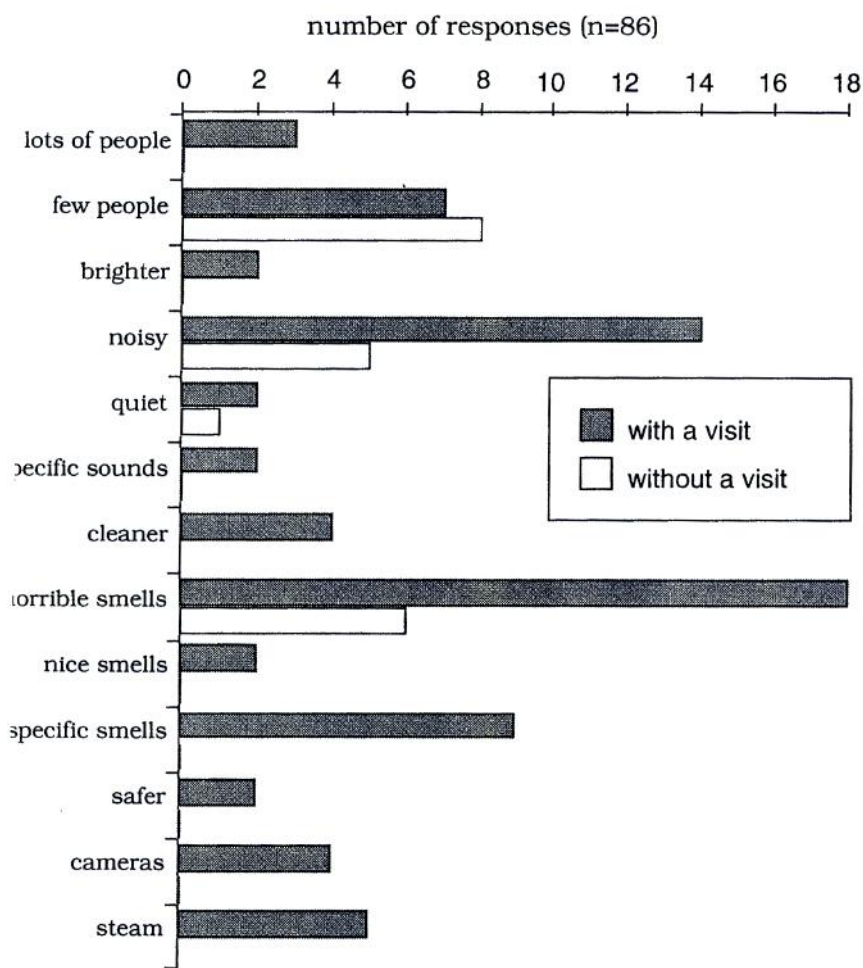
Overall, children visiting a site gained a more realistic knowledge of the working environment of a chemical plant than those who simply saw a video. However, both experiences led to children gaining an appreciation of:

- the control room and the use of computers to control chemical processes
- the small number of people needed on site.

With these points in mind, it is also worth noting the following:

• In the pre-intervention interviews, all groups of children talked about 'machines'[11] in broad terms. After the intervention, children referred to machines less frequently, but talked about filters, heat exchangers and tanks, etc. Thus they were more aware of the specific process equipment being used, and used the language appropriately. The small number of children who still spoke of machines commented on how different they were to what they had expected, or how many more there were on the site:

> "Like nearly all of us mentioned machines before - that they would be big machines, and they were. Mostly all the machines that we described were totally different. I didn't know there'd be big boilers and pans and things."

> (S6/C2/173)

• Smells and noise are a significant feature of children's post-intervention descriptions, with the majority disliking the smells on a site. Although this is not a very positive memory of a chemical site, it is a reality in most cases. There are a smaller, but significant number of children who described specific smells and sounds, but did not refer to them as either horrible or nice. Only five children felt the site had been quieter or nicer smelling than they had expected.

• The popular image of the production line, with simple processes and equipment has been replaced with a more accurate picture. This picture captures the reality of chemical sites, in that children became aware of many more of the functions performed and those on a site visit saw the actual process equipment. For example:

> "I found out that there's not many people working there, its mostly on computers."

> (S4/C2/280)

Figure 4.8 (
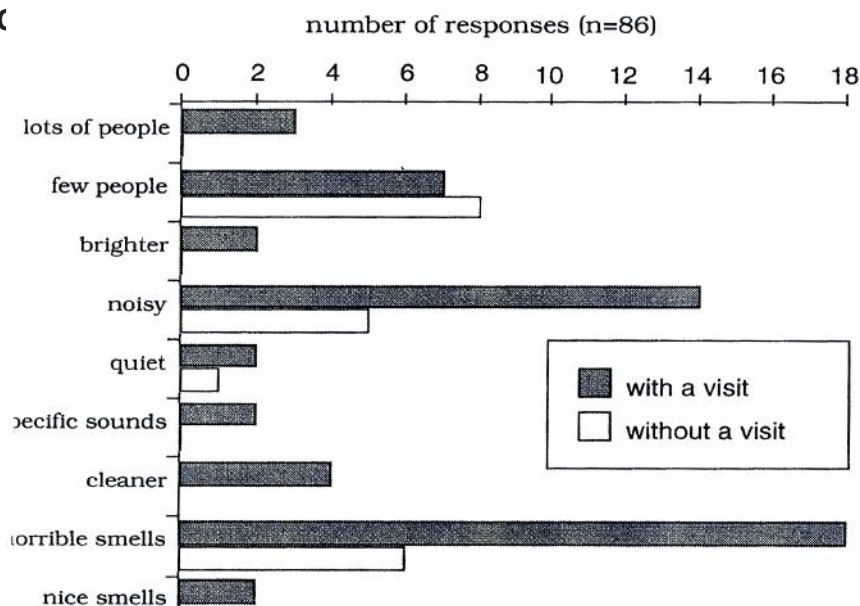
The number of furnaces, ovens and particularly chimneys dropped significantly. Figure 4.8 provides details of how many children added or deleted chimneys from their drawings. Those visiting a site have had the greatest appreciation of the site layout, and realised that the sites they visited perhaps had one chimney (which could account for children adding a chimney

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[11] Machines may have been represented in children's drawings, both before and after the intervention. However, the blank boxes drawn were not categorised. Boxes labelled for 'mixing' etc., were categorised as simple process equipment.

to their drawing). Without the site visit, the number of chimneys represented has actually increased. This may be due to the nature of the industrial video shown, which partially focused on reduced emissions and honed in on the site's chimney.

Table 4.3 Children's new ideas about the processes required to make products.

new knowledge	number of responses (n=65)
different processes	14
several processes required	10
several raw materials	6
different or several raw materials/products	16

Processes and raw materials were referred to in conjunction with the equipment used. The data show that a significant number of individuals or groups of children recognised that:

- different processes occurred to those they had envisaged, as one child exemplifies when describing extrusion:

  "I didn't know they would have a mincer, and spaghetti kind of thing coming out. I thought it would be just like a mould."

  (S2/C2/197)

- several processes might be needed to make a product, which was often an intermediate product, and not one they saw on the supermarket shelves

- processes required to produce a familiar finished product would occur in several factories:

  "I didn't know that Thomas Swan did a little bit of the ingredients of things, and they got passed on to another chemical factory."

  (S10/C2/62)

- a wide range of raw materials are used to make a product. For example, plastics are not made just from glue (in fact, not made from glue at all), and washing up liquid is not just water, colouring and perfume!

Therefore, the number of children thinking that, for example, a plastics company takes the raw material and makes bottles - and may also fill them with washing up liquid, dropped after the intervention.

4.2.4   The place of manufacture - individual views

The focus of this section is on a small, but significant set of data; the pre- and post-intervention drawings completed of the site. These drawings enable direct comparisons to be made of individual children's ideas. The means by which an individual's pre- and post-intervention drawings were compared is described in detail in section 3.4.2. Each child's score represents a change in the features represented in the child's drawings. A positive score indicates better knowledge of the place of manufacture, and a negative score indicates poorer knowledge of the place of manufacture.

The data are represented in a series of graphs in Figures 4.9 - 4.11. The scores for six children from the same school form one graph, and the school's code identifies that graph. Each figure then divides the school graphs in two boxes, grouping schools which did visit industry, and

those schools which did not. Absences on the day of the site visit were not recorded, therefore this factor cannot be taken into account. It is therefore possible that some children whose scores are shown in section (i) of each Figure did not actually visit the site. In addition, some children's drawings were not possible to analyse, due to the child's standard of drawing. These children were given a score of zero.

It should also be noted that data for school S38 should be treated with some caution. Indications from these children about other aspects of the questionnaire are that there was substantial teacher input. Therefore, it is likely that the teacher supported children in their drawings too. The data have been included, as this teacher support can only be surmised.

Figure 4.9 shows scores for drawings of the external aspects of the factory, Figure 4.10 shows scores for the internal aspects of the factory, and Figure 4.11 collates both sets of data to give an overall score for each child.

It can be seen from the graphs that the vast majority of children improved their knowledge of the 'factory'. In some cases, this may purely by realising that a conveyor belt would not be used, or that a fork-lift truck would be used. In other cases the change would be more substantial, such as a child representing reactors , a control room, or the vessels used to store raw material. (Figures 4.12 and 4.13 give examples of such drawings.)

Five of the 59 children (8.5%) had an overall score of zero, indicating no overall positive change in their perception of industry, and one child had a negative score. However, 90% of the children had a positive score, with 45% scoring 4 or more (i.e. these children were able to incorporate at least four more accurate features in their post-intervention drawings).

However, it is more interesting to break down the data into smaller sub-groups, and analyse the significant patterns emerging. The data analysed in this section are taken from ten schools, six schools which visited industry, and four which did not.

Firstly, data from Figure 4.9 show that the site visit had a far greater impact on children's awareness of all the site functions which are not inside one (or any) building. The kind of features included in these children's drawings had been seen firsthand, e.g. storage tanks and drums, safety signs, buildings for different functions, and road tankers. Children from school S38 (the school with probable teacher input) tended to draw similar scenes of a storage area depicted on the video. The average score per school visiting industry was 14.2, whereas the average per school not visiting industry was 9.0 (reduced to 6.33 if school S38 is excluded).

When looking at data in Figure 4.10, this same picture is not repeated. There appears to be no overall pattern, and the average score per school for those visiting industry (8.2) is lower than that obtained by those not visiting industry (11.5, or 11.3 not including S38). However, a pattern does emerge when looking more closely at the site visit data. Schools S22, S32, and S37 all visited sites whose personnel had received training from the project officer, and had adapted their site visit to meet the needs of the children. The average score per school in this case is 12.3, as compared with an average for the other three schools of 4.0. The latter three sites received details of the children's classroom work prior to the visit and were offered advice by letter, but were not trained by the project officer on how best to meet the children's needs.

The overall changes in children's perceptions of industry highlight this difference even more, with scores for those schools visiting trained sites averaging 28.3, scores for those visiting untrained sites averaging 16.3, and scores for schools not visiting industry averaged a score in between these two, of 20.5 (17.7, not including S38).

One site visit left both the teacher and the children with a negative image of the industry. These children were interviewed, rather than completing questionnaires. The children felt that they had not been allowed to look around the main 'factory' because it was too dangerous, and that they were being taken round the outside whilst the workers were beavering away somewhere 'inside'. The children used the word 'dangerous' repeatedly when describing their visit.

The children recounted information with some confusion, as the level of the explanations had been too high:

C: *They told us that the most dangerous chemicals are water and cyanide … because some people can drown in water as well.*

I: *What was the cyanide for?*

C: *To go into the jeans to make an indigo colour in the jeans.*

(S6/V2/C2/230)

I: *What do they do to clean it (the water)?*

C: *They sent it through a sand bed or something to get small molecules of chemicals out.*

I: *Right. What's a molecule of chemical?*

C: *I think it's just a little part.*

I: *A little part of the chemical?*

C: *Yes.*

I: *Right. OK. And was that anything like we did in the classroom?*

C: *No, I don't think so.*

C: *You don't think the sand was like a filter?*

I: *Because the sand it was just in one little tube and I think they were shoving the water through it and the sand was just collecting it.*

(S6/V2/196)

This is not to say that the site staff were at fault, as it is likely that they made every effort to simplify their explanations. However, working with children is helped if staff are trained to appreciate the levels at which the children are operating, in general terms, and in terms of their scientific learning.

The choice of company may also need careful consideration in terms of the specific image portrayed of the chemical industry. For example, two companies visited by children during this project reinforced the heavily peopled production line image, as they were involved in the final stages of production of (i) pharmaceuticals and (ii) plastic cups. These companies are not typical of the industry's bulk production of intermediate chemicals, and although they will add to the children's broad picture of industry, they may do little towards understanding the chemical industry.

This does not, however, explain why the children not visiting industry expressed a more accurate picture of the inside rather than the outside of the factory. What does is that the majority of these drawings depicted images from the video they were shown. This video did depict images of the external features, but focused on the processes occurring inside, whereas the site visit tends to balance both aspects.

Therefore, one can conclude that the best way to improve children's knowledge of industry is to follow up their classroom activities with a well-planned visit to an appropriate company. It could also be argued that a video which shows a balanced range of images of the industry is more effective in changing children's views than a visit that has not been adapted to meet their needs.

However, the data collected in this area is limited, and further investigation should be made before claims can be substantiated. Companies invest large amounts of time, effort and money in arranging and conducting site visits. It must be important to know what kind of impact these visits are having on the children, and whether a negative stereotype is reinforced, or whether children leave with a more accurate picture of the industry.

Figure 4.9 Changes in children's drawings of the external view of a factory

(i) schools which visited industry
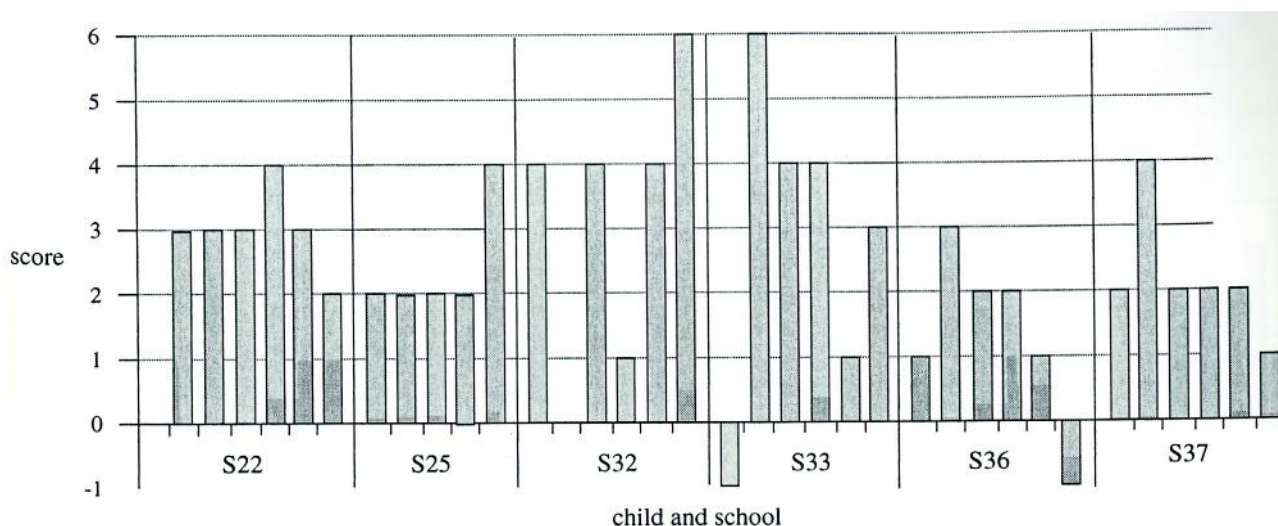
(ii) schools which did not visit industry
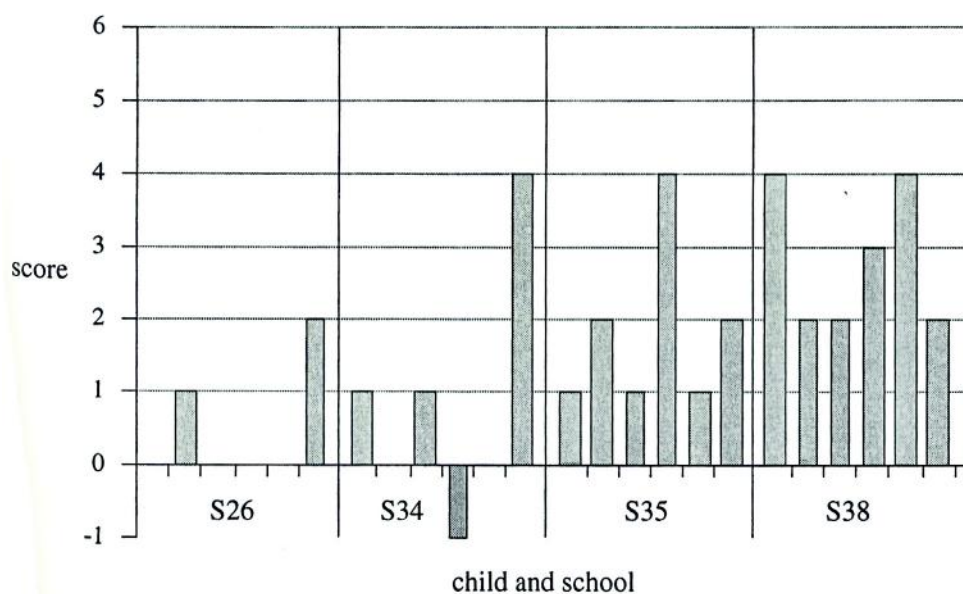
Figure 4.10 Changes in children's drawings of the internal view of a factory

(i) schools which visited industry
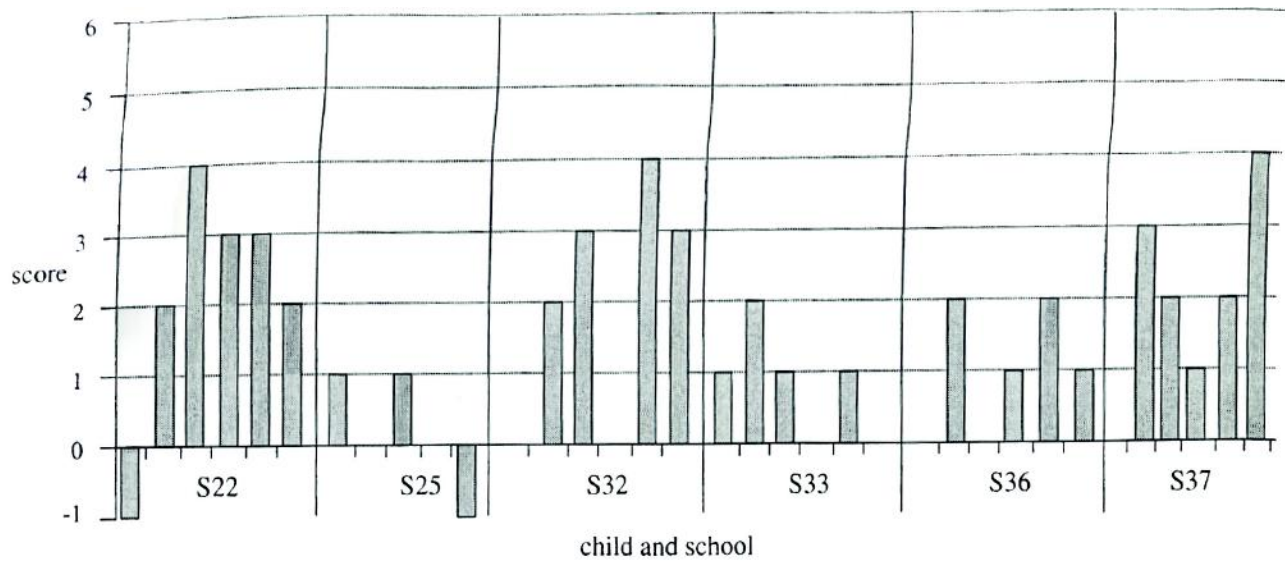
(ii) schools which did not visit industry
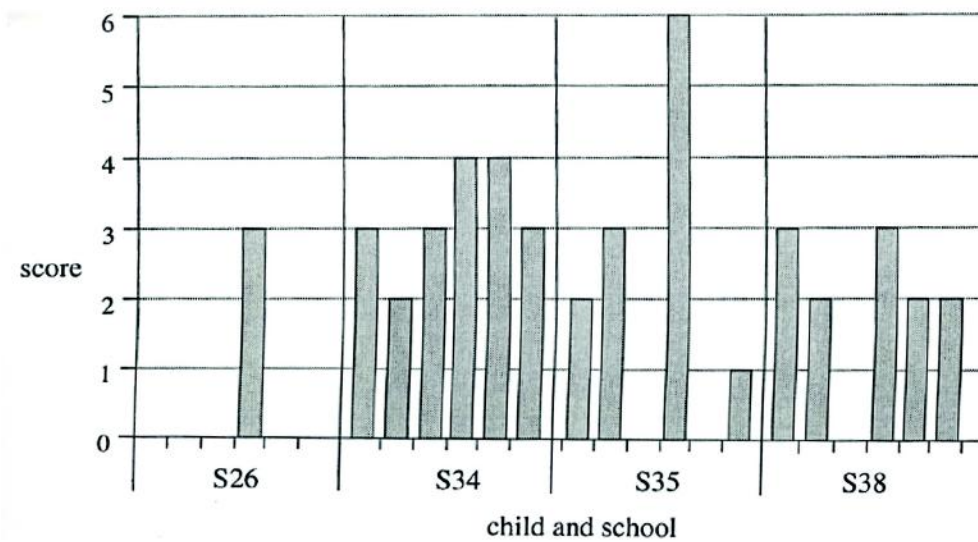
Figure 4.11 Overall changes in children's drawings of the factory

(i) schools which visited industry
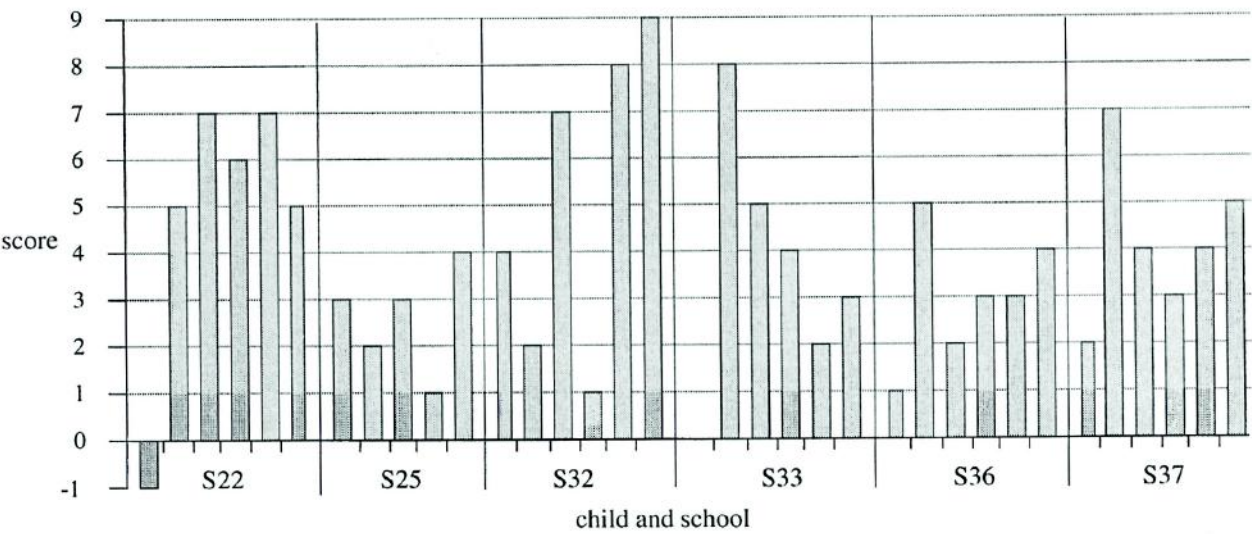
(ii) schools which did not visit industry
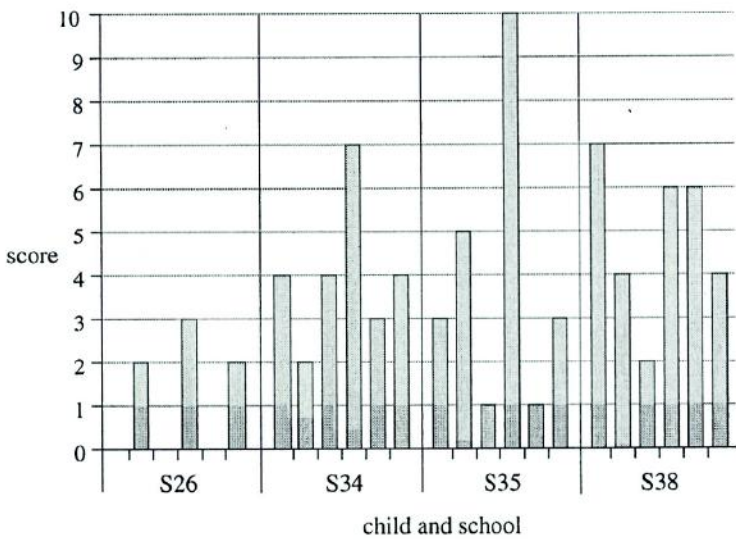
Figure 4.12 Child's pre- and post-intervention drawings with a high positive score
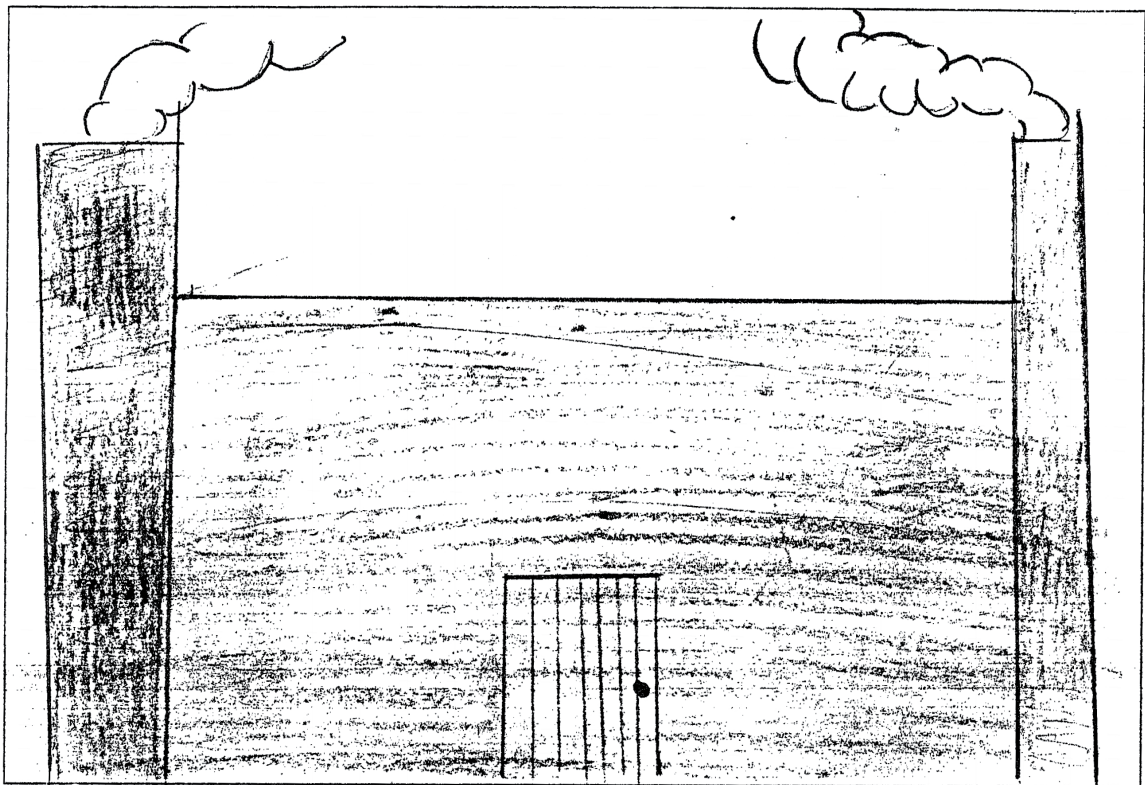
S32/c1/3
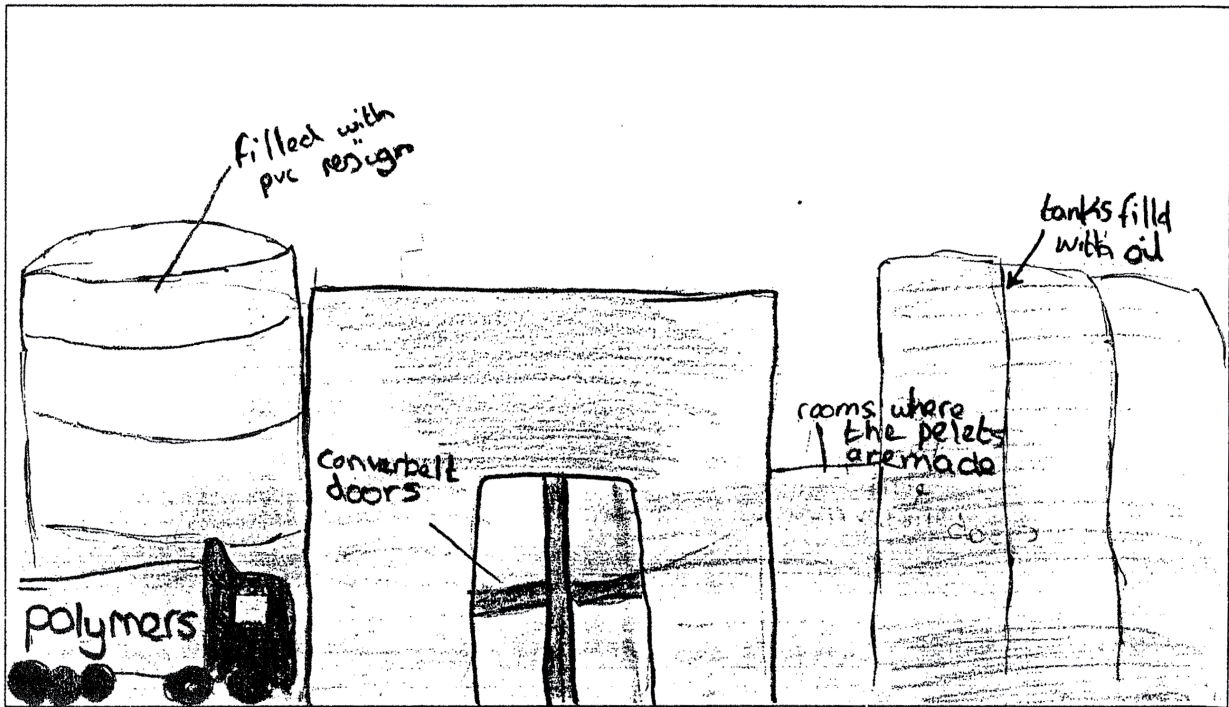
S32/c2/3

Figure 4.13 Child's pre- and post-intervention drawings with a low positive score

S35/C1/6

S35/C2/6
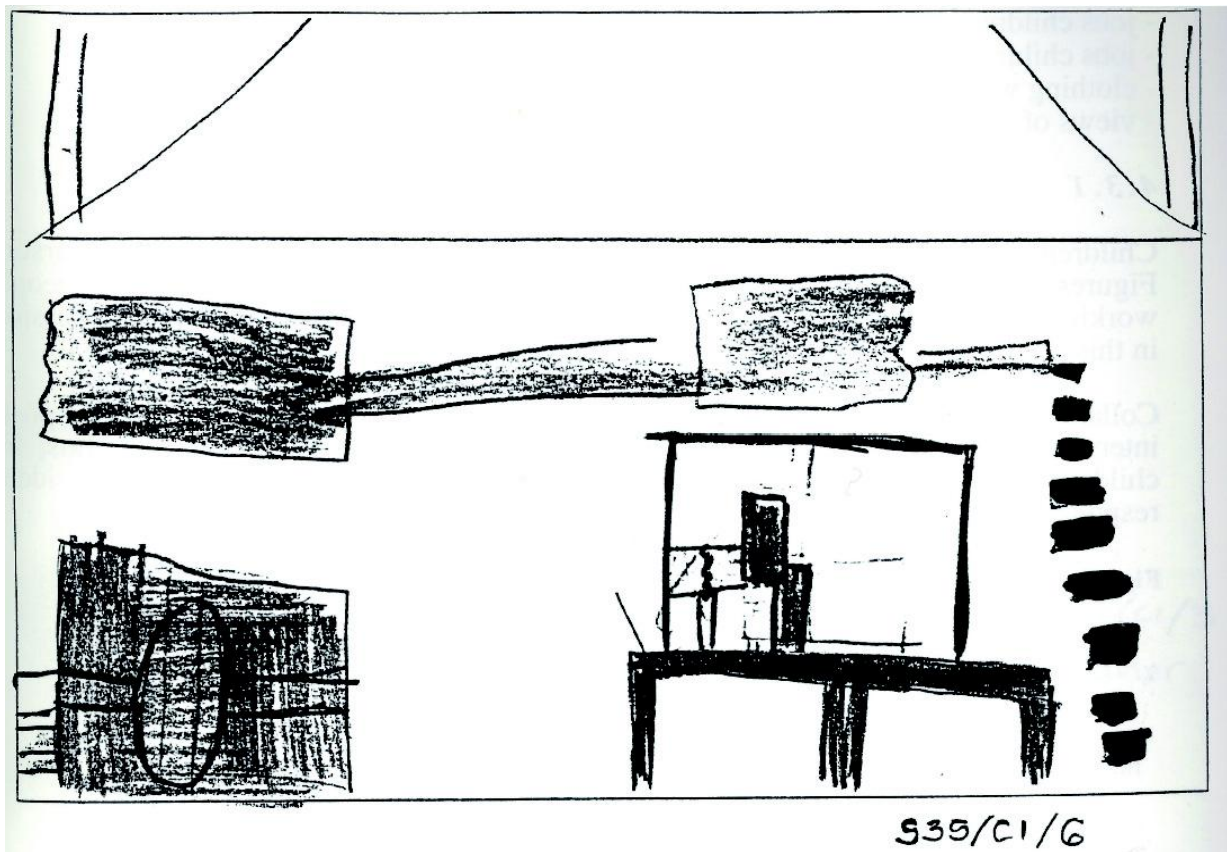
4.3   Children's views of jobs in industry

This section deals with the kind of work children felt occurred in the workplace. The discussion of the data is divided into four parts:

-       jobs children thought occurred in industry
-       jobs children felt they would prefer to do
-       clothing worn for the jobs cited
-       views of carrying out these jobs.

4.3.1   Perceptions of jobs available

Children were asked to list jobs, and draw or describe the clothing worn by the person. Figures 4.14 and 4.15 give examples of pre- and post-intervention drawings of people working in industry. These drawings typify the data collected, and support discussion in this section.

Collated data is presented in Figure 4.16 and, as with previous data, the post-intervention data represents any new jobs of which children are aware. Thus, all children responded to the pre-intervention questions, and only children with new ideas responded to the post-intervention questions.

Figure 4.16 Jobs that children stated as occurring in industry
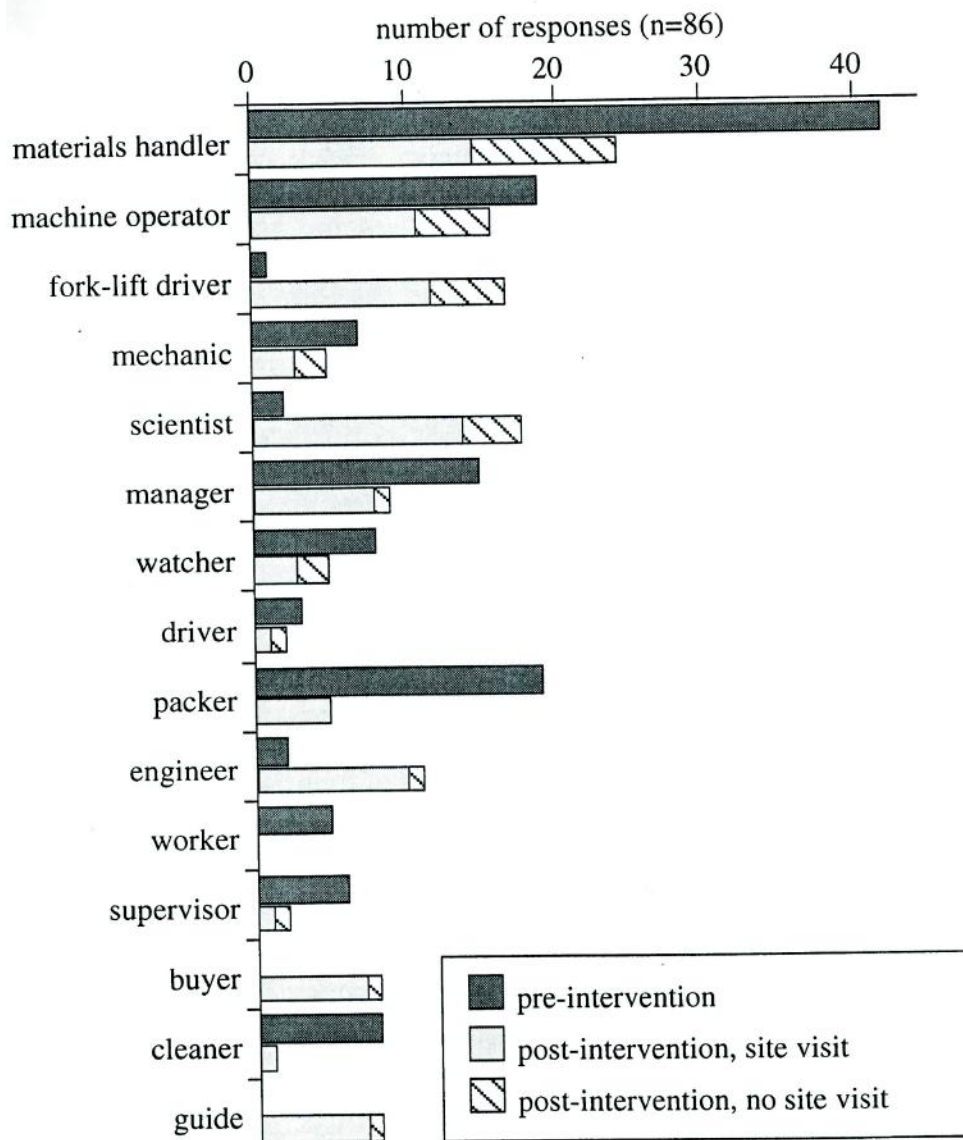
Figure 4.14 Pre-intervention drawings of people who work in industry
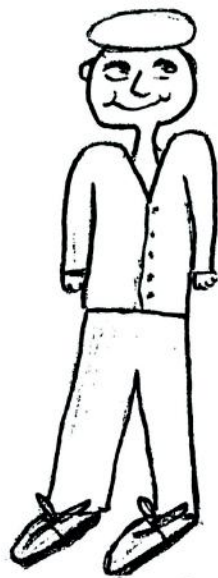
S22/C1/5
he makes sure the
machinery is safe

S24/C1/3
cleaner

S34/C1/6
'machinery'

PL.
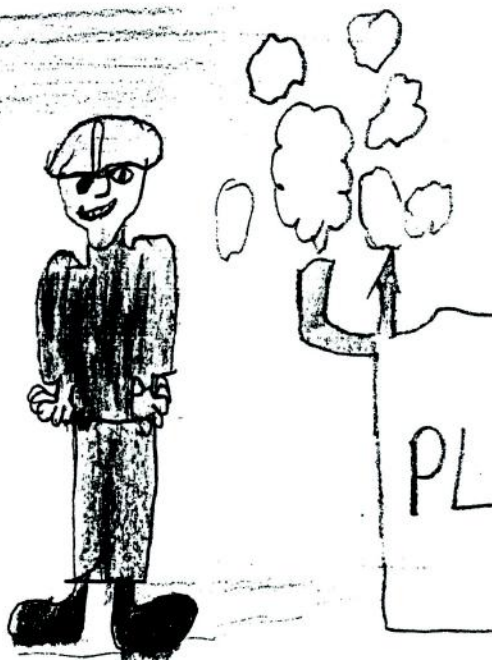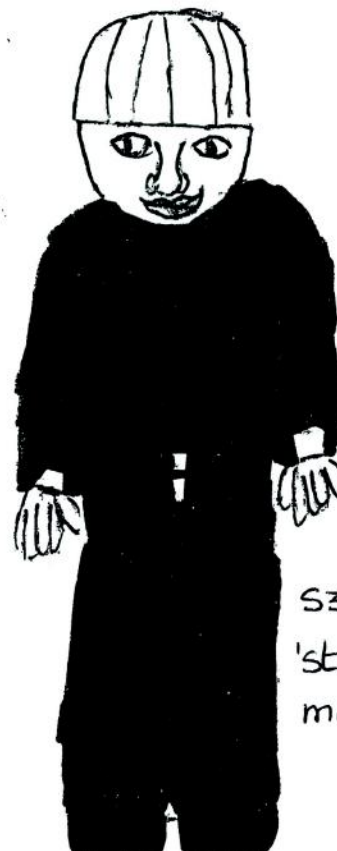
S35/C1/3
'starts the
machines'

Figure 4.15 Post-intervention drawings of people who work in industry

S22/c2/5 scientist

S24/c2/3 unloading resin

S34/c2/6 expanding polystyrene

S35/c2/3 fork lift truck driver
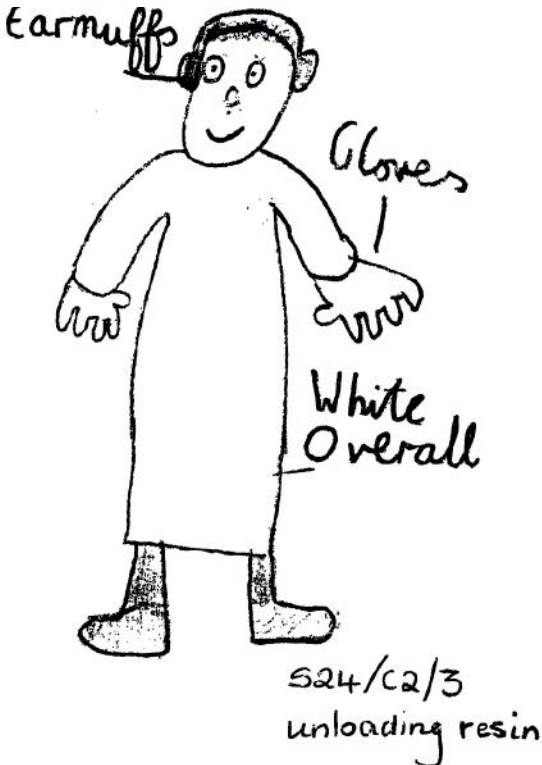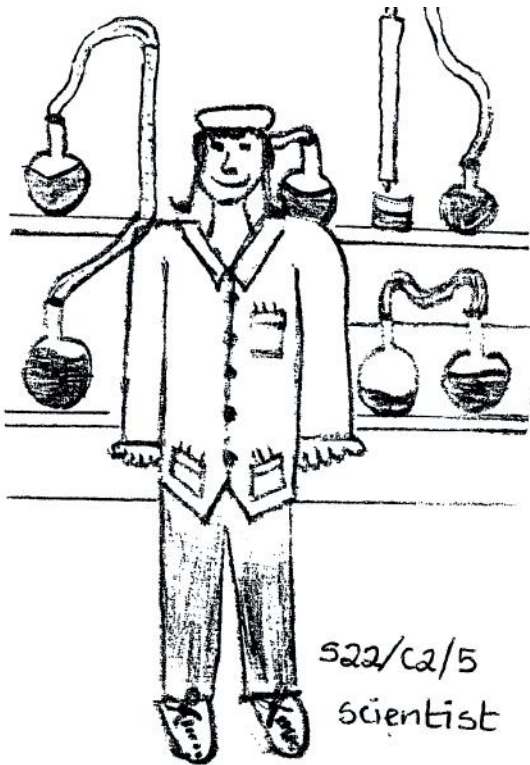
The job of handling materials directly (e.g. pouring, mixing, heating, squashing) was the most frequently stated job as occurring in a factory. However, those who stated this job post-intervention, did so often with reference to specific jobs seen on-site. For example, children saw people transferring large wheeled tubs of powders on one site, and people breaking up trays of toffee-like resin on another.

Post-intervention, jobs such as cleaner, packer and 'worker' are less prominent, and new jobs are cited which are of a more professional nature - scientists, engineers and buyers. The fork-lift truck caught the interest of many, and featured in several children's drawings, and as preferred jobs (see Figure 4.17).

Three of the girls who had had the opportunity to meet female chemists on sites, drew female scientists on returning to school. There were no drawings of female scientists in cases where children did not see any role models. In fact, few females appeared to be drawn at all[12]. All female images are listed in Table 4.4. There were more female images before the intervention, but these tended to be involved in manual work. Although the industry has a predominantly male workforce, there are female scientists, engineers, etc. and the masculine image was hardly altered by the intervention. This perhaps highlights the need for future site visits and video footage to redress the balance.

Table 4.4 Images of females in children's drawings (n=65)

job	pre-intervention	post-intervention
materials handler	10	2
scientist	0	3 (all from site visits)
watcher (of materials/machines)	1	0
supervisor	1	0
nurse	1	0

During the training session offered to company personnel, the project officer suggested that those acting as guides use this opportunity to explain to children what their own jobs were. Children remembered the people they talked to on a visit, and several drew their guides on returning to school. Where this is not done, children think that being a guide is a full time job (this does occur on a limited number of sites), as can be seen from Figure 4.16.

The site visit certainly has the biggest impact on children's awareness of the variety of jobs required to run an industrial site. A small number of children who did not visit industry mentioned scientists, engineers, managers, etc., but the vast majority of references were made by those who had been on the site and met many of these people face-to-face.

As some children initially thought that all aspects of a product would be made in one factory (e.g. the Mars bar factory also made the wrappers, printing inks, glues and boxes) it is also worth noting that the number of children citing jobs related to other products fell substantially from fourteen to one. As discussed in section 4.2.3, this is due to children realising that a factory does not make all associated products, but perhaps makes an intermediate product to be passed on to another factory.

[12] It was only possible to categorise the gender represented in 74% of children's drawings. This was done primarily using he/she statements accompanying drawings.

4.3.2 Children's job preferences

The pre- and post-intervention data have been collated in Figure 4.17, with post-intervention data consisting only of different preferred jobs. Therefore, only children that had changed their minds during the course of the intervention responded to the question. Hence, there are no data for the categories 'none' and 'don't know'.

Any changes in children's preferred jobs seem to relate to the jobs they saw on the site visit, or those they were made aware of during the classroom sessions and videos. Clearly, the biggest shifts are in the number of children who would like to be scientists (or 'testers') and computer users.

As previously stated, the control room was a prominent feature of both the site visits and the video seen by many children. As primary children are generally confident when using computers at home or school, and they enjoy using them, it is hardly surprising that some children would wish to continue to use computers in the workplace.

The number of children wanting to be scientists is made up equally of those who did and those who did not visit industry. This may have depended on the site which the children visited, and the emphasis each site placed on the importance of scientists to the work of the site. Sometimes, companies can be keen to tell the public about what they make, but spend little time linking the processes to the people behind them, and how this relates to children and the work they carry out at school. The classroom sessions were designed specifically to link the science done in the classroom with that done by professional scientists on a site, therefore it is good to see that this message came across, regardless of the site visit.

Figure 4.17 Jobs that children stated they would prefer to do in the factory
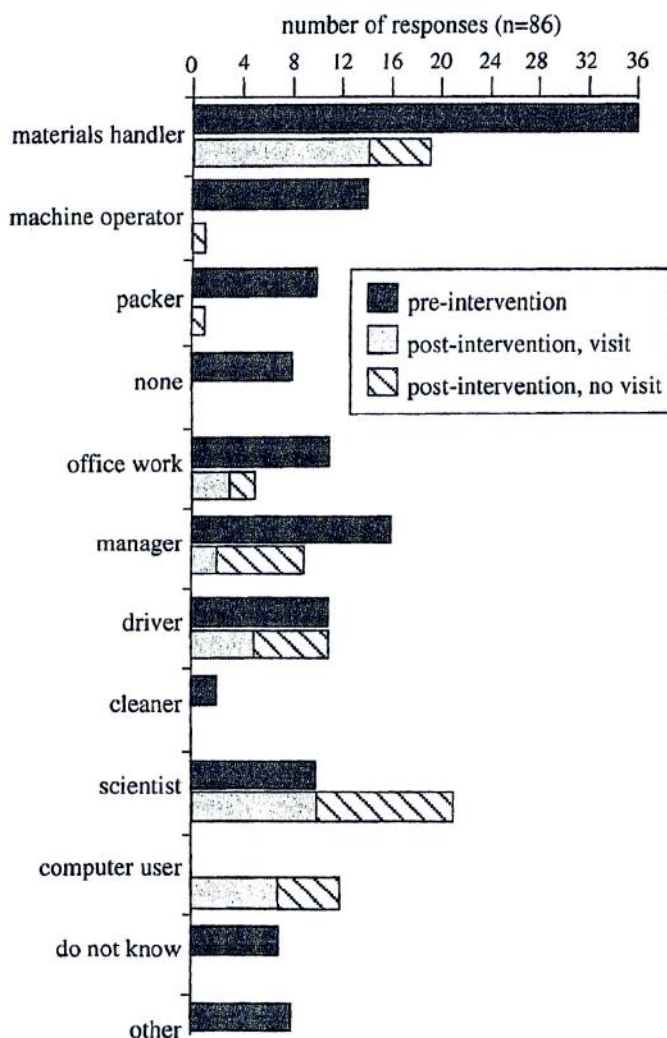
4.3.3 Clothing worn in industry

The children's drawings in Figures 4.14 and 4.15 give examples of the views of clothing worn in industry. Children's initial view was typically one of a man wearing overalls, some kind of head protection, and boots. As this is also quite typical of people seen around a chemical site, little change was noted when the initial drawings were compared with those drawn after the intervention. There were some slight differences, which can be seen in Figure 4.18. Overall, more children drew people wearing laboratory coats, ear defenders and glasses, which links with other findings that children represented a wider range of jobs after the intervention. Less significantly, fewer people appeared to wear boots and company badges. However, it was not always possible to distinguish boots from shoes.

Figure 4.18 Children's drawings of clothing worn in industry
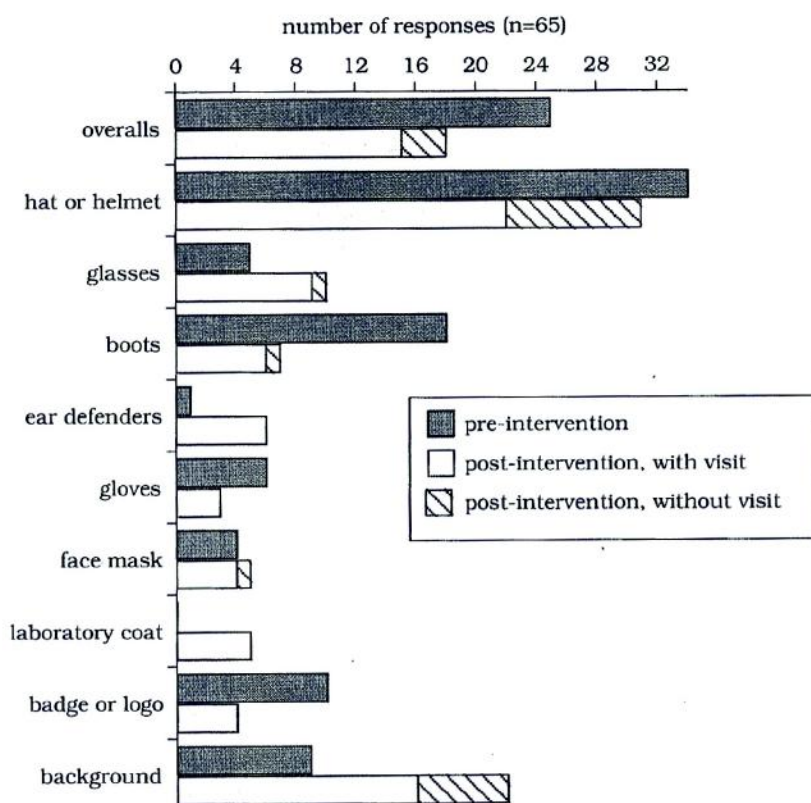
The total number of safety wear depicted hardly differs, being 93 before and 87 after. Due to the nature of the children's drawings, and the option for them to draw a different person after the intervention (i.e. a new job which they had learned about), it was not possible to compare an individual's drawings.

However, the interview data shows that a number of children did feel that they had either over-dressed or under-dressed their initial employee. These feelings were expressed by children from eight schools that had visited industry, and six schools which had not. These children have gained a more accurate view of the safety wear, whether it be a reduction from complete head-to-toe protection (rather like an astronaut), or a realisation that gloves had to be worn in some areas of the site but not others:

> *"Their whole face wasn't covered up. They just had like a shield to pull down over it, because there wasn't really much of a risk of getting it splashed on you as I'd thought."*

> *(S10/C2/204)*

To counterbalance the increase in laboratory coats, some children realised that not all scientists dress like this stereotype, and do not always need to wear protective clothing:

> *"The scientists don't wear big white coats, gloves, goggles and a hat. They just wear jeans and a T-shirt sometimes."*

> *(S8/C2/86)*

The majority of the safety wear depicted in drawings after the intervention were by those who had been on a site visit. So, although children saw video images of people in safety wear, the biggest impression was made upon children who met employees face to face.

It is also interesting to note that few children initially placed their employee against a background, and these tended to portray simple process equipment, tables, furnaces and box¬like machines. The higher number of children adding a background after the intervention tended to add a background that they now knew of, via the visit or video. For example, children added fork-lift trucks, scientific testing equipment, and processes seen.

In interview, children were asked why they thought any safety wear was worn. The responses fell into three main categories:

-      for personal safety: 12 groups
-      to keep clean or dry: 6 groups
-      to protect the product: 6 groups.

All of these responses are appropriate, depending on the nature of production. On most sites manufacturing bulk chemicals, the prime function of safety wear is to protect the employee from various hazards, such as contact with chemicals or damage to hearing. However, on sites manufacturing pharmaceuticals, the prime function of the safety wear is to maintain a sterile environment, and thus protect the product.

4.3.4 Views of working in industry

Children's initial views of working in industry were gathered, and these are presented in Figure 4.19. The responses were quite varied, and it must be borne in mind that many children were describing particular jobs that they thought would be the best jobs on the site, such as the manager, the 'heater', or the 'tester'.

The majority (66 responses) thought it would be hard, tiring and boring. These children were often referring to the worker on the production line, mixing raw materials, packing boxes, and 'watching' what was happening. Responses from 44 children and interview groups felt the job would be exciting, fun, good or interesting. A small number of those who thought the job would be exciting, did so because they liked the idea of dealing with explosions and dangerous situations. On the other hand, children from six interview groups thought that the job would be acceptable as long as they knew exactly what to do, and could therefore avoid dangerous situations.

Several of those who thought the work would be easy were referring to particular jobs of interest - such as office work, being the 'boss', or operating machinery.

Other comments made by children fell approximately evenly into either positive or negative views. For example, negative comments made included the work being fast, dull, unsafe and 'stupid'. Positive comments included the work being adventurous, brilliant, well paid and outstanding.

Figure 4.19 Children's views of working in industry

number of responses (n=86)

Category	
tiring or hard	(bar to ~37)
repetitive or boring	(bar to ~28)
easy	(bar to ~28)
fun or exciting	(bar to ~36)
acceptable with knowledge	(bar to ~5)
good	(bar to ~3)
messy	(bar to ~3)
interesting	(bar to ~1)
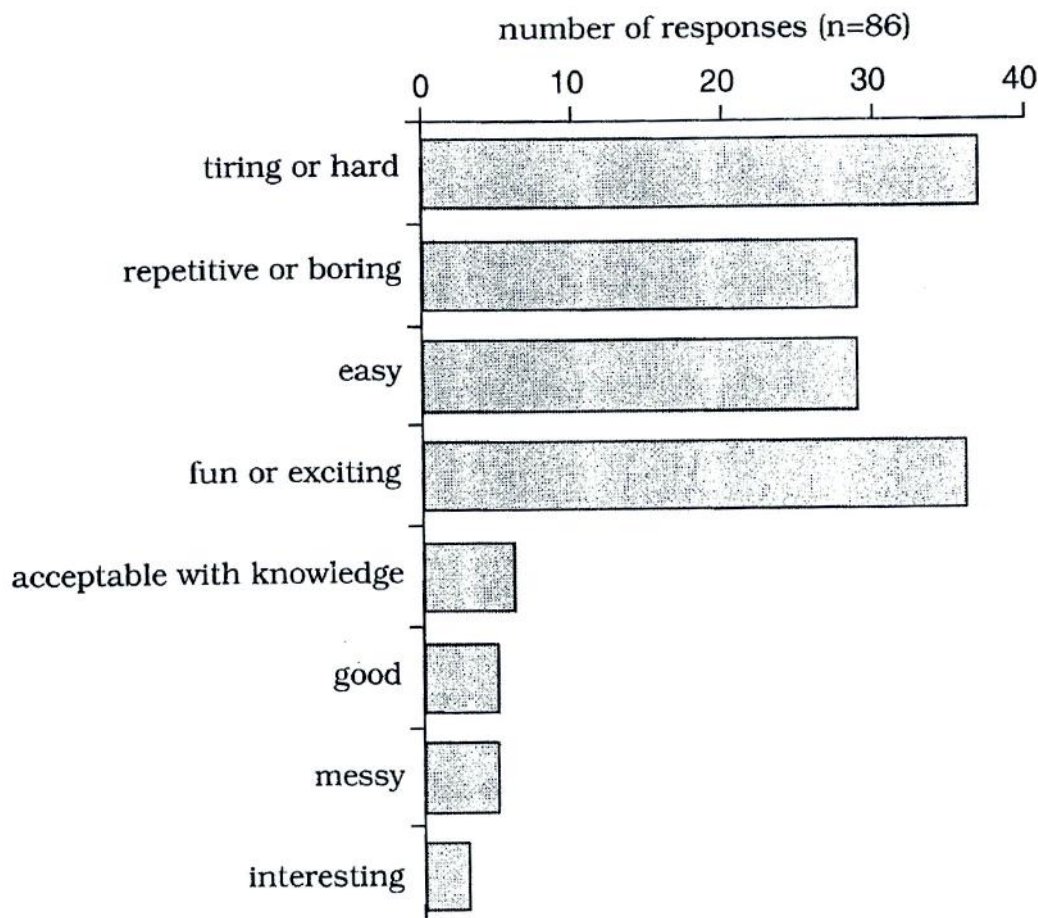
4.4 Origins of children's views

During interview, children talked very generally about the origin of their ideas, and clearly pieced together their information from several sources - be they fact or fiction. These ideas were also not specific to a product, but any factory they had seen in any context. Therefore, the information in this section relates to factories that might produce cars, chemicals or clothing. Children had limited images of factories, and tended to gather these images together to create one picture. The numbers of children citing different origins of their ideas are shown in Figure 4.20.

The most common source of their ideas is the television, with eight children also children mentioning newspapers or radio. On four occasions, children referred specifically to programmes for schools, but the vast majority identified programmes they watched at home. Twenty children or interview groups specified the news, including Newsround, specifically designed for children. Other programmes included nature programmes, science fiction (such as the X-files), soap operas, and one reference to science programmes.

A high number of children felt they gained their ideas from passing factories, either on local industrial estates or the large industrial complexes on Teesside. There was also a surprisingly high number of children who said they had visited industry. Occasionally, these visits had been via their school, but most frequently they were as a result of a family member taking them to see their place of work, or the places they went to during the course of their work (e.g. security work or driving). Types of work places children had visited varied from clothes factories to security lodges, as children grouped many work places under the umbrella heading 'factory'.

Figure 4.20 The origins of children's ideas
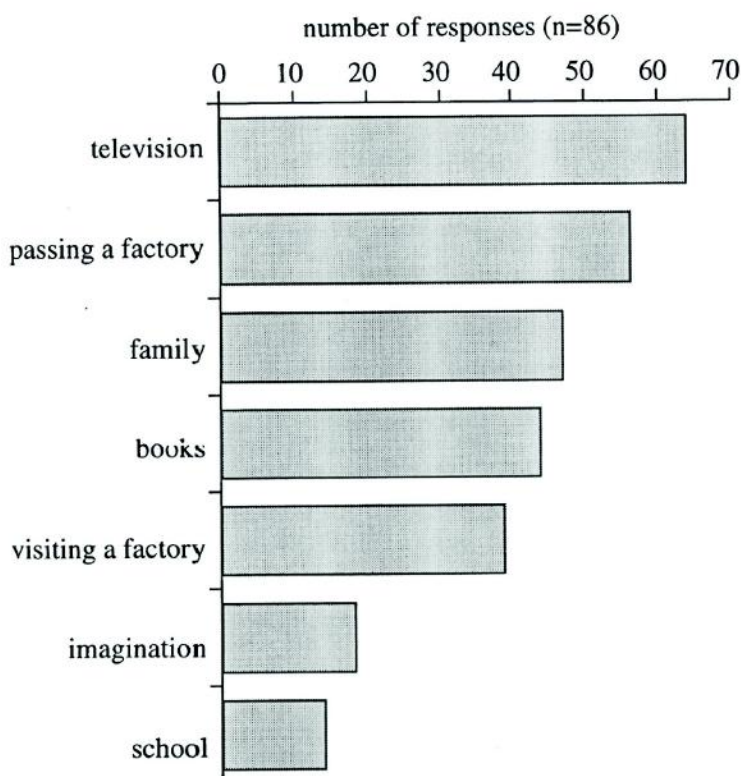
It is most interesting to note that the least mentioned source of children's ideas was school or their teachers. Only fourteen children felt that they gained information about industry during lessons. This lack of information from school is discussed in more detail in chapter five, where the teachers' views of school-industry links are described.

4.5 Teachers' views of industry

4.5.1 The chemical industry and its products

Before participating in the project, 41 teachers were asked to describe the chemical industry (Table 4.5). Over half of these teachers expressed either a lack of confidence or found it difficult to describe the industry. Over half the descriptions offered were general or vague and included phrases such as the industry makes chemicals or 'things'. However, it is worth remembering that 85% of the teachers involved in the study had no industrial experience. Of those who had had experience, this ranged from manual labour on chemical sites to software engineering and water treatment management.

Table 4.5 Teachers' descriptions of the chemical industry

Description	Number of teachers (n=41)
not confident to describe	22
makes chemicals	15
makes 'things'	11
polluters/dangerous	14
mysterious/little information	10

Three teachers referred loosely to intermediate chemicals or compounds, with the majority of teachers feeling much more comfortable listing familiar products, whose origins were seen to be in the chemical industry (Figure 4.21). To be fair to the teachers, definitions from informed

sources tend to include a list of products to which the industry contributes (CIA, 1995; CIEC, 1998), in addition to references to chemical changes. For a definition of the chemical industry, as proposed by the Department for Education and Employment, see Appendix Nine.

One teacher did describe raw materials being changed or 'baked' by various processes to produce something to be used by another industry - and this was one of the most technical descriptions.

Teachers referred most frequently to plastics. As many of these teachers were about to embark on the series of activities related to plastics, it is possible this may have affected the products that came to mind - a link which one teacher actually stated, saying:

> *I can't get my mind off plastics now, its the only thing I can focus on.*

> *(S31/T1/56).*

There is a fairly even spread of responses between household products (washing up liquid, bleach, toothpaste, soap, etc.), agrochemicals (fertilisers, pesticides and feedstuff), inks, petrol and clothing. One or two teachers referred to food additives, batteries, contact lenses, and beer. Two teachers talked on a similar level to the children, referring to the production of 'liquids', with one stating:

> *"Its got to be liquid, in my mind, paint and ink and things that can be melted and moulded and cooled again."*

> *(S35/T1/30)*

Figure 4.21 Products that teachers associate with the chemical industry (n=41)
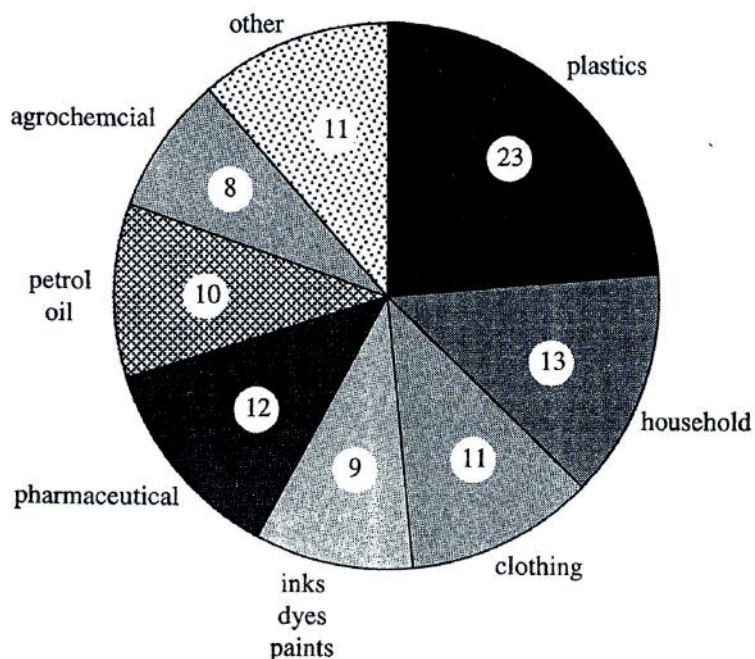
It seems that because intermediate chemicals do not play a role in our daily lives in the obvious way that the finished products do, they were not part of the teachers' definition of

industry. As two teachers stated (one of whom had worked on a chemical site, installing plant equipment):

> *"So you tend to think of it in those terms - large mysterious things. That you haven't got a clue. You don't know what the start of it is, you don't know what the end of it is. It's just mysterious."*

> *(S16/T1/12)*

> *"I think the only problem is, there's more of a mystique about it [the chemical industry, in relation to other industries] because a lot of the things they produce, apart from the ones that you see obviously marked up with 'ICI' and stuck on the outside of feedstuffs, agricultural chemicals and fertilisers … you don't often see things that are overtly chemical in nature."*

> *(S6/T1/16)*

This sense of mystery and lack of knowledge led some teachers to describe the chemical industry in a fictitious way similar to the children - and note the similar inclusion of chimneys:

> *"You still see chimneys with smoke coming out of them, not old fashioned mills and things. I have this vision of men in white coats and test tubes and things bubbling away. It's a bit like a James Bond scenario."*

> *(S28/T1/8,16)*

One teacher, who was aware she had limited knowledge, knew that there were some technical aspects, and combines this with the more common 'dirty' image:

> *"I know a friend's husband who works at ICI. He works in the computer bit of the department, so I do know that its not all hands-on, dirty stuff."*

> *(S29/T1/18)*

There were a small number of teachers who did appreciate the wider picture of the chemical industry. One teacher described a site as a 'large chemistry set', and another talked about the 'high tech.' nature of the work, with few people on-site. Three teachers did link science with the industry, as they described the research and development work with which companies are involved. However, these were the minority, and were made up of people who had either worked in industry, or who had higher level science qualifications.

When asked about any local chemical companies (Figure 4.22), teachers were more likely to refer to the company name or location (e.g. on Teesside, or on a nearby industrial estate) than be aware of the products manufactured by that company, or the processes used. ICI was the most frequently mentioned company. ICI has a long history on Teesside and is close to County Durham and readily observed from a major road through the area.

Over a quarter of the teachers described accidents or leaks from local companies as a major element of their knowledge of that company, as one conversation with the interviewer shows[13]:

> T: I don't know what it's called now, it used to be called the Darlington Chemical and Insulating Company. I don't know whether they've dropped the Darlington bit.

> I: Do you know much about what they do?

> T: Not really.

> I: No. But you just know it's there?

> T: know it's there, and it was one of these things that it had it's little land mark which was a huge multi-coloured slag heap. It was on the outskirts of town.

> *(S1/T1/50)*

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[13] T = teacher, I = interviewer

Figure 4.22 Knowledge teachers expressed of the local chemical industry (n=41)
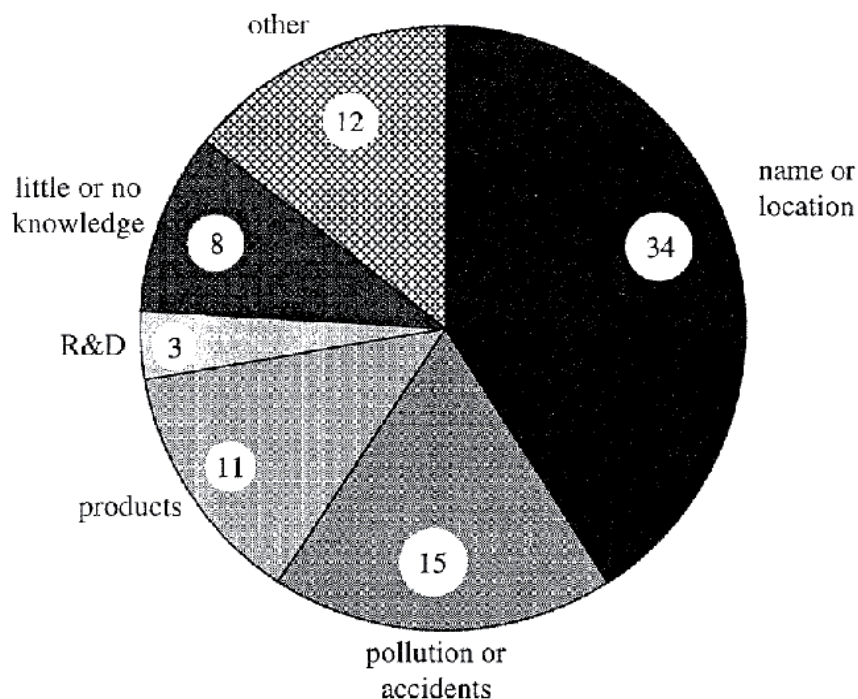
However, a high proportion of teachers did appreciate the influence of media coverage on their knowledge of the chemical industry (see Figure 4.23), and acknowledged that this always presented a negative image. In fact, several teachers stated that this was their only source of information, as they did not know anyone who worked in industry, and they did not actively seek out the information. They therefore felt that many of their thoughts were based on ignorance.

Figure 4.23 Sources of teachers' knowledge of the chemical industry (n=41)
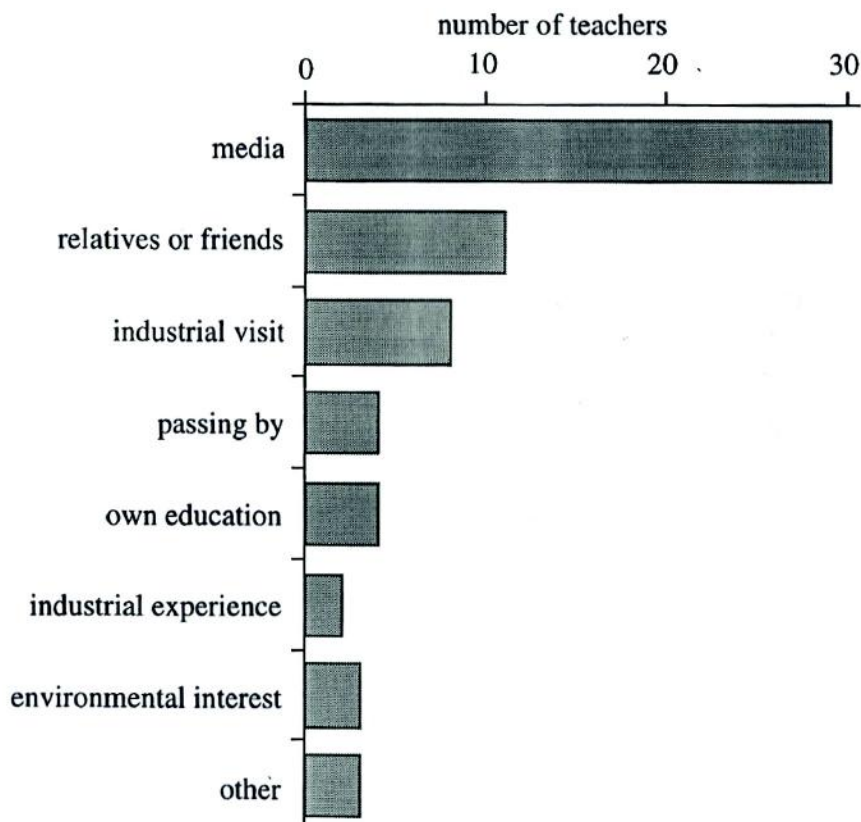
Only one teacher felt that the media underplayed how bad a particular incident might have been:

> *"Oh, pollution I think is the main risk, but that's possibly my biased view due to the way its presented on TV. You don't get lots of chemical stories on chemical this that and the other, its always chemical pollution. Its always paint factories or someone dumping something in a local river or a stream that you're reminded of all the time. Although I do feel when you get the reports the news is unbalanced. I think they're often undefined, they don't play up the facts that these are chemicals which we should have control of and they're just seeping around you in the local environment."*

> *(S9/T1/42)*

Any other source of information was far less common. Of those who had close family and friends in industry, it appeared that they relied on anecdotal evidence, with some teachers being unable to describe the work carried out by these people. One teacher's father had suffered from a serious accident whilst working in the chemical industry, though his overall image of the industry was not negative - as he felt that the industry had tightened its health and safety record in the last 25 years.

Eight teachers recounted industrial visits, ranging from a trip to Sellafield (the nuclear industry was often included under the umbrella title the 'chemical industry') to a trip to one chemical company twenty years previously. Most teachers had had positive experiences, with the exception of two teachers who had visited one company, coincidentally, and felt that they gained little from the visit.

The four teachers with an interest in the environment honed in on any information about the effects of industry on the planet, and all held negative views of industry. Four teachers used the visual image of industry seen from the motorway - reflecting a popular source of the children's information.

The majority of teachers felt that the main impact of the industry on their lives was the use they made of related products (see Figure 4.24). Almost a third of the teachers felt that this impact was substantial, as the chemical industry had an input in almost everything they used. Nine teachers said that the industry did not really impact on their lives at all - and the majority of these teachers had not been confident to describe the chemical industry in any way.

Figure 4.24 The effects teachers feel the chemical industry has on their lives
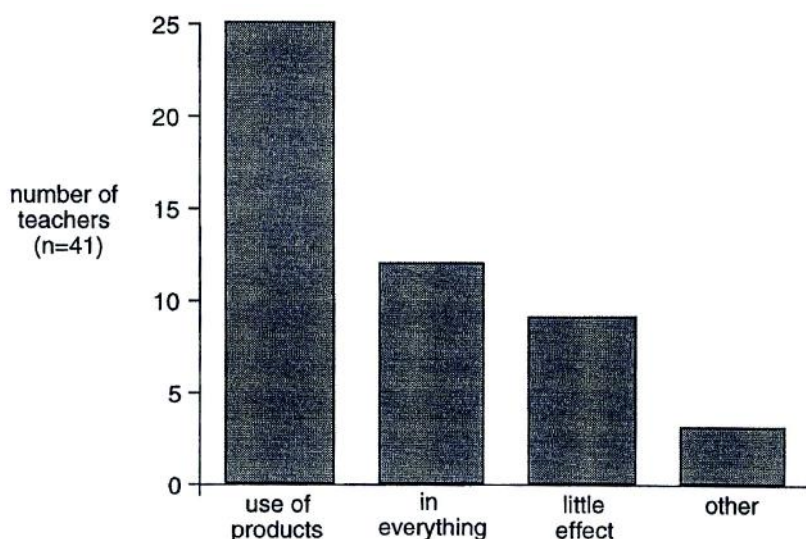
One or two teachers reiterated their concern for the environmental impact of the industry, and another felt the impact was so complex she could not begin to discuss it.

4.5.2 Risk and the chemical industry

Responses to the question about the nature of risks attached to the chemical industry were quite varied. Most teachers began by citing specific risks, such as air or water pollution (66%), fires and explosions (37%) and risks to health (39%). Again, there was acknowledgment from many teachers that the media reported most widely on these aspects of the industry. A typical response was:

> *"Of course you don't hear about such and such a company has had five years without anybody being hurt or any serious business. You only hear when there's a problem ... when someone's had an accident at a chemical plant. Or when you hear there's been a spill or a leak, and people in a certain area are advised to keep their windows closed and things like that."*

> *(S35/T1/46,122)*

Half of the teachers cited accidents that have been in the headlines over the last 30-40 years, including local and worldwide incidents, as well as those which occur in the nuclear industry. Half of the teachers applied their feelings about risk to the whole chemical and allied industry, whilst the other half felt that the nature of risk was variable. There were a range of thoughts (spread evenly between the teachers concerned) as to why this was the case.

The risks could vary with:

- the nature of the product and the raw materials used
- the location of the company (UK or abroad, or whether near populations in this country)
- the amount of money made available for health and safety
- the company concerned (and the reputation of the company's health and safety record.

The two quotes below represent two of these views:

> *"I'd say there were worse risks connected to certain kinds of industry than others. For example, the pharmaceutical industry isn't going to harm the environment as much as say an oil refinery or something that could pollute the sea."*

> *(S32/T1/56)*

> *"Living in a town with this company, I'm well aware that there is a balance between safety, pollution and money."*

> *(S3/T1/38)*

Seven teachers felt that the risks were low, as they were carefully monitored and controlled, whilst only two teachers thought they were high. Twenty nine teachers (70%) felt that the risks were well controlled in the UK and that, due to their lack of information, they had to trust those in power to ensure this continued regulation. A quarter of these teachers referred specifically to government legislation being responsible for this control, but almost half of these teachers felt it was individual companies which took responsibility for monitoring and controlling risk.

Only six teachers felt that the industry should be better regulated, and four teachers felt they knew too little about risk to pass comment.

Half of the teachers felt that the risks were acceptable, largely due to our economic need for employment and the wide range of products that we rely upon in our daily lives. Twelve teachers

(29%) felt the risks were unacceptable, with some of these teachers stating that no level of risk was acceptable, and every effort should be made to achieve zero risk levels. Two teachers referred specifically to chemical warfare, when stating that risks were not acceptable.

Over a third of the teachers felt they did not know enough to assess the acceptability of the risks. There was some overlap between these teachers and those who felt the risks were acceptable. This was due to teachers feeling they could not assess the risks, but felt they were probably acceptable, and would trust the powers that be to make it so.

4.5.2 Changes in teachers' views

Teachers were asked what they felt they had learned during the project. The majority of responses to this question are dealt with in chapter five, as they focused on science-industry links, rather than their knowledge of industry. However, 31 teachers (76%) cited new information about industry, with only three teachers saying they felt they had gleaned no new information at all. This new information varied considerably from teacher to teacher, ranging from an awareness of the processes which occur to the range of jobs required, the automation, and the health and safety controls in place.

It was difficult to categorise the teachers' learning of industry, as the amount of learning a teacher felt they had gained varied with each individual's starting point. Some teachers pin-pointed specific new facts, whilst others felt they had a whole new picture of industry, as they had known so little prior to the intervention.

An example of a teacher who felt their whole picture of industry had changed follows. Most of the teachers expressing such a change of view visited industry during the project.

> *"I've never been in a factory like that before. I've never seen those machines. Whereas now I have got a far better understanding of what actually goes on, where it comes from. Yes, I know it came from oil and natural gas, but now I see what they actually do to it and where it goes. Next time I teach it I'll have a far better understanding of that."*
>
> *(S11/T2/208)*

Others were amazed by the effort that went into each area of production:

> *"It [the project] made me think a bit more about all the different processes that go on just for one simple job [providing water for industry]. I suppose I could think about it any time, but it made me look at one specific thing and focus on it a bit more."*
>
> *(S5/T2/22)*

Several teachers reflected the thoughts of children, as the following three quotes reveal. The first teacher came to realise that the company involved did not make an end product but an intermediate product. The second teacher learned a great deal about the team of people working on a chemical site, and the third teacher was surprised at the small number of people required:

> *They'd [the company] process it as far as they can and then dispose of things, and send things on to other firms. And they don't sort of make one thing, it's linked to other things to produce a final product."*
>
> *(S27/T2/94)*

> *"Like the children, I didn't realise how many different occupations were actually in the chemical industry. I mean, I had visions of laboratories, just laboratories. But seeing the plant at Consett, and the different areas and people who all come together to produce the chemicals or produce the ingredients for other things, it*

was an eye opener for me as well."

"I was a bit shocked at the number of people. I rather hoped that somewhere as big as that would employ a few more people."

A research study into teachers' views of industry, carried out in Australia found similar changes of view (Ball et al, 1995). For example, one teacher's original view of an industrial workplace had involved loud noise and dirt with mundane and boring jobs. His perception was changed during a teacher placement scheme - which the authors were evaluating. Another teacher realised how limited her perspective had been - viewing industry as the environmental 'bad guys' and teachers as the 'good guys'. These kinds of placements are perhaps best for increasing teachers' understanding of industry; which was, of course, the aim of their project. However, this is less likely to affect the children they teach than the Children Challenging Industry project, as links with the curriculum were not made, and children were not involved at all.

So, for some teachers, the project had quite an impact on them, especially if they had visited industry. For others, the changes were more minimal, with one or two new pieces of information about processes or equipment or testing carried out. However, the changes in teachers' views about how to link the industrial world of work with the science curriculum were greater, and are one of the main foci of discussion in chapter five.

4.6   In summary

4.6.1 Children's views

Children's initial views of industry as a large mill or warehouse filled with people working on a busy production line are far removed from the reality of chemical sites. These images come primarily from the television, family, and seeing sites when walking or travelling. Therefore, providing children with information, via classroom intervention and visits to industry, allows them to change their views and become more informed.

Overall, a more accurate awareness of industry was measured in the following areas:

- raw materials used
- processes involved, and the number of processes per site
- equipment used to carry out processes
- general physical appearance of a chemical plant
- working environment
- jobs carried out. Especially those requiring technical and scientific knowledge , and which resulted in more children wanting to carry out these kinds of jobs.

In all areas where the influence of a site visit was measured, it was found that a greater appreciation had resulted.

The comparison of individual children's data revealed that 90% had altered their views to encompass more accurate information about the chemical industry, though some in a very limited way.

Those who experienced the greatest change were as a result of visiting a site which had been adapted to suit the needs of the class and their science curriculum. Where children visited a site that had not carried out site visit training, it resulted in a change of view similar to that achieved through the use of video and photographic images used during the classroom sessions. This suggests, therefore, that if a site is going to invest time and money in conducting site tours for primary children, it does so with the knowledge of the needs of schools and children. If this is

not possible, it would appear to be more productive to use a video with appropriate images of the industry, rather than to offer a site visit which leaves the children with an unchanged, or more negative perception than that with which they started.

4.6.2 Teachers' views

The majority of teachers expressed little knowledge of the chemical industry, other than its links with everyday products and its media-reported effects on people and the environment. They appreciated the essential nature of the industry, in that we rely upon its existence for virtually everything we do and use.

Teachers were conscious that the bulk of their knowledge (or, in some cases, all their knowledge) was based upon news reports of the 'negative' aspects of the industry such as chemical spillages, leaks, explosions, and fires. Therefore, although teachers were aware that their views were biased, biased they often were.

Teachers expressed more knowledge of risk than any other aspect of the industry, albeit predominantly media-derived. Risks were felt to be low, on the whole, but major when something did go wrong and thus given heavy media coverage. Teachers again acknowledged their ignorance, and the majority felt they had to trust the companies concerned and government regulations to ensure good quality monitoring and control.

Chapter 5   Views of children and teachers of science and its links with industry

The discussion in this chapter is divided into two sections; the teachers' views and the children's views. Section 5.1 describes teachers' views of the National Curriculum for science and the links between this curriculum and industry. Section 5.2 describes changes to these views which resulted from the project intervention. Section 5.3 presents children's views of the science activities carried out during the project, and their views of the relevance of this classroom science to the industrial workplace.

5.1   Teachers pre-intervention views

Primary teachers must teach ten subjects, and although they have an interest in teaching about industry, it is not a high priority on most school agendas. Of the schools involved, only four had a policy statement on industry-links, and these were of a broad and general nature. For example, schools included links with supermarkets and the Post Office under the umbrella heading of 'industry links' or 'community links'.

Fifteen schools did, however, have some informal links with companies, even if it was only for sponsorship of school events or equipment. A small number of schools were keen to develop as many links as possible, and took several different year groups of children out to visit local industrial companies. The range of companies was wide, including Fisher-Price, Black & Decker, BASF and Toyota. These links were usually not curriculum-specific, and the school built upon the visits in which ever way they felt was most appropriate after the event. These links were not necessarily made by the teacher participating in the project, but by others in the school, and were maintained on an ad-hoc basis. Initiating or developing these kinds of links was still felt to be important to only five of the teachers participating in the project.

5.1.1   Teachers' views of the National Curriculum for science

The spectrum of teachers' views is presented in Figure 5.1. Unless otherwise stated, numbers shown in this, and all subsequent figures in this chapter, refer to the number of teachers expressing the views.

The majority of views fall into four main categories, each held by approximately half of the teachers. The most commonly cited view was a positive one, and expressed the importance teachers felt the science curriculum had in providing a balanced curriculum in the primary school.

> *"I think it has given a status to science that perhaps it lacked in the past. I mean, we all know the view of twenty years ago where people took science as nature study. And then only in the summer. So there was no science for the rest of the year, science didn't happen. We have moved away from that. Because people are being directed in certain areas, they are becoming a little more confident and a little more adventurous."*
>
> *(S6/T1/194)*

However, there were a number of concerns about the implementation of the science curriculum. Firstly, the prescriptive and detailed nature of the curriculum was felt to result in an over laden curriculum that could not be covered satisfactorily in the allocated time in the school week. Some teachers felt that this combination of detail and limited delivery time led to a restrictive curriculum in which teachers could not spend time covering or diverging into an area that was of particular interest to the children.

Figure 5.1 Teachers' views of the National Curriculum for science (n=41)

View	Count
good/important	21
some difficult concepts	19
too much to cover	18
difficult for non-specialists	16
too restricting	5
SATs not good	4
spoils secondary school science	5
other	8
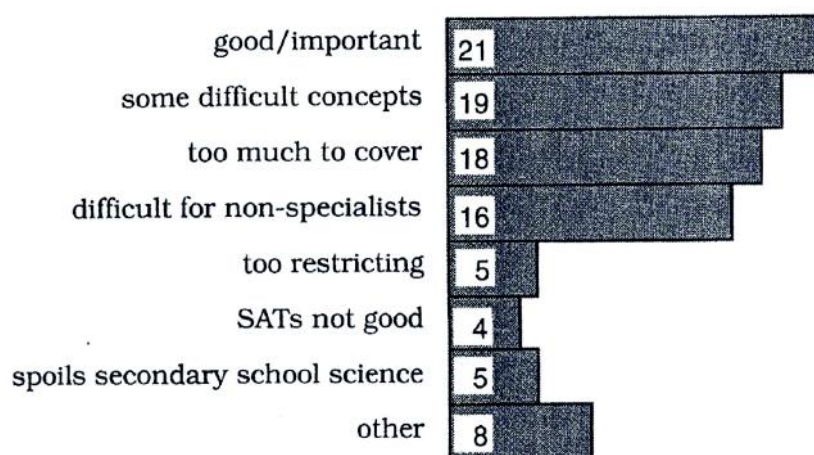
Teachers also felt that several of the concepts were too difficult for primary school children (such as forces and motion), and were best left until the children were older and more able to cope with abstract concepts:

> "I think there's an awful lot to cover. And I think children find biological concepts a lot easier to handle than say physics and chemistry. Concepts that are in physics are, in my mind, a lot more obscure to understand. But maybe the understanding can increase as a child becomes older. But biological concepts like how we grow and plants grow and that sort of thing, seems to be an easier concept for children to understand in my view. I think the science curriculum has too much in it. I find that there's too much to cover and too many concepts to try and get across. And sometimes I just wonder whether we're just teaching children things almost, not parrot fashion, but learning a lot of facts when really the understanding is lacking behind that. And I think we try too early on to get them to understand electricity and forces like gravitational pull and that sort of thing."

> *(S26/T1/132)*

Some teachers also felt that by tackling a wide range of concepts with children so young, it spoilt the pleasure of the freshness of learning science when children moved to their secondary schools.

Sixteen teachers (39%) were concerned that non-specialists have to deliver the science curriculum. As shown in chapter three, the majority of these teachers have no science qualifications, and therefore may have little knowledge of the concepts themselves:

> "A lot of primary schools, including ours, are staffed with people who were arts trained. Especially in a small primary school. We haven't got a science specialist. We've been asked to do science, so that's involved training. But the turnover of staff - quite often they got trained and then they moved on, or retired in our case. ... But we are learning, we go on courses. The Government used to fund science courses, but there don't seem to be so many of those. Plus, we have to follow the national curriculum by law anyway, so we just do what we're told and we sort of ham up on things."

> *(S33/T1/132)*

One or two teachers also described lack of resources, classroom space and technical support as hindering the teaching of science.

Four teachers described the inadequacies of the Standard Assessment Tests (SATs), the tests that children take in the final year of primary school (Year 6). The science tests were felt to be of little use, and meant that much of the time in Year 6 was spent revising and sitting the tests.

The majority of teachers felt that the broad balance that already existed within the curriculum was important, though a number of teachers felt that specific areas of science were particularly important to primary school children (see Figure 5.2).

Almost half the teachers felt that an investigative approach to science was important, in which children enquired for themselves and learned the scientific process. Eight teachers (20%) felt that the most important science was that which children could experience for themselves, and did not rely upon abstract understanding. Three of these teachers felt that the science of 'life and living things' met these needs particularly well. Four teachers felt that 'doing' science was important - this again raises the idea that concrete experiences are best for children of this age.

Figure 5.2 Important aspects of National Curriculum for science
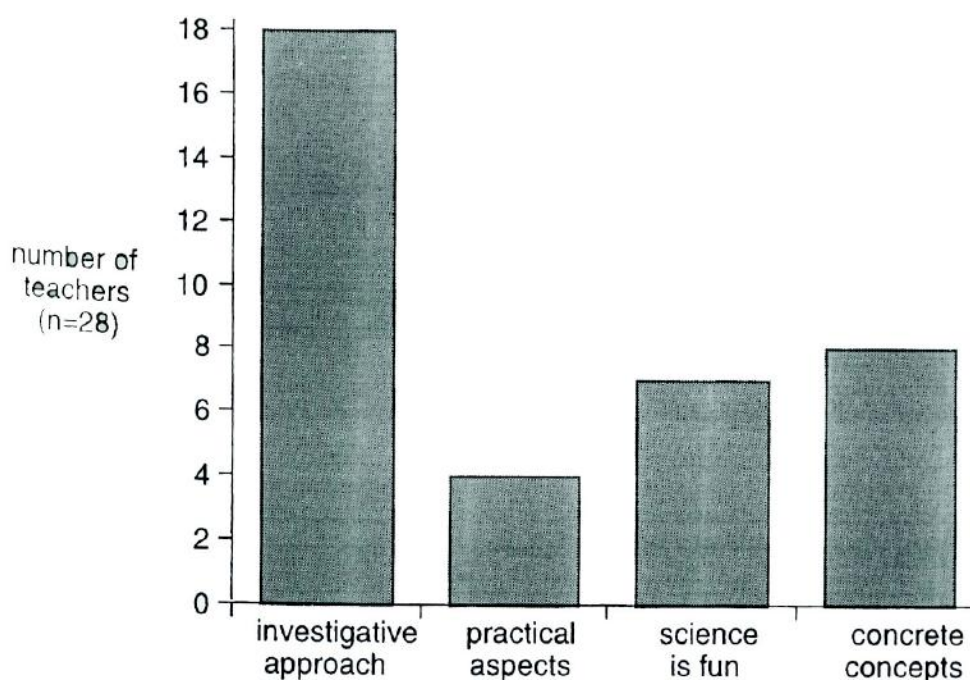
A third, smaller set of responses relates to science being fun. This was felt to be important for the teacher as well as the children. If teachers were to motivate children in science, they had to be motivated themselves. Two teachers cited 'science being fun' as the most important aspect of primary school science.

5.1.2   Linking industry with the primary curriculum

Prior to the project intervention, teachers were asked about the links they already had made with industry. 21 teachers (48%) made some links with industry, as shown in Figure 5.3. Thirteen of these teachers linked industry with the geography curriculum, and predominantly with pollution of the environment. Six teachers covered the historical development of industry, through the Industrial Revolution or the local history of coal mines and steel works.

Only one teacher looked at industrial processes, and only four teachers made a positive industrial link with science (one teacher again covering pollution). Three teachers linked science with industry via an opportunity to visit a local nuclear power station, and thus linked the use of turbines to topics on forces and electricity. In this instance, the power station staff plan and carry out the science activities on-site with the children, in the company's education centre.

Figure 5.3 Pre-intervention curriculum links with industry (n=41)
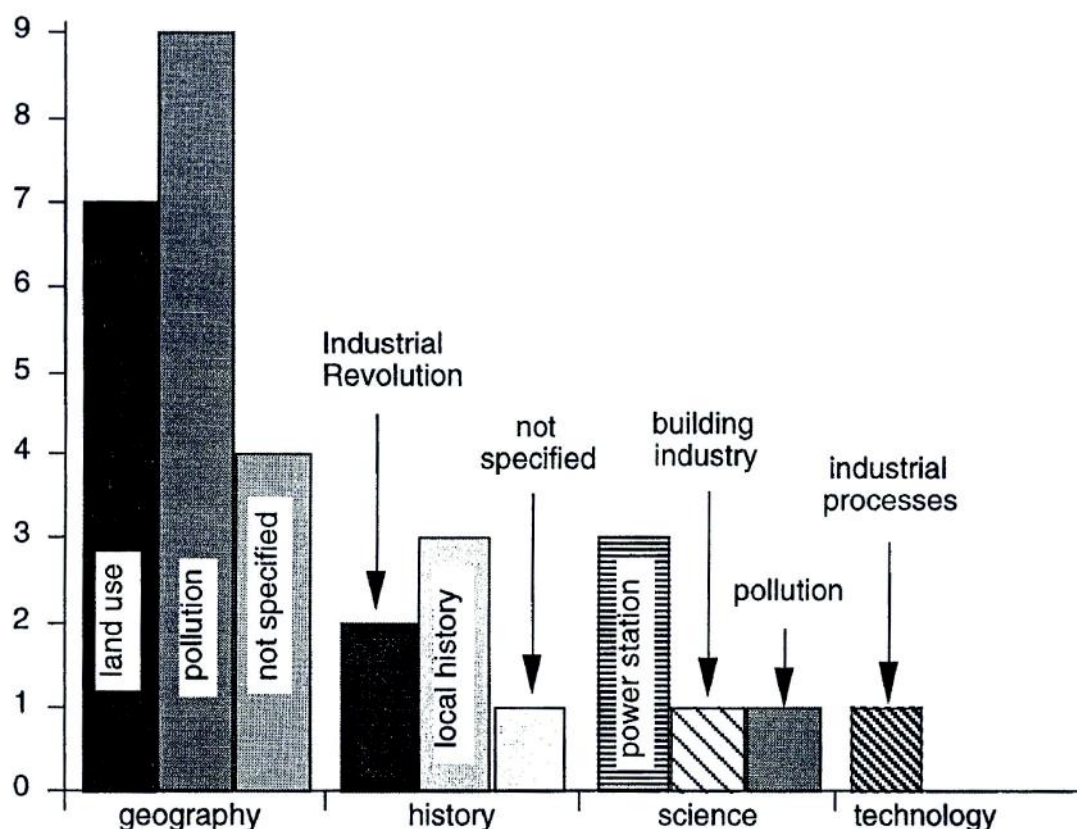
Therefore, of 41 teachers, only 5 made any links between science and industry, 21 made no links at all, and 16 portrayed either a historical or polluting image of industry. It is not, therefore, surprising to recall that only 16% of the children involved in the research cited school as a source of information on industry. Nor is it surprising that the image held by many children is one of a mill-type of building with many chimneys churning out smoke.

As one teacher who made industrial links with the history curriculum pointed out:

> *"But I can't really cover much about industry if I don't know much about industry anyway."*

> *(S30/T1/103)*

The combination of a lack of many teachers' knowledge of both science and industry leads to a low possibility of teachers making a link between the two. However, the fact that all of the teachers volunteered to take part in the project shows a willingness to have support in these areas. As mentioned in chapter three, of the 250 schools invited to take part in the project, 23% were keen to participate. So what was it that teachers were hoping to gain from this science-industry links project? The next section discusses this is in detail.

5.1.3 Teacher expectations of the science-industry project

Teachers saw the project as benefiting both their own professional development and the children's learning. They wanted to increase their own and the children's knowledge of science, industry or both (Figure 5.4), through the liaison with an 'expert' in these areas. The majority of teachers talked first and foremost about gaining personal knowledge, and only talked about the gains for the children when asked specifically about this aspect. Some were wanting new and stimulating ideas for science activities, whilst others wished to learn more about teaching primary science effectively, rather than reflecting the methods used during their own secondary school education. This links with the teachers' lack of knowledge in science, as one teacher exemplifies:

Figure 5.4 Teacher expectations of the project (n=41)

improve children's knowledge 35
improve teacher's knowledge 32
science-industry links 27
expert support 19
new person in classroom 13
provide resources 5
other 5

32

teachers' knowledge of

13 science
13 industry
8 general

34

children's knowledge of

16 science
20 industry
2 general
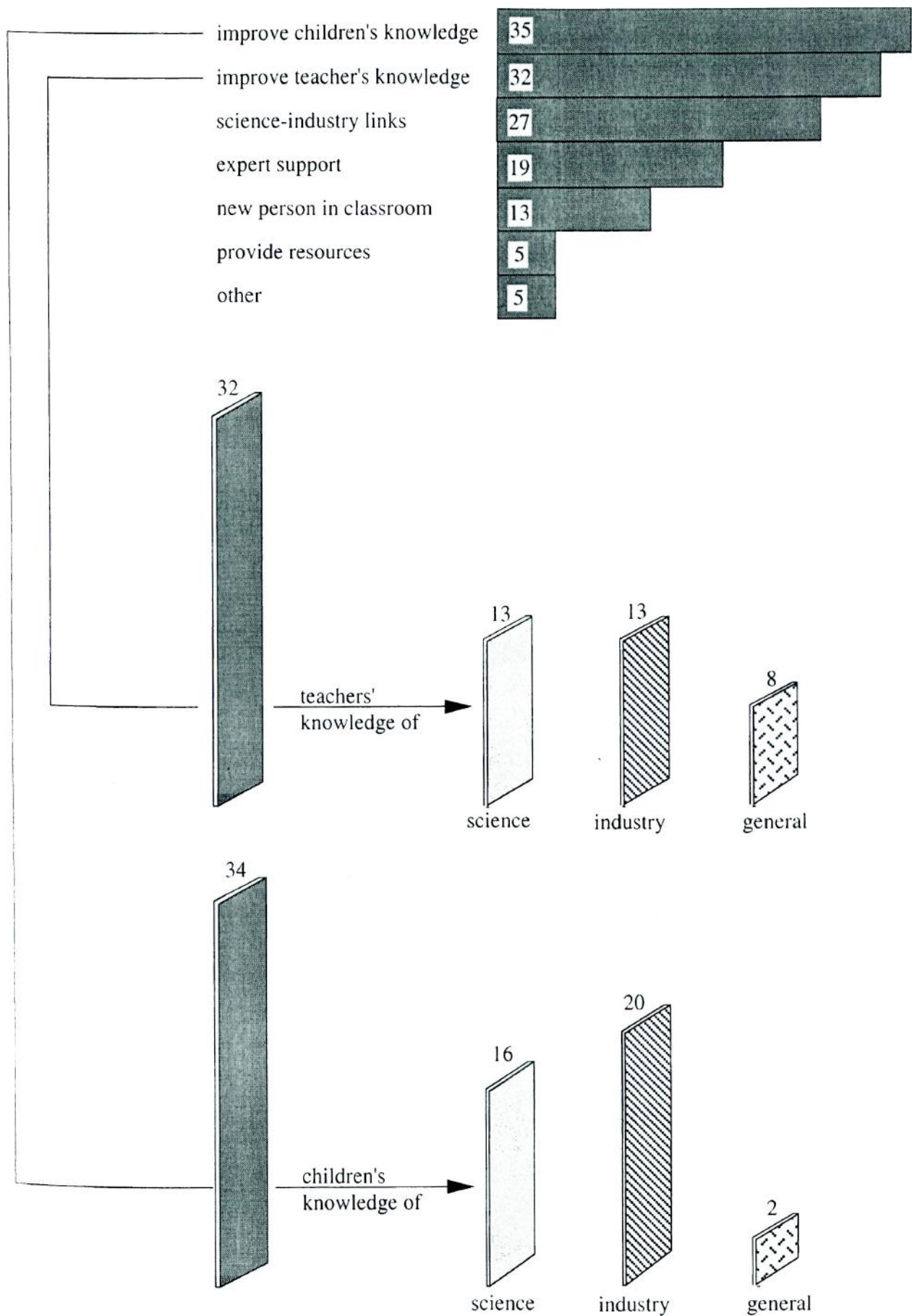
I struggle with science because my own primary school science experience was the nature table type. And what we are trying to do now is something very different. The things that I perceive I am trying to do with my children are things that I can remember doing leading up to 'O' Level in senior school. And therefore I have hang-ups about it because I feel I am trying to tackle something that I met at a much later age with children that are much younger than I was. And the perception that I really ought to have an 'O' Level in one of them to be able to teach them to the children. I'm becoming to realise that I ought to simplify everything, I need to simplify everything. It's finding the right level, and that's what I'm hoping to get out of this, is to find a level for investigating things which, as I say I remember doing it at a much later level, which I struggled with at the time. I'm not a scientist in any sense.

(S1/V2/T1/151)

Several teachers described greater knowledge leading to personal motivation, which would, in turn, be passed on to the children they taught. The importance of motivation is expressed by the following teacher:

"They're very enthusiastic scientists are children. I've found that they always are. The only thing that holds them back is the teacher! And I'll hold my hand up and be honest about that one. There are certain aspects of science that I'm not comfortable with because I don't know enough. So to have people come in and demonstrate an aspect, that will help to fuel their enthusiasm. Enthusiasm helps the learning process because you need to be motivated to learn, and this kind of project provides a great deal of motivation."

(S10/V2/T1/68)

Teachers were also keen to increase their own knowledge of industry, particularly in relation to their classroom teaching, and linking industry to the curriculum. In addition, some teachers linked this with increasing their confidence to address industry in the classroom:

"Well hopefully it will enhance my understanding of the industry and give me experience and confidence to actually then talk to the children and see things from a different point of view. Perhaps use activities that I wouldn't have basically dreamt of using or haven't seen in resources I've looked at. So really, to enlarge upon my skills and knowledge. And, of course, the children having somebody else here who's specifically teaching about the industry. That's going to be to their advantage."

(S1/T1/60)

The largest response from teachers was that of increasing children's learning about industry, although this was often mentioned after their own knowledge gains. Teachers were aware that children knew little about industry:

"I am hoping that it will give the children an insight into the world of work really. I was surprised last year that the children who live here didn't know what was on their local industrial estate. And a lot of them didn't have the faintest idea of what went on around them."

(S11/T1/132)

85%[14] of the teachers wanted some outcomes to be about industry, be it increasing their own or their class's knowledge, or whether it was to see a specific link being made between industry and the science curriculum. As industry was an area that most teachers did not cover in any depth, if at all, it is not surprising that teachers felt this was an important gain.

[14] The other 15% of the teachers talked more generally about children's learning, their ability to work in groups, etc.

Almost two-thirds of the teachers felt that the most important message to get across to the children during the project was that science links with the world of work and everyday life, rather than it being an isolated or abstract classroom activity:

> *"When we do science in the classroom, its often quite removed from science at work. Its more like 'today we're learning about forces', and ... they don't get a sense of real time, something's actually going on out there and that now, somewhere, someone needs forces at work. So hopefully a project like this is going to make them think and they're going to see that there's a use for science."*
>
> *(S9/T1/48)*

> *"I'm actually very positive about science. My background is in science, so I'd like to make science interesting and applicable to real life. So when I do teach the children I try and relate things to real life ... Different children learn in different ways. I know that I learn if I can relate something to something else, so if something's meaningful then I will learn it. If it's just an abstract thing, then it doesn't mean that much to me. ... So I think ... with science, that if it was shown to have relevance and you can show different applications then children will be more inspired by that."*
>
> *(S14/V2/T1/218)*

Teachers want children to realise that the products they use every day are as a result of research carried out by scientists, and that industry is responsible for providing us with these products. Some teachers acknowledged the role played by industry in scientific research, and felt this was part of the message to get across to children.

Few teachers felt there were disadvantages to participating in the project. Three teachers were concerned about the time the project would take from the planned curriculum, but felt that on balance, this alternative use of time would be worthwhile. Two teachers were concerned that children may gain too positive an image of industry, and that they may have to do work on 'redressing the balance' after the project input:

> *"It may be that the children could get a biased view, from having people from industry coming in. Obviously they will enjoy time with them, but they might get a biased view. So, for instance, if you came in and spoke about the nuclear side of things then they may get the idea that it's totally all right. Whereas obviously environmentally, there are issues that would say it wasn't. But that's the only disadvantage that I can see and I am sure that can be balanced afterwards anyway."*
>
> *(S30/T1/91)*

In an opposite vein, four teachers felt the project would redress the negative image commonly portrayed in the media, formed from seeing the chemical sites on Teesside, and from the environmental coverage industry is often given in the primary school:

> *"I think it's quite important for myself, I would like my knowledge widened. I would like to hear it from the horses mouth as it were. The good things that are going on, instead of just hearing the bad things through the press. And I think that would be good for the children too, to experience industry other than the pollution that they study in school because that's the kind of thing that tends to be done. If you're doing environmental work that comes out quite a lot."*
>
> *(S29/T1/90)*

5.1.4 Views on chemical company sponsorship

The question of why a chemical company might sponsor a project of this nature provoked a lot of thought amongst the teachers interviewed. Most teachers' immediate response was that of uncertainty, followed by one or more of the reasons in Figure 5.5.

Figure 5.5 Perceived advantages for the sponsoring chemical company (n=41)

Reason	Count
potential workforce	18
improve children's knowledge of the chemical industry	17
good public relations	17
improve children's attitude to science	11
unsure	9
develop an informed public	6
for research outcomes	4
good education liaison	4
altruistic	4
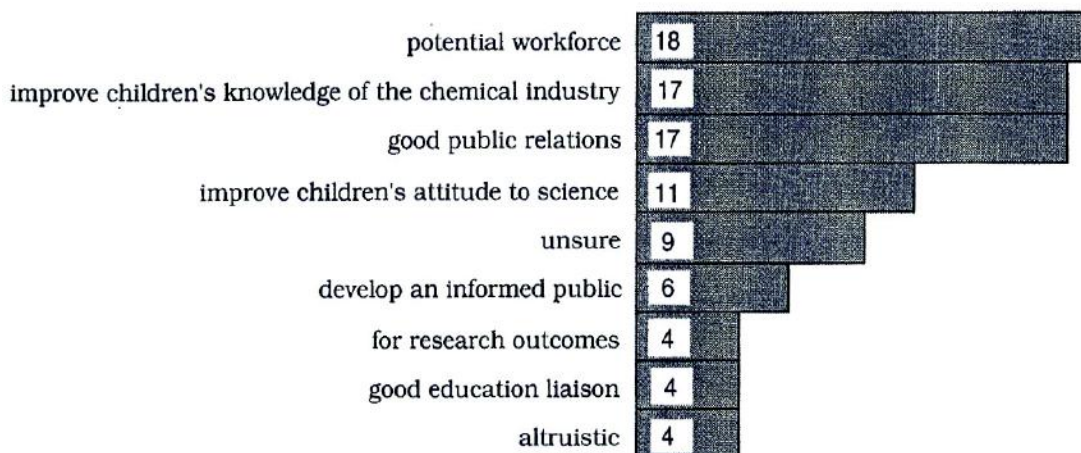
Two thirds of the teachers felt that the knowledge gained during the project would result in them thinking more positively about science and the chemical industry. Almost half of the teachers felt this would result in a potential workforce for the future. Some of these teachers saw this as a direct benefit to the sponsoring company (predominantly those whose schools were located close to Thomas Swan & Co.), whilst the majority felt that the industry in general would benefit:

> "How can they [industrialists] alter children's perception of what's going on in industry? Let the children see. Children don't know what goes on. Perhaps they might fancy working somewhere like that. If you ask a child what they want to be they'll say a train driver or a fire man or something like that. Very rarely do you have somebody saying, 'I want to be a scientist in an industry somewhere'. It gives them experience of seeing other things."
>
> (S29/T1/118)

> "I think it's a positive development, to work with industry from an early age, to get the children to have a positive attitude to business and industry ... To have people who want to be scientists or work in a science industry can only benefit both employers and schools."
>
> (S33/T1/94)

Eleven teachers said that improving children's attitudes to science would benefit the industry, as the project would demonstrate how classroom science linked with the 'real world' and industrial workplace; and would also hopefully show that science is 'fun'.

Six teachers developed the view of increasing children's knowledge of, and attitude towards, science and industry, by describing an 'informed public':

> "Children are the people who are going to be the workers in the future, and they're the people who are going to form society's attitudes in the future. Everything I said about my hesitation of the chemical industry I feel comes from ignorance. It's obviously going to be through the children, if they understand they're going to have better attitudes in the future - more informed attitudes in the future, rather than totally blind prejudices one way or the other."
>
> (S21/V2/T1/188)

Only four teachers cited the research as a reason for sponsoring the project. These few teachers, however, felt that it was important that people in industry learned about education, and what children's perceptions were, and whether the project made any impact. In a similar vein, two of the four teachers citing educational liaison felt that it was advantageous for the company to learn about primary education.

The response that "its good PR", and that the company want local people to think of them in a positive light simply because they put money into education, was cited by 17 teachers. Some of these teachers stated that this was their cynical side responding, and cited other reasons also. Others felt the view was cynical but true, as demonstrated by a teacher who had recently moved from industry into teaching:

> *"I don't think they'll do anything for nothing, that's my general experience with industry. They are wanting something in return. 'We support education therefore we are a good company, we have a clean image, a good image, one that works with children, therefore our products are good products that you should buy,' ... Their sales people will know what they are doing. ... It will click with someone. There will be an MD there talking to a customer who happens to have a thing about companies that help education and 'oh we'll buy from you'. It certainly sounds very cynical, I think that's true, only we used to do it."*

> *(S14/V2/T1/194)*

5.1.5 Desirable industrial support for primary education

Teachers were keen to receive industrial support, and felt there were several ways it could be offered (Figure 5.6), in addition to the kind of support being offered by this project.
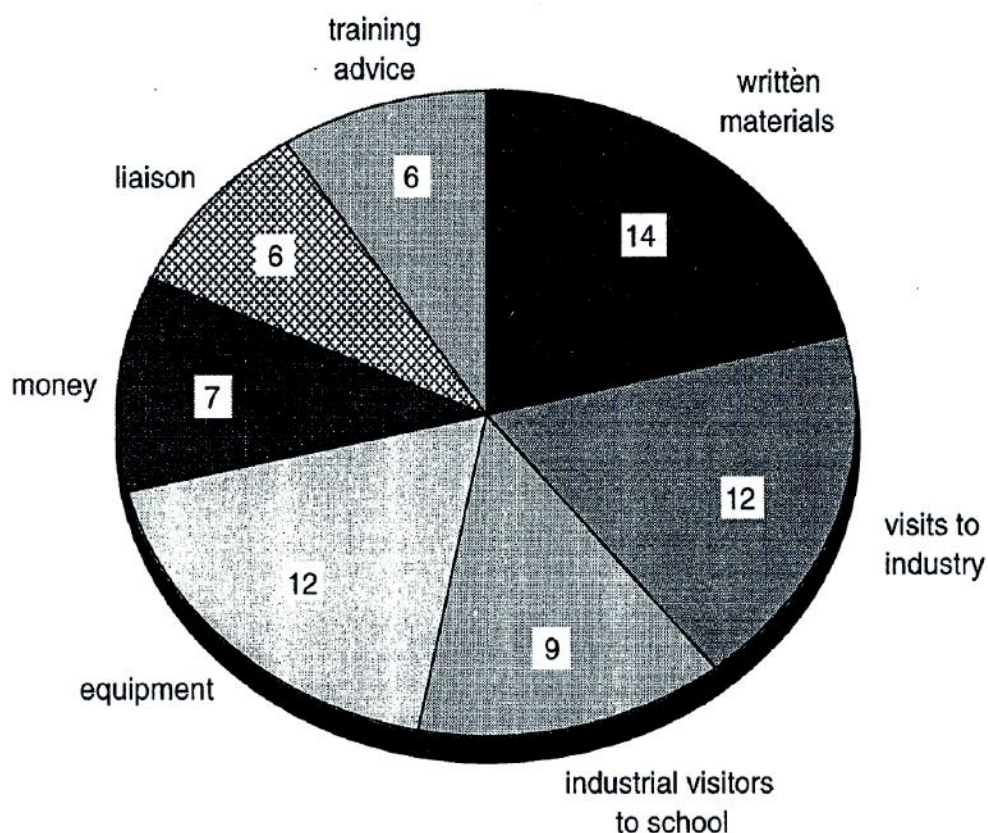
Interestingly, the majority of support strategies suggested by the teachers were elements of the project on which they were about to embark:

...

71

- each teacher received two written activity packs
- a visit to industry was arranged for 50% of the schools, which would pave the way to continued liaison
- each teacher (and in some schools, two teachers) received classroom-based training
- the project officer provided equipment for the sessions (though, ideally, teachers would have liked to keep this)
- two schools received visits from industrialists.

Money was not given directly to schools, though was done so indirectly in the provision of all the other project elements. Although this may seem like an unfair request, perhaps a look at a school budget might put it in perspective. One teacher from a school of 250 children had an annual budget of £100 - 200 (40p - 80p per head) for all science equipment, including consumables.

Overall, the provision of written materials was favoured slightly, with one third of teachers citing this option. Teachers described the characteristics which the materials should have to make them a valuable classroom resource (Figure 5.7).

It is clear that teachers are not fundamentally against resources that have been developed by industrial companies, but are wary of anything that may be deemed to be propaganda, or that over-uses the company logo. Teachers' priorities lay in the appropriateness of the material rather than it's source. Therefore, the material must:

- fulfil one or more criteria of the National Curriculum requirements or the school's scheme of work
- be educationally sound
- be at an appropriate level for the age range for which it is intended, not only in terms of the science content, but also in relation to English and mathematics (e.g. reading age, measurement skills, etc.).

Figure 5.7 Desirable characteristics of industrially sponsored materials (n=41)
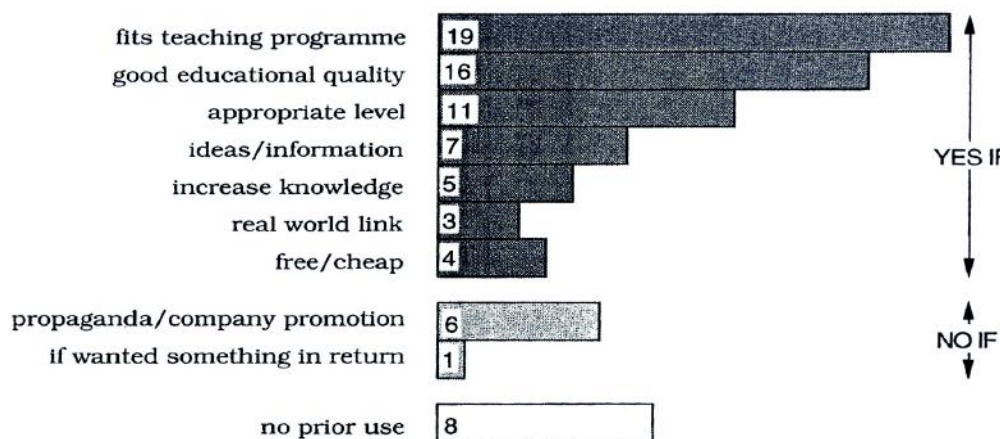
Less important was the price of the material (though for some it seemed implicit that the resources would be inexpensive), and whether the material covered industrial links. Of importance to 10-15% of the teachers was the information that packages on industry could provide, which could potentially increase both the teachers' and children's knowledge of industry. This information could then be used to spark teachers' ideas on how to cover aspects of their teaching programmes.

Almost 20% of the teachers had never used, or had no knowledge, of industrially sponsored resources, and felt unable to comment on their suitability in the classroom. Making teachers aware of the merits of these materials is not an easy task, as there is little time in the teachers' day to read them:

"I've been fishing through the cupboards and the shelves and pulling out all the stuff that's been sent to the school over the years from Glaxo and Ciba and so on. All these wonderful sheets, and they've probably never been used, and no one's ever taken them off the shelf. Someone's said, 'oh yes, yes that's wonderful', but it's how you actually get people to buy into the ideas."

(S14/V2/T2/119)

Therefore, the combination of the classroom-based training which utilises directly the activities from such materials enables teachers to realise the resources' value, by providing them with a reason to read the resource and then see the activities being performed with their own classes. Section 5.2 discusses these teachers' views further.

5.**2**   **Teachers post-intervention views**

5.2.1   Views of the classroom activities

All but one teacher felt the sessions had been very good and a worthwhile use of curriculum time. One teacher felt the sessions had been 'satisfactory' and that the SATs would show how beneficial the sessions had been. All other teachers felt that both they and the children had 'got a great deal' from the sessions in a variety of ways that will be discussed in this section.

Teachers were asked to describe the strengths and weaknesses of the sessions, and these are summarised in Figure 5.8.

Figure 5.8 Strengths and weaknesses of the classroom sessions (n=40)
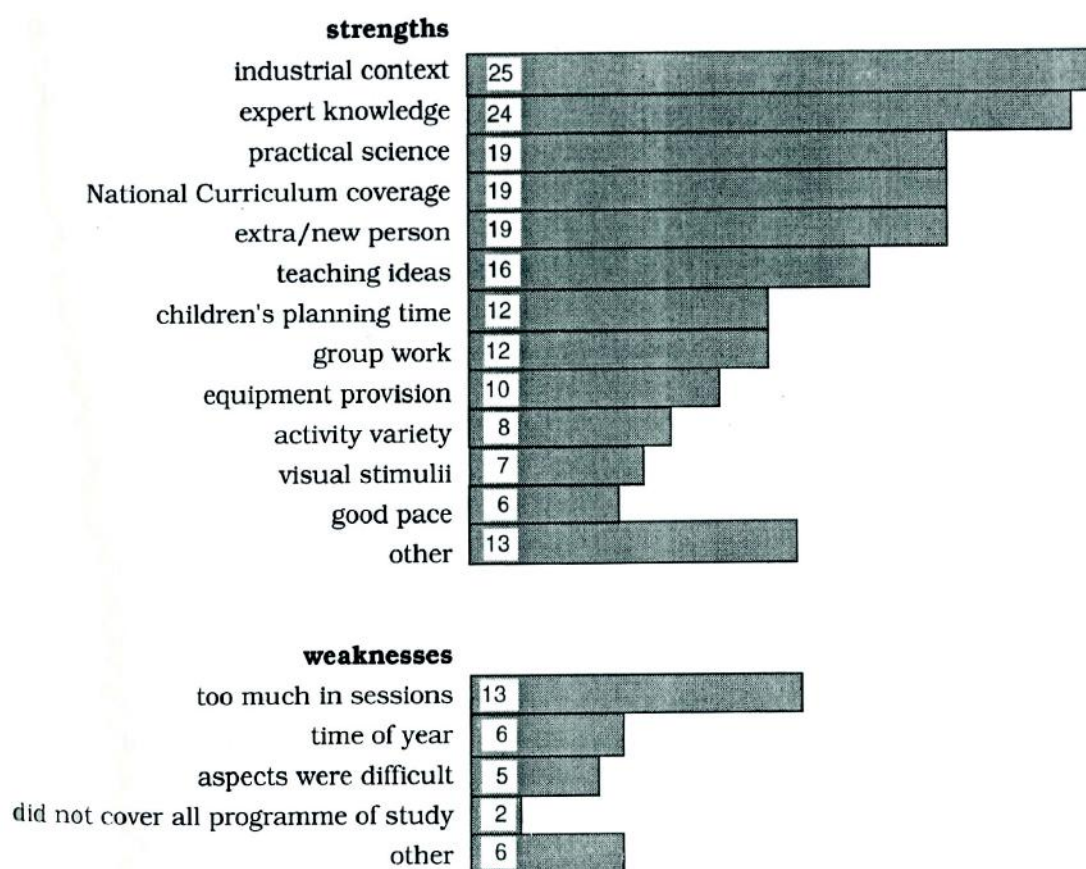
The industrial context and the presence of an 'expert' were seen by the teachers to provide children with greater motivation and a purpose for carrying out the tests and investigations. The following quote comes from a teacher who had little inclination to use industrial contexts prior to the project, but was working alongside a teacher who had participated in the project during the previous year:

"The problems set gave them a real live task and they liked that. So I shall play very strongly along those lines of 'they have been asked to do something and they are going to come up with a solution'. That gave them the motivation to do it. Putting it into some sort of context rather than it being something the silly old fool wants us to do!"

(S14/V2/T2/35)

Post intervention, his opinion had changed quite dramatically, and he could see the benefits in providing a context which interested the children and provided them with a reason for doing science. This teacher had worked in the chemical industry and had had input on industry liaison during teacher training, during which he had visited a large chemical company. These experiences had put him off any industrial liaison work prior to participating in this project (see page 80 for a quote from this teacher on site visits).

46% of the teachers used the word 'expert' to refer generally to the knowledge that the project officer was able to share with them and their classes. The other 54% of the teachers specified the nature of this shared knowledge, and felt it was predominantly with themselves and was about science, as the following figures demonstrate:

29% referred to knowledge shared with themselves 17% specified knowledge shared with children 25% of the teachers specified scientific knowledge 4% specified knowledge of industry.

Almost half of the teachers also felt that more practical work was carried out than in their own science lessons. They cited lack of confidence, support and equipment (such as thermometers, funnels, and stop clocks) as reasons for not doing much practical science. Some teachers commented that with insufficient equipment, they would have used demonstrations to cover the concepts. One teacher expresses this view:

"It's good that they [the children] have been doing it. Because sometimes I still do the investigations, but it's me at the front. I feel I don't have the equipment or enough confidence to let the whole class do it, but I still feel it is better than nothing. At least I am doing it at the front and they're predicting and watching. So the fact that they did it themselves I think was good."

(S10/T2/6)

Unfortunately, she did not appreciate that by using demonstrations the activities were no longer investigative in nature.

In addition to the scientific and industrial input, the project officer offered an 'extra pair of hands'. This kind of support was cited by some as not usually being available during science lessons, thus reducing opportunities for practical work. A small-scale study of good practice in primary school science teaching identified the use of adult support in the classroom as one of the strengths of the lessons (Summerfield, 1997). In future phases of the project, this aspect of developing practical science could be encouraged.

Another teacher realised that, even with poor classroom facilities, it was possible to carry out practical activities:

"We actually just dived in and did the practical stuff which, given the nature of the classrooms - I mean they don't lend themselves to that sort of activity. I've worked in classrooms where there have been bench areas to set up things and had things easily available, where you've got water in the classroom, plenty of power points, and places to store equipment. We didn't have those facilities within the classroom

and so yes, I would probably be less likely to do that normally. But you come along and you've got all the equipment, you've got all the activities and we just jumped in - both feet - and we made it work."

This teacher repeated the activities with a parallel class, using the same practical approach as the project officer, which he would not have done prior to this project.

Another strength for twelve teachers was the inclusion of thinking and planning time for investigative activities. These teachers felt that the importance and time that this aspect was given during the sessions ensured that children were challenged to plan their investigative work thoroughly.

"It involved making them think independently, which was a huge thing for the children. It was a really good project from start to finish It brought everything together so that they could see how it would work in the real world. All the areas made them think independently and got them to work on their own initiative and I think that if we can get them to do that we've sort of succeeded at primary school."

Other strengths that were mentioned included the time spent on discussions, the progression incorporated into the activities, the concentrated block of time on science, and the 'wow' factor:

"I thought the polystyrene demonstration was super and so did they, they were so impressed by that. It was like the 'wow factor' in science which I think you have to have every now and again because that keeps them interested. I thought that was really effective and visual and they were all involved."

The main aspect of the sessions that teachers were concerned about was the pace. Indeed, this was of concern to both project officers concerned. Each, at the start, tended to fit too much into the sessions. This is reflected in the result that thirteen teachers felt that the sessions should have been longer in order to cover the number of activities and/or concepts. The project officers did, however, respond to this concern and some sessions were modified during the project. Nevertheless, one cannot satisfy everyone, and six teachers felt that a good pace was a positive aspect in maintaining the children's interests!

Furthermore, it was necessary for the temporary project officer, who had had limited experience of primary school work, to reduce the sophistication of the scientific explanations, as can be seen from Figure 5.8. This was a valuable experience for the project, namely the detail of briefing needed for the person carrying out the intervention.

Six teachers felt the time of year was a crucial element, with four teachers stating that September was a bad time, as the relationship between themselves and their classes and ground rules had not been established prior to a visitor coming to work with the children. One teacher felt that the summer term was not a good time for 10-11 year olds who were winding down after SATs and preparing to move school (though others felt this was a good time for the same reasons). The sixth teacher was reeling from the school's OFSTED inspection, and found this a difficult time to work on a new project.

Other weaknesses included the length of discussions, the slow pace, the lack of equipment for teachers to be able to repeat all the activities, and the difficulties in fitting the project into the school timetable. For example:

"I haven't been unhappy with any of the aspects but it's just that the way that it's been timetabled with us, with everything else that's been going on, I've found that I've been having to rush off and do other things as well as concentrate on this. I would have preferred to have been able to concentrate on this more. But with things like sports day in the afternoon and we've got visits planned and plays and things, so everything's sort of come at once."

(S38/T2/34)

This comment links with others made about the timing of the project in the school year. However, the primary school calendar is full, and it would be difficult to find a time of year which suited all schools. The visits to some of the last schools to participate were planned two years in advance, and perhaps this was too far ahead. Future similar projects would be best planned a year ahead, thus allowing teachers planning time in the knowledge of the school's other calendar commitments.

Many of the strengths and weaknesses of the sessions also relate to the teaching methods used, as shown in Figure 5.9. Approximately a quarter of the teachers felt that the project officer was able to structure or focus the sessions more, and this was often linked with the fact that the officer had a better knowledge of teaching science. On the other hand, three teachers felt that they carried out more structured lessons, because they found it difficult to allow the children to have the freedom to investigate a topic too widely. Similarly, three teachers found the sessions more adventurous than their own, and they felt they now would try similar methods.

Figure 5.9 Comparison between the project officer's and the teachers' teaching methods

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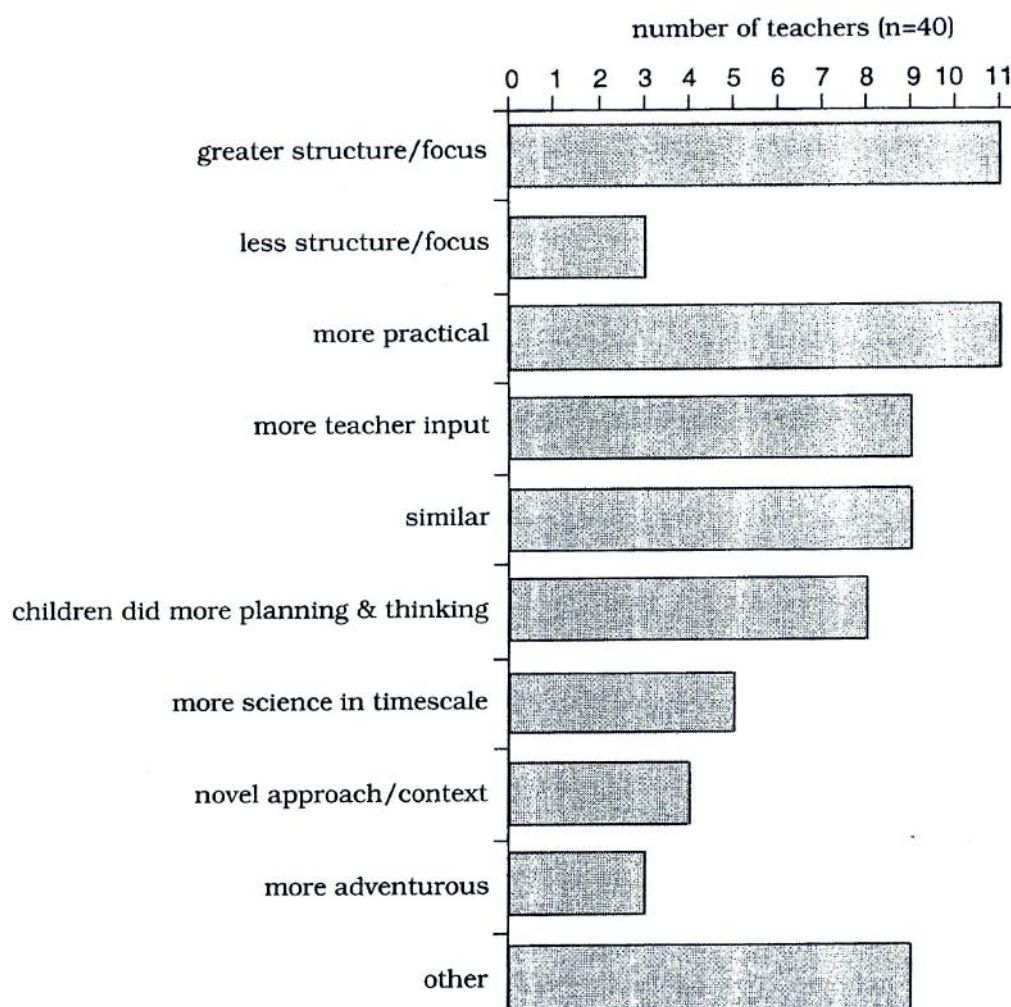
Five of the nine teachers that observed the project officer using similar teaching methods to themselves felt that this had reinforced their direction, and confidence that they were tackling science positively. Other positive comments included the well planned activities, the use of an industrial context, and the use of questioning:

> *"On a personal level, I liked the way you questioned the children. It taught me different ways to ask questions and you explored some avenues more fully than I would have done and yet you didn't explore other avenues that I would have probably prattled on about for a while, that you moved it on. So I found that personally a main strength because it taught me how to do it better in the future*

> *(S33/T2/34)*

No criticisms were made of the teaching methods used, though one teacher said the children recorded more during his science lessons, in order to provide evidence of their learning. He felt **the focused discussions replaced this element during the project activities.**

5.2.2 Views of the industrial aspects of the project

Teachers summarised the aspects of industry covered during the project, and these included aspects covered during site visits, where applicable. The findings are summarised in Figure 5.10, and three main categories arise. Industrial processes were felt to be covered in both the classroom sessions and the site visit. The nature of the classroom activities was often to model industrial processes, so this is perhaps not surprising. The people involved in industry were deemed to be covered more frequently when children visited the site and met with real people, and talked about the jobs they did. This was a minor component of the videos shown, and though the role of the scientist in industry was emphasised during the classroom sessions, other jobs were rarely touched upon. The applications of science were also felt to be best covered during a site visit, when children saw, for real, the links between their classroom activities and an industrial site.

Other aspects of industry covered included an appreciation for the scale of chemical sites, safety issues and the financial management.

Figure 5.10 Project input on industry
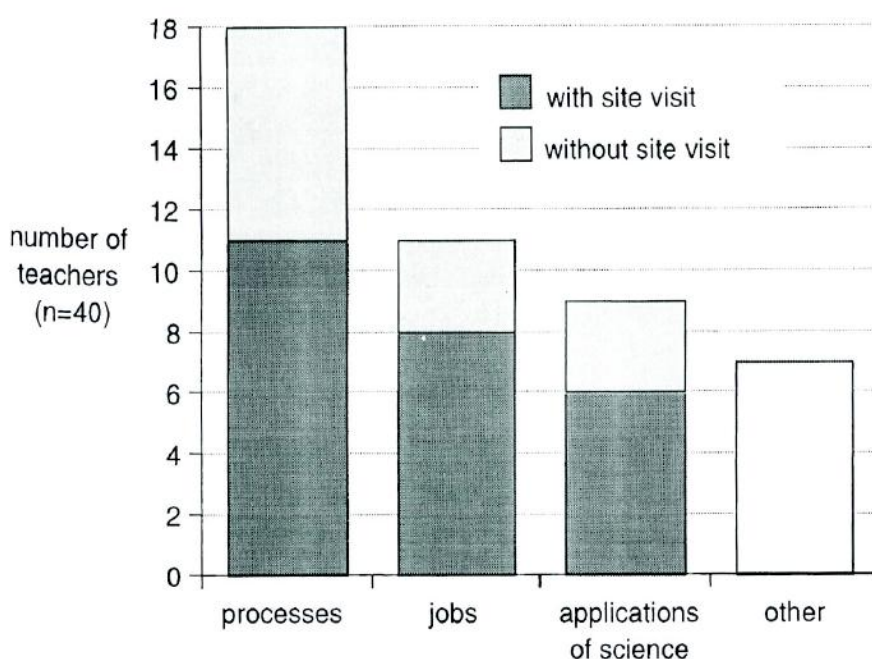
Over half of the teachers felt that the balance between the input on science and that on industry was appropriate, regardless of whether the children had visited industry or not. However,

thirteen teachers would have liked to have had additional input on industry. Eleven of these teachers' classes had not visited industry, and felt it would have pulled all the classroom activities together for the children.

All the teachers who visited industry felt it was an important, if not essential component in making the link with science meaningful and real. One teacher said the children would have been 'left in mid-air' had they not visited industry, and thus reflected the views of those who missed the opportunity.

Two teachers wanted children to visit another industry, but for different reasons. One wanted children to see the next stage in the process whilst the other wanted children to see a 'dirtier' environment to counter balance the clean industry they had seen. It is not known whether these teachers went ahead to arrange these visits.

Some of the companies involved in the site visit were prepared to tailor their visit to the children's needs (taking advice from the project officer, as described in chapter four). However, less successful visits resulted from inappropriate tours. The following quotes are all from teachers who had visited the same site. The first quote is from a teacher who took children to visit the site. The teacher felt that the links between the classroom science and industrial practice were made well, but acknowledges the dull nature of the visit. Children in his class reported to the project officer that the site was dangerous and, due to this danger, they had not been allowed to visit any production areas. The second and third quotes are

from teachers who visited the site as part of their post-graduate teacher training courses. Their visits had put them off liaison work with industry.

> *"The pipe work for the process is exposed, they don't go digging holes to repair pipes, and the children saw all three hundred and eighty something miles of it."*
>
> *(S6/V2/T2/60)*

> *"[The site] was mysterious. They tended to tell us a lot about how they were kind to wildlife. I had the feeling they were trying to brain wash us. I didn't find out anything about what the industry actually was. Whilst on the bus we were told 'We can't get off and look at that.' and 'No, we can't go too close to that' and it was just so unnamed. I never knew what anything was."*
>
> *(S16/T1/24)*

> *"I'm not convinced to be honest. I went round a site with a large group, it was a student group, and none of us were very impressed. I don't think there would be very much for the children to actually see. We were taken on the standard school party trip which was a bus trip and there was a cooling tower, and told 'that's a holding thing for such and such a chemical' and' that's this' and 'that's where people get dirty' and 'this is this' and 'this is that', and then we went back into the centre. They had a lovely education centre and they talked to us about forming polymers and using chemicals and that was fine but that could have been done in any classroom."*
>
> *(S14/V2/T1/26)*

These comments reinforce the findings discussed in chapter four, that a site-visit needs to be adapted to meet the needs of the children, and a site needs to enter into dialogue with the teachers in order to be able to meet these needs. If teachers feel they are being offered a 'standard visit', then it is difficult for them to see how the visit might enhance the children's learning.

No-one thought that there was too great an input on industry. The fact that the curriculum had led the project, rather than the industrial sponsorship was a pleasant surprise to several teachers, especially those who had initially been suspicious of the company's motives:

"I think if there had been a greater or direct industrial content, or if there'd been something for just a specific product or something, I wouldn't have been happy. I think the balance was just about right. They learnt something. They learnt something about the industry generically."

(S6/T2/50)

This teacher touches upon the children's learning, which the next two sections discusses in more detail. Section 5.2.2 focuses on the children's learning outcomes, as perceived by the teachers, whilst section 5.2.3 concentrates on the learning outcomes for the teachers themselves.

5.2.3 Children's learning outcomes

The positive outcomes cited by the teachers related predominantly to the science curriculum they must teach, and particularly the investigative element of the curriculum (Figure 5.11). The activities were felt to assist children in many areas of the investigative process, including planning the investigation, using skills such as measurement to carry out their experiments, and recording and analysing the outcomes:

"A lot of my science tends to be relatively safe in the sense that it's focused towards outcomes which I know and therefore is directed at AT2, AT3, AT4. And I think the principal learning outcomes (of the project) were that the children were actually doing real science and there was a lot of investigative science. There was a lot of AT1, and AT0 as well, because they were having to think for themselves what they wanted out of an experiment. And then they had design the experiment, and then they had to execute the experiment and interpret the findings. So there was a huge range in terms of what we're expected to do in schools."

(S6/V2/74)

Figure 5.11 Teachers' perceptions of the children's learning outcomes (n=40)
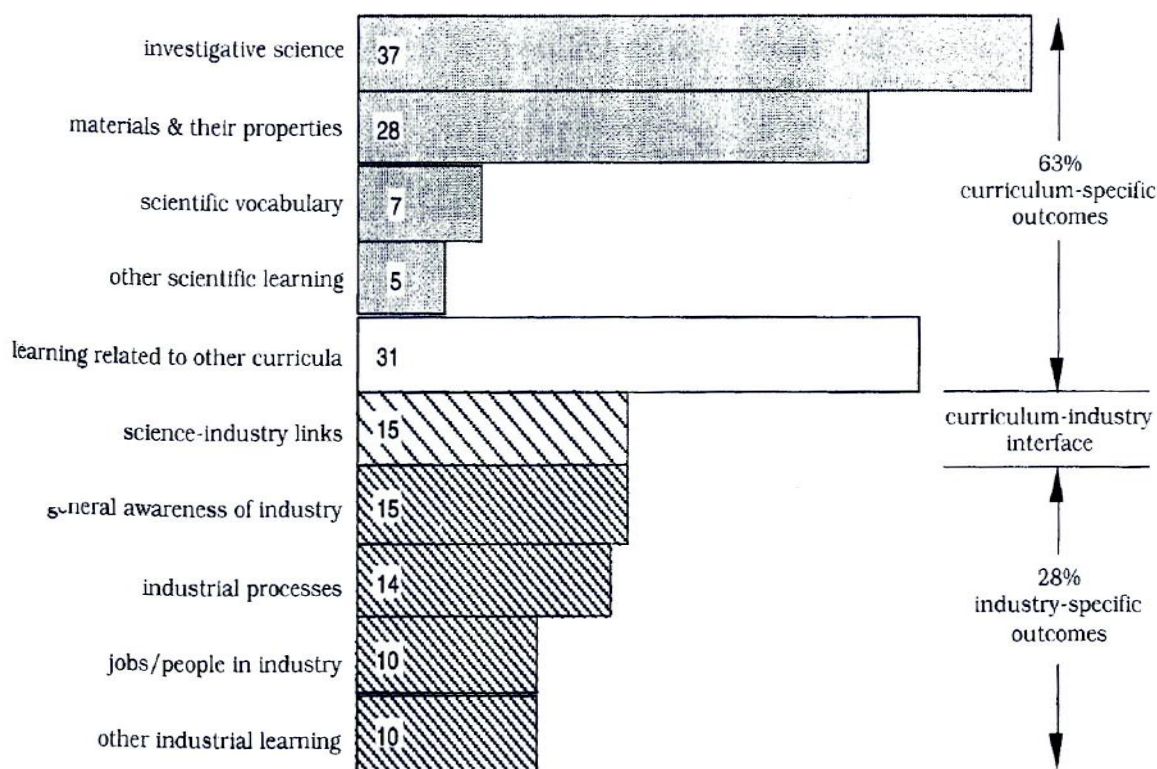
Aspects of the science National Curriculum attainment target 'materials and their properties'

were also covered in varying degrees, depending on the set of activities with which the children worked. The activities on salt and plastics had a strong bias towards this attainment target, whilst the activities on water usage covered a more limited number of aspects.

The cross-curricular links were apparent to teachers, and these were predominantly in mathematics, English and technology. Mathematical activities included the use of measuring equipment (stopclocks, thermometers, weighing scales); recording results in tables and bar charts; and working to a budget. English activities included speaking and listening skills during discussion; letter-writing; report writing; and reading and following instructions. The plastics activities incorporated a 'design and make' technology activity, in which they used their scientific knowledge of materials.

Teachers also commented positively on children's learning about industry, both to motivate and to teach children about industrial processes:

> *"You could see the processes that you'd been talking about. I thought the expanding polystyrene was very impressive, that children could actually look at that. And although it was simply done from your point of view, the children were enthralled. So was I! To see something like that happen in the primary classroom that doesn't normally happen."*

> *(S2/T2/24)*

Three teachers described the children having a sense of belonging, that prior to the project, industry was part of the adult world, but after visiting industry they felt it was part of their world. One teacher said the children felt like the company was 'their company'.

Only 9% of the outcomes were related to the links between science and industry, though these were cited by over a third of the teachers, and they all focused on the value of the industrial context in making the science meaningful, and on the science having a role outside the classroom:

> *"The children have actually been able to apply themselves in a real way, its not just a table of results and lets have a chat and put it away. Someone else somewhere actually does this, and some of them were quite surprised that this is the kind of thing a group of people would do. That they produce the plastics to be used, someone has to test them, and that's reinforced with the video, when you actually saw it being compressed and stretched and snapped.*

> *They're actually seeing that their work has got some value because someone else, somewhere else actually makes a living from doing it. Its not something the teacher just said I want you to do, there's a value in actually doing a test on a product."*

> *(S9/T2/48)*

All the teachers described the children's responses to the project as positive, saying they enjoyed the work, and were motivated and enthusiastic (29 teachers); were interested in the science; and got a great deal from their involvement (21 teachers). The following quotes from teachers reflect these feelings:

> *"I think the sessions went very well. The children enjoyed them. I know that for a fact, because they have written some reports, the end of term school reports, and in science they have said they liked best the lessons that Ms Parvin did."*

> *(S10/T2/2)*

"The levels of interest were very high during the sessions and the children were well motivated, and I feel that they have got a great deal out of the sessions."

(S8/T2/2)

"The ones who are much more capable have got an awful lot out of it, but there are other unexpected children who have really taken to this and they've got such a lot out of it. They have been so animated with all the work, and it doesn't usually happen."

(S16/T2/91)

The only negative responses cited were by two teachers, one felt the children had got a great deal from the work, but had been impolite to the project officer, and another teacher felt that the children had been somewhat lethargic, due to them being final year children who were about to leave the school. There were occasions on which the role of disciplining the children was not defined prior to beginning the project. This was certainly a learning outcome for the project officer, who realised that the classroom roles of the teacher and the officer had to be defined and agreed prior to commencing the classroom sessions. In most schools it was agreed that the project officer would play a minor role in classroom discipline, and that this area was best left to the teacher, who had established ground rules with the children. However, this is a broad generalisation, and each case was dealt with individually to some extent.

5.2.4 Teachers' learning outcomes

The greatest learning outcome for 65% of the teachers centred on how to teach about industry (Figure 5.12). Some of these teachers were more confident and prepared to carry out industry-related activities or to contact local industry. However, others were enthusiastic to carry out the activities, but still wanted support in actually contacting local industry. When interviewed a year after the project input, a third of the teachers interviewed had visited industry (Figure 5.13, page 85), but this rarely related to the industrial contacts made during the project. For example, one school visited a farm and another school visited a nuclear power station. Only one school had contacted one of the company's involved in this project. Perhaps the fact that the project officer set up the visits for the schools, and offered guidance on what to do in the future, did not adequately prepare teachers for making contact themselves. A future model may be to arrange the site visits alongside the teacher, ensuring that the teacher is involved in the crucial stages. For example, the teacher could talk to the company's contact to discuss the timetable for the visit.

Figure 5.12 Teachers' learning outcomes (n=40)

81
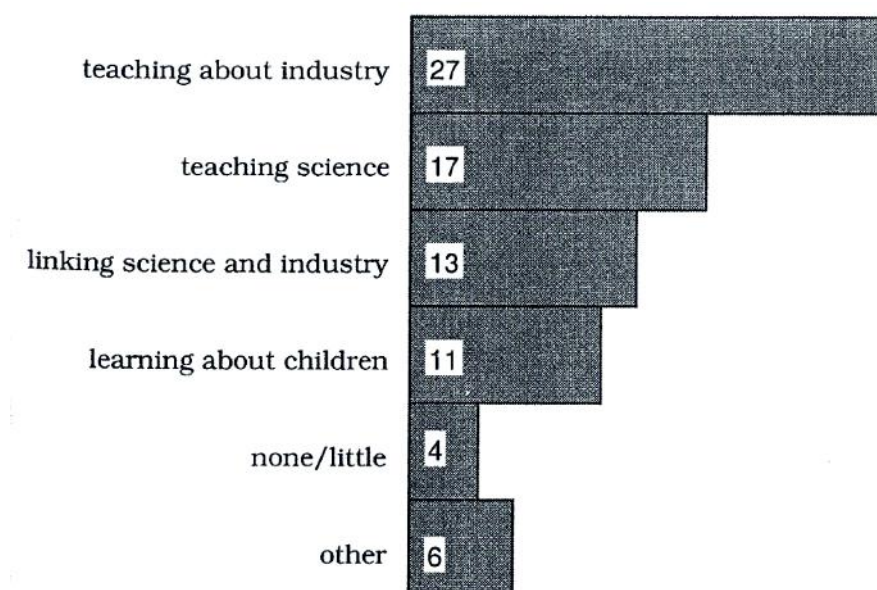
In having an opportunity to observe the project officer teaching science, 40% of the teachers felt they had learned how to teach the subject more effectively. This was predominantly by enhancing their own methods such as questioning or organising practical work, and sometimes by enhancing their own scientific knowledge. For example, one teacher felt she had gleaned ideas on how to manage her science lessons:

> *"It's taught me about bringing the whole thing together. It's taught me that that's a good way to do things. It's taught me different ways of teaching, for a start, and different ways of trying to get them to work on their own initiative. It's also helped me to focus science into manageable bits, so that they can manage. It's been very helpful."*

> *(S30/T2/56)*

Another teacher felt she had been tackling science at too difficult a level, because she was using her own O-level education to try and get across concepts to 10-year olds:

> *"I thought 'yes, I never thought of doing it like that', the sort of investigations and the setting up of their tests. I think also I suppose I made it difficult for myself because I'm not a scientist anyway and the last time I did science would have been at O level. You feel or you're made to feel that you are inadequate within that area. You feel as if you should know a little bit more or be a little bit better and I think watching you it suddenly made me realise that perhaps I have an expectation that doesn't need to be fulfilled in terms of my delivery and knowledge. Its the actual skills and the approach and the observation side of it (that I've learned about), because they are looking and thinking and recording and all that sort of thing."*

> *(S7/T2/6)*

Thirteen teachers expressed an increased willingness or confidence to contact local industry, as they felt the link was useful in enhancing children's learning. This is an important outcome of the project if it is to have any lasting impact on classroom practice.

> *"I think it [the industrial context] makes it relevant, it makes science real. It's not just a little experiment that's in isolation. Yes, it's teaching them about, you know, things around them. But it's putting it into a context and it's giving a reason for science."*

> *(S8/T2/162-166)*

Other outcomes were improved confidence, awareness of the support available, and the desire to inform future teaching.

This classroom-based training has clearly been effective in developing teachers' ability to deliver the science curriculum, and to do so using industry as a vehicle. Only four teachers (10%) felt they had learned little about industry, and only a limited amount about science teaching. These teachers were confident science practitioners, and felt other staff would have received greater benefit from the input. Although the invitation to join the project laid great emphasis on the training element, perhaps future phases should highlight this even more so. In addition, project participation could be offered to teachers of younger children, thus offering more teachers the opportunity to be involved and receive training.

5.3   Long-term effects of the intervention

One year after participation, all the schools involved in the first two years of the project (22 schools in total) were approached for data concerning their industry-links. Where possible, the teachers involved were interviewed. In five cases the head teachers were interviewed, as the teachers had left the school. The majority of these data are collated in Figure 5.13. Percentages rather than numbers of teachers have been represented, as of the 44 teachers involved over three years, only the first 22 teachers were interviewed a year later. Of the five headteachers

who were interviewed, none of them had any idea whether the written resources had been used since the intervention, and any industrial links they referred to were with other organisations or industries. How these outcomes are used to inform the design of future phases of the project is discussed in chapter six.

It was encouraging to find that 41% of teachers had repeated project activities, using the written material provided, and that a further 36% intended to do so. Those who were still going to use the resource, intended to repeat the activities at an appropriate stage in the school's two-year planning cycle. This kind of cycle is a common approach adopted by primary schools, in order to reduce the quantity of knowledge, skills and processes that are taught from the National Curriculum in any one year. Therefore, aspects of the 'materials' topic will be repeated every two years.

It was, however, discouraging to find that only 18% of the teachers had used any similar material. Each school was offered an additional free activity pack produced by the Chemical Industry Education Centre, which was similar in style to the ones used during the project intervention. The decision to offer these packs came at the end of the first year of the project, so some schools were offered the packs retrospectively. Only nine teachers (41%) took up the offer of this second resource. The remaining 13 teachers could not remember receiving this offer, or had not made time to look at the catalogue of resources from which they could choose, or had not made time to look at the ordered resource. Five teachers did intend to use the resource in an appropriate point in the two year cycle. These data should also inform future project design, and this is discussed in the next chapter.

Figure 5.13 Comparison of predicted and actual science-industry link work carried out after project participation
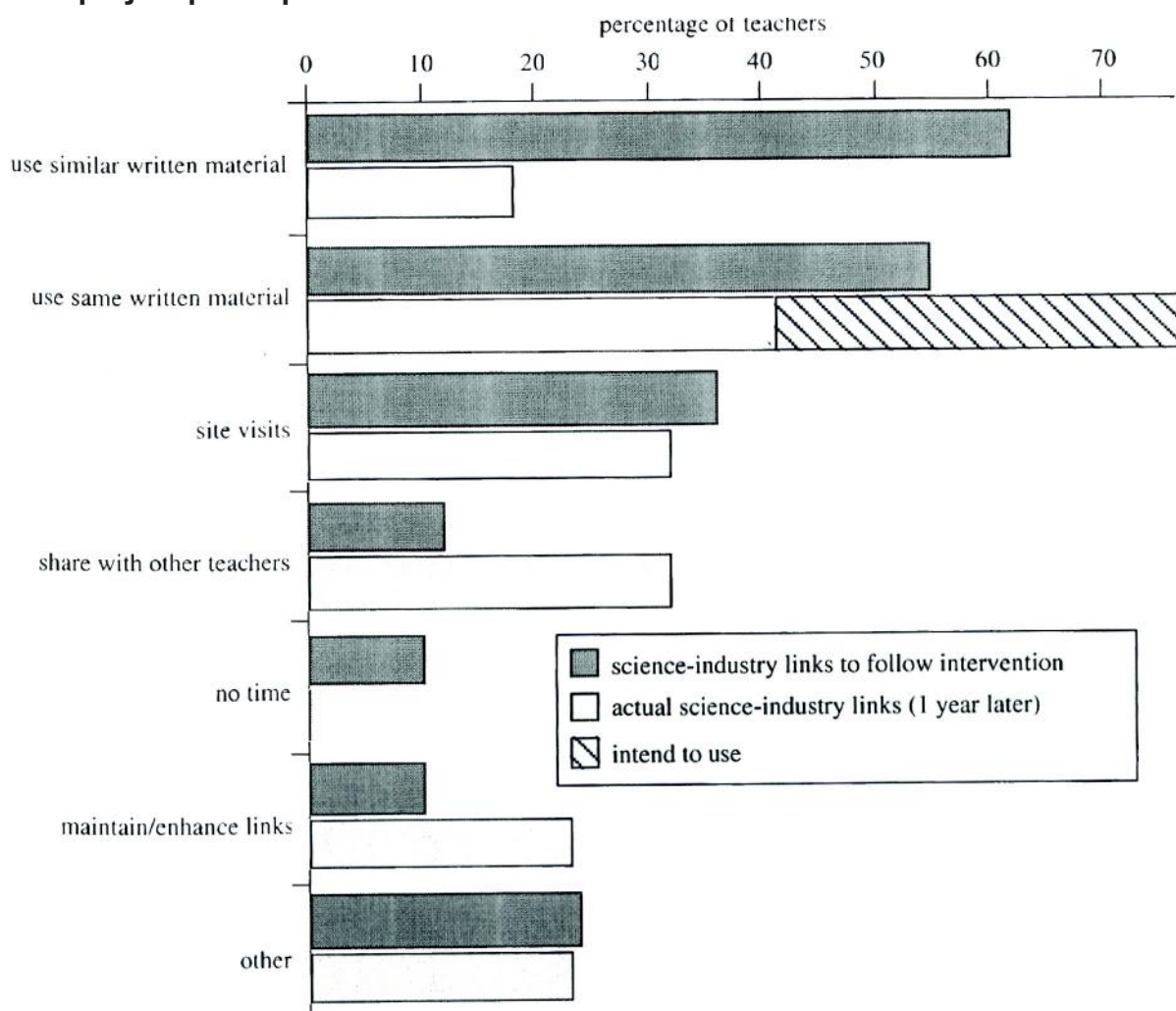
A higher percentage of teachers than predicted chose to share the industry-linked activities with other teachers in the school. The instances in which this sharing occurred were one of the following:

- another teacher taught the same age group
- the additional pack ordered fitted into another year group's teaching programme
- high quality of the material.

Reasons for not sharing the packs with others were similar, i.e. the written materials were only suited to the one class's teaching programme; and some teachers wanted to keep the high quality materials to themselves rather than share them with others.

24% of the teachers had maintained or enhanced their industrial links. In some cases, development of the links was as a direct result of the intervention. For example, in one school the links had been broad community links, and after the intervention the links had gained a science-focus. In another case, a teacher had been inspired to contact the local university and make links with the physics department. In two cases, the material had been used to highlight the needs for industry links with the science co-ordinators.

Other industrial links included teachers attending courses run by the Durham Business Education Executive (DBEE) and one teacher inviting an industrial visitor into the classroom. During the project, the project officer provided information to the teachers about the DBEE, and suggested they contact them about funding for transport to industrial sites. This resulted in several schools joining the DBEE, and others to rekindle their links.

The long term effects of the science input were very encouraging. 16 of the 17 teachers interviewed (as the head teachers could not comment on the science support received by the teachers who had left) felt the science input had effected their science teaching in some way. Table 5.1 summarises the changes which teachers felt had occurred:

Table 5.1 Changes in teachers' science teaching as a result of the intervention

area of teaching affected	number of teachers (n = 17)
more investigative work	5
more practical work	4
use techniques/ideas from project	5
other	7
no change	1

The one teacher who felt he had gained no science support felt that 'primary science was impossible' any way, as he did not agree with any of the National Curriculum or what was expected of him and the children. However, all other teachers described positive changes. Nine of the teachers referred to changes in their investigative or practical work - two strongly linked areas. Two teachers describe increased confidence to give the children more opportunities in the practical/investigative sphere:

> *"The sessions encouraged me to be more practically minded. My science always has been practically based, but there has been a limit to the extent to which I would allow children to explore very open ended activities. I've tended to know, in most cases, what the outcome should be, even if it doesn't appear. But I think I'm more confident in terms of allowing them to investigate rather than to find out as it were."*

> *(S6/T3/90)*

"I think I became more adventurous in what I tried with the children. ... I thought, well why not? We'll try and just take things that bit further. So I think for probably the more able children, it extended them that bit more. Whereas before I perhaps was being satisfied with a lower standard, or a lower aim. So I felt a bit more capable. Because I'm not a science person. I was trained as an art teacher which is totally the opposite end of the spectrum, isn't it? So I felt more confident to try things and not be afraid if they failed."

(S4/T3/360)

Other teachers described using new ideas and techniques to manage their science investigations:

"Before [the intervention], my investigations had been very much open ended, and as a consequence they didn't the same narrow and defined focus as Joy had in her lessons. She got her investigations completed in one session and I rarely did. We were always hanging on and hanging on. I saw the benefit of having the beginning and conclusion within the same session. It definitely helped the children. I have tried since then to have the same kind of focus to my science and have all the science investigation and conclusion done in the same lesson. I had found conclusions and looking at your results and that sort of thing went by the board, because there was then something else that we had to move on to."

(S17/T3/72)

Other areas in which teachers felt they had gained in the long term included one teacher's direction in science being set, another having enjoyed the project's science topic most during that school year due to the support received, and a teacher who felt she had gained personal knowledge from both the written material and the project officer:

"I was more on a par with the children when Joy first came in and it was all new to me. What they learnt, I learnt also so it furthered my knowledge of basic scientific principles as well as how industry would work. I thought it was an excellent package and Joy's support was invaluable."

(S16/T3/62)

Three quarters of the teachers had wanted to improve their own knowledge of teaching science during the project, and so it is pleasing to find that this change had occurred for nearly all of the teachers. The intervention had predominantly affected the nature of the science activities they carried out with the children, by offering structured investigative and practical work. These kinds of science activities are certainly popular with primary children, as the next section shows.

5.4   Children's views

5.4.1 Views of the classroom activities

The three series of activities offered to schools can be categorised into different styles, as shown in Table 5.2. In open-ended investigations, children are expected to be responsible for the design of an investigation, carrying it out, recording the outcomes and (to a limited extent) analysing their findings.

In a semi-structured investigation, children were provided with some information on which to base their investigation. For example, in one such activity, children were asked to find the best material for a water pipeline, and were asked to use a steel can, a plastic bottle and an aluminium can during the investigation. They were also provided with a table in which to write their results.

Table 5.2 Types of classroom activities offered

activity type	plastics activities	water activities	salt activities
open-ended investigation	1	2	2
semi-structured investigation	1	2	1
structured practical	1	0	1
practical demonstration	1	0	1
technology practical	1	0	0
question and answer activity	1	0	0
video	1	0	1

In a structured practical, children were given instructions to follow. For example, they were told how to add rock salt to water, filter it and evaporate the water to separate out the salt.

Demonstrations were carried out by the project officer in front of the whole class, with participation from 'volunteers' and by questioning during the activity.

Children were given cards showing the titles of all the activities they had done (e.g. 'table salt from rock salt') and asked to select the most and least interesting. Their choices were collated in to the type categories, as shown in Figure 5.14. Children found 71% of all the activities very interesting, and 29% not interesting.

Figure 5.14 Children's interest in different types of science activity
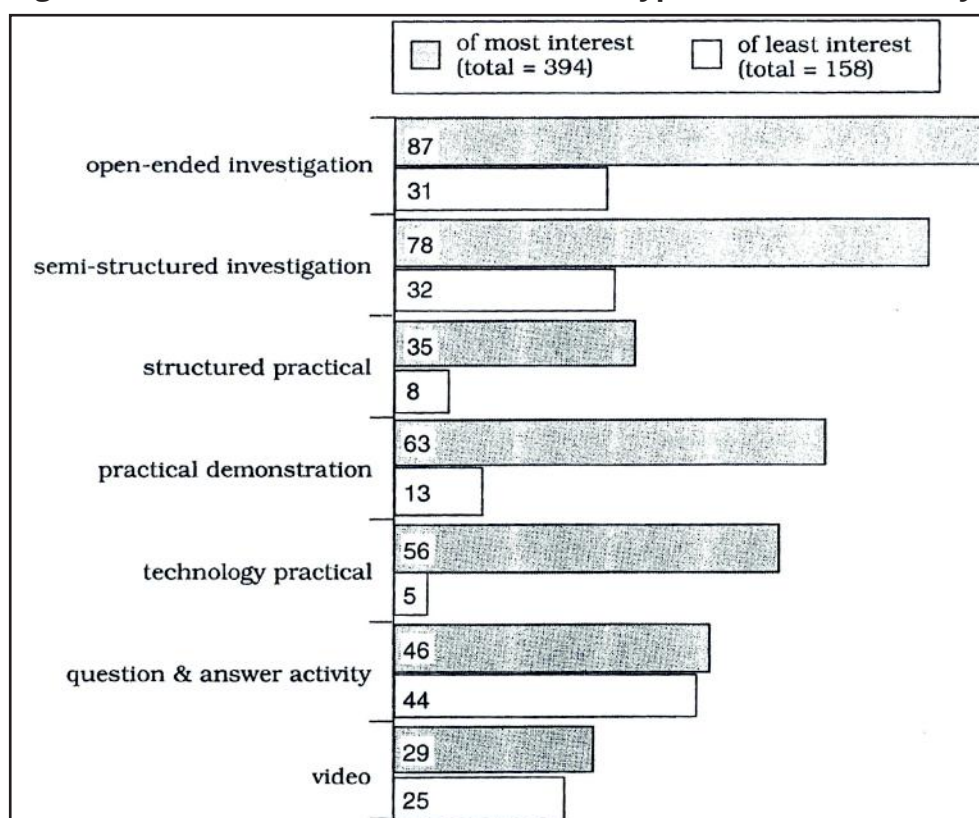
The reasons why children enjoyed these activities are collated in Figure 5.15. Some children found it difficult to express reasons, and simply stated that the activities were fun. Many children could respond in more detail and offered a variety of reasons. Learning something new, and seeing outcomes to experiments, which were often unexpected, were important to children enjoying an activity.

Figure 5.15 Children's views on what makes science activities interesting (n=86)

reasons for interest	
new knowledge	68
surprise outcome	41
seeing outcome	63
responsibility	46
experiments	37
range of equipment	47
challenge	46
easy	26
fun	58

reasons for lack of interest	
not new knowledge	14
did not always work	20
not enough to do	27
waiting too long	28
boring	32
too difficult	11
too short	14
too easy	14
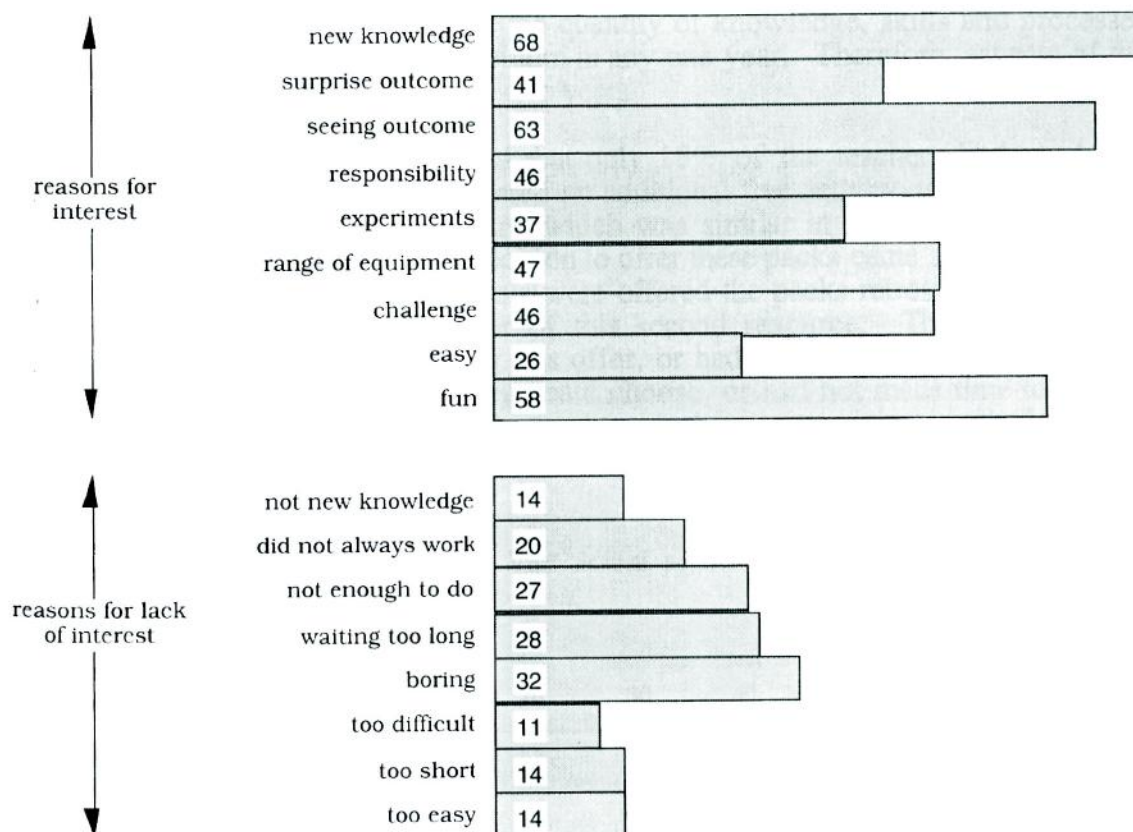
One research study, conducted prior to the prescribed curricula in the UK (Hadden & Johnstone, 1982) found that 80% of primary school children with limited experience of learning science at school were interested in the subject. Further probing revealed the two most frequently cited reasons for this were the expectations of

- exciting, interesting experiments (35%)
- acquiring new knowledge (15%).

(All other reasons for interest acquired a 1.00 - 4.3 % response rate.)

These findings are similar to those of the Children Challenging Industry project. Children in the Children Challenging Industry study describe interesting science activities as having these features. They are able to talk in more detail about the aspects of the experimental work than Hadden and Johnstone's study group, as they have actually carried it out. Therefore, they describe enjoying using the equipment, carrying out experiments independently, and observing the outcomes.

It was also important for children to be given responsibility to carry out investigations independently, and to use a range of equipment themselves. This sense of independence, with guidance, was also found to be the most importance feature of the learning environment in a research study of 10-11 year olds (Heath, 1999):

> They did not feel secure with free investigation, nor with prescribed activities, but preferred a compromise between the two, giving them a structure within which they could freely explore their own ideas.

> (p.32)

Many children enjoyed the challenge that these independent activities gave them, though a sizeable minority preferred the activity to be 'easy'. Nurturing independence of this nature was a key feature of the project officer's teaching style, and is a characteristic of 'good practice' identified in observational studies (Summerfield, 1997).

The videos shown were met with mixed reactions. Some thought the videos were very interesting, as they learned new things, and others found them dull and 'boring'. As the videos were not made for this age range, it is understandable that children found them boring, as some of the language was fairly complex. One video about salt was used with some children, and this was aimed at lower secondary school children. The video seen by most children was about plastics. The project officer had pieced together aspects of three chemical company's videos, two of which were aimed at their customers, and one was aimed at secondary school children. Unfortunately, the project officer was unable to find any material on the chemical industry which was ideal for primary school children.

The project officer tried to overcome these problems by stopping the video at various points to discuss the images portrayed, and sometimes turned off the volume and discussed the images with the children as the video played. Some school equipment did not allow for freeze-framing the images, which made describing aspects of the video difficult. Reducing the volume, of course removed all the background sounds the children would have heard, which was dissatisfying for some.

Reasons for activities not being interesting were almost a mirror image of those given for high interest levels. Children did not enjoy activities in which they were relatively passive, due to having to wait too long for an outcome, or not having enough responsibility. Again, there was a split in opinion between the interest level of easy or difficult activities.

Children wanted outcomes to their experiments, and did not like it when things 'didn't work' and they had to repeat the activity, or time prevented them from repeating a test.

So, in summary, the activities which held the greatest appeal to children were those which had provision for:

- new knowledge
- an achievable outcome
- active participation
- use of simple scientific equipment
- a challenge, but which is not too difficult.

Some of these characteristics link with the teachers' learning outcomes. Having observed the project officer providing experiences with these characteristics, teachers described an increased confidence and ability to offer children similar lessons. The aspects of the lessons which the teachers focused upon were:

- structure and focus; resulting in achievable outcomes
- practical and investigative nature; resulting in the active participation and use of scientific equipment.

5.4.2   Sources of further information on industrial products

Children were asked, pre-intervention, to say where they got their information about industry. The major source cited was television, with 'passing industry' following in close succession. Post-intervention, children were asked where they would find more information on the products which related to their scientific activities (e.g. plastics, salt, cooling water). The most frequent response on this occasion was to look in books, but suggestions were made which related directly to industry (see Figure 5.16).

36% of all the suggested sources were to contact industry directly, either by talking to people from industry, or by visiting an appropriate site (or 'factory'). Children also specified some television programmes and videos that were about industry.

20% of the suggestions were for the children themselves to carry out further science tests on the products concerned, thus realising that the science activities could teach them about the properties of the products.

Figure 5.16   Children's suggestions for sources of further information about the project topic (n=86)
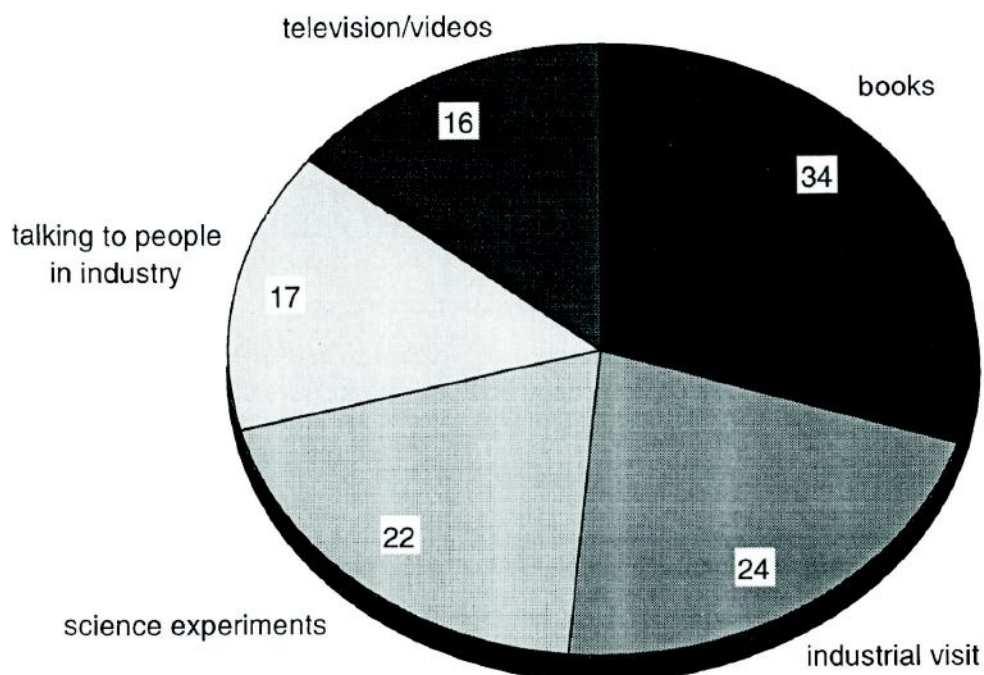
The following quote is from a group of children who did not visit industry, but felt that a combination of repeated science tests and an industrial visit would answer the questions they still had about water pipelines[15]:

> C: *I'd like to find out more about the sealing (sections of pipeline), even though we did it I'd like to see like the glue gun, it didn't work with us because we didn't seal it properly but there's no proof that we didn't seal it properly.*
>
> I: *So what is it that you want to find out more about?*
>
> C: *I'd just like to find out if there's more things that will seal it and ... I: To look at other things for sealing. Yes?*
>
> C: *I'd like to find out about sealing as well, like go round and see like what kinds of pipe joins they use on pipes.*
>
> I: *To actually go to the site and see what they're doing. Jade?*
>
> C: *I'd like to go onto a site as well, to see what they're doing and see all the different things.*
>
> *(S1/C2/132)*

In another school where the children did not visit industry, they were very keen to visit a site where they would see the method of transporting and using cooling water in a real situation. In the following quote, children describe what they would like to know and how they could find out:

> C: *Like the heat exchanger, and you know what we did in the bottle, well how would it have been done in the factory?*

---

[15] C = child, I = interviewer

I:	Right. How would you go about finding that out?
C:	You would have to go and visit.
I:	Yes. Any other way you can think of finding out, or is that the main way?
C:	Don't know.
I:	That's the main way, go and visit them to see? James?
C:	Well, it's a bit like Jazz said. You go and visit, you know, to like the control room to see if they've got like a camera what's inside to see what the pipeline's like.
I:	Right. So do you think that visiting industry would be the best way to find out?
C:	Yes or writing letters. They might just send you a photograph.
I:	They might send you a photo of what the heat exchanger's like and so on, yes. Anything else that anybody else would like to know more about other than what Jazz has said? Laura?
C:	The filter, how they actually clean the water. I:. And how would you find that out?
C:	Asking people that work there.

(S12/C2/56)

There therefore would appear to be more awareness of the link between science, industry and everyday products. The sense of 'belonging' to a world that includes industry, which some teachers described, seems to be reflected in the number of times and ease with which children suggest contacting people in industry. It is no longer an alien and adult domain, but one which impinges upon them in their daily lives.

5.4.3 The role of science in product manufacture

The link between science and industry is further reinforced, when children are asked to describe whether their school science tests have any relevance to the industries which manufacture the products they have been studying (Figure 5.17).

Figure 5.17 Children's perceived importance of science to industry (n=86)

90
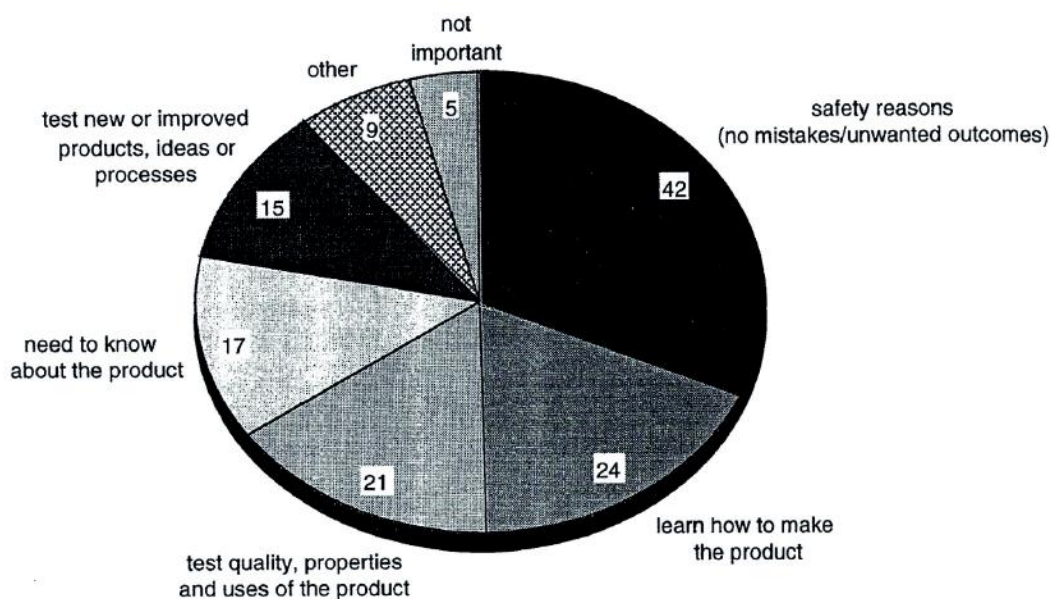
Before the activity sessions, children linked science indirectly with the manufacture of products by talking about testing or checking products to ensure they were of good quality. Only one child mentioned a laboratory in her description of the factory, saying "there's lots of tests and labs where they test the chemicals to make new things". Also, the range of jobs which children thought would be done in the factory rarely included 'scientists', though 'testers' were occasionally referred to (as mentioned above). However, it should be mentioned that children were not asked a direct question on the relevance of science to industry in the pre-intervention interview/questionnaire. This is perhaps a flaw in the data collection methods that should be borne in mind.

Post-intervention, many children felt that the tests they had done were relevant to several areas of product production. Children felt knowledge of the product was the most important reason for carrying out science tests, in terms of how the product is made and its properties, uses and quality. The children in the following two quotes describes the importance of testing the quality and properties of plastics:

> *"Miss, I think it's important to test their products. Miss, 'cos if there was a plastics barrel on a building site, you wouldn't want the colour to just go off and you wouldn't just want it melt down or something, So they'd have to test the different things that it can stand, different types of weather."*
>
> *(S2/C2/256)*

> *C: One -the polystyrene is important for plastics and stuff.*
>
> *I: What do you mean? What do you mean by important for plastics?*
>
> *C: It would be important how you make them and test to see how strong they are to hold the stuff.*
>
> *(S4/C2/232)*

Safety was deemed to be another important reason for industry to carry out science tests. Children thought that if tests were not carried out which related to the ways in which products were made, any unexpected or unwanted outcomes could be dangerous and 'anything could happen', for example:

> *C: Because they've got water pipes going everywhere carrying sewerage and some will probably be carrying the chemicals into vessels and things like that.*
>
> *I: So why would science tests be important do you think?*
>
> *C: Because a very poor sealant or very poor material for the pipes, they would easily crack, and they have to consider that.*

Only five (4%) of the statements made about this link suggest it is not important, and one of those was because the child thought industry would already 'know the answers'.

5.5   In summary

Teachers must work within the constraints of the National Curriculum, so linking this project to some aspect of this curriculum was imperative. The feelings on the nature of the science curriculum were mixed, with half of the teachers acknowledging its importance, but with reservations as to its complexity and scope. This complexity affects both the children and their teachers, as training opportunities and funding are limited whilst the need remains.

This project met the needs of many teachers in terms of science support, with the vast majority making changes to their methods as a result of the intervention[16]. Changes were noted most

[16] This majority is based on 16 of the 17 teachers interviewed one year after the intervention having made changes to their science teaching.

strongly in relation to teaching aspects of the science curriculum which teachers deemed to be important for primary-aged children; investigative and practical work.

Teachers had also hoped to gain knowledge on industry and how to link it with their science lessons. Half the teachers had made no previous industrial links, and those who had made the links mainly in geography, focusing on land use and pollution. Teachers were aware that their industrial awareness, prior to the intervention, came directly from the media, and several teachers accepted that this was a negative and one-sided image.

83% of the teachers felt they had gained knowledge of industry, and especially how to teach about industry by linking it with the science curriculum. The classroom sessions were warmly received, as teachers described the increased motivation in the children, due to the practical nature of the sessions and the industrial storyline or context. Any hesitation teachers had had about the industrial aspects of the project was removed as the sessions progressed. No-one felt that the project had been a promoting platform for the sponsoring company - as had initially been felt by some. Instead, half of the teachers whose children had not been able to visit industry, regretted this, as they felt this would have been important in completing the project satisfactorily.

Those who did visit industry felt it had been a valuable experience, though one or two changes were desired by some teachers, in relation to the structure of the tour and the language used, in order to make the visit more accessible to these young children. Teachers also require motivation, to incorporate a site visit into their teaching, and therefore liaison between the two groups (schools and industry) is essential. These findings reinforce those in the previous chapter, in that the children who received visits which were adapted to meet their needs, came away with a better understanding of the site, its employees, and purposes.

Few teachers carried out site tours themselves during the year after the intervention, and suggestions for overcoming this are made in chapter six.

The research findings suggest that the teaching methods used during the project would need little modification for wider use in other similar projects. The pace of the sessions came up as both a strength and a weakness, with fewer teachers seeing this as a weakness as the project officer became more experienced at delivering the sessions. This pace could become a focal point for discussion with the teachers in future phases of the project. It could also be ensured that future projects avoid the first half term of the academic year, to allow teacher-class relationships to become established.

The style of the sessions also appealed to the children, with one or two activities being slightly less popular, due to the less active participation by the children. The videos used during the classroom sessions were met with mixed feelings, and would be better replaced by a video which was intended for the age range, rather than having to 'make do' with one aimed at older children and adults. Children enjoyed the investigative and practical activities (which made up the bulk of all the sessions), as they liked being given responsibility to plan and carry out an experiment using scientific equipment. Changes in teachers' methods cited a year after the intervention would have hopefully continued to provide children with these kinds of experiences in science.

In addition to the increased awareness that scientists work in industry (described in chapter four), children also saw the industry as a source of information on the products manufactured. Prior to the intervention, the two main sources of information cited on the manufacture of the same products were the television and travelling past industrial sites. Post-intervention, the best source was felt to be industry itself, by either visiting a site, or contacting people who worked there. Children also appreciated that they could find out more about the products by carrying out their own science tests, as the activities they had carried out had seeded questions about the products that they had not given thought to prior to the intervention.

Chapter 6 Conclusions and the way forward

6.1   Project aims

The aims of the study were to:

-        improve primary school children's perception of the chemical industry and its relationship with science
-        increase children's enjoyment of science
-        provide classroom-based training for teachers in teaching the National Curriculum for science.

The research questions set to measure the effectiveness of the project to meet these aims were:

-        what are children's views of science and industry?
-        what are primary teachers' views of science and industry?
-        do the industry-focused science lessons alter the views of children or teachers? - do site visits alter the views of children or teachers?

6.2   Summary

Prior to the project intervention, views of teachers and children of industry were based predominantly on media images. A finding in keeping with MORI polls in 1992 and 1994, looking at the wider public perception of the industry; Ball (1995) on teachers' views of industry; and Hutchings (1996) on children's views of occupations generally.

Children's images came from a range of fiction and non-fiction programmes, whilst teachers' views came predominantly from news programmes. Children held a Dickensian view of industry. Teachers held a view of a mysterious, hazardous and polluting industry that they were unlikely to teach about.

After the project intervention, all children described changes to the way in which they perceived industry. Where changes to the views of individual children could be measured, 90% expressed a change of view in some way. Increased awareness of industry was measured predominantly in the following areas:

-        raw materials used
-        processes involved, and the number of processes per site
-        equipment/machines used to carry out the processes
-        general physical appearance of a chemical site
-        working environment
-        jobs that existed and were desirable - especially those requiring scientific or technical knowledge
-        sources of scientific and related information.

These changes were further enhanced by well-planned industrial site visits which met the needs of primary school children. Teachers were enthusiastic to incorporate a site visit into the project. They felt it was an important element in completing the industrial input during the project; the visit rounded off the classroom activities by seeing a real situation, with real people carrying out real science-linked work.

Teachers described changes in their confidence and willingness to:

-        teach about industry
-        teach about science
-        make links between science and industry.

One year after the project intervention these changes remained, with many teachers:

- making changes to their methods to teach science
- repeating the industry-linked science activities with other classes of children.

Teachers' descriptions of the children's learning of industry fell into four main categories:

- a broad awareness of the existence of such industrial workplaces
- industrial processes
- the links between science and industry
- jobs/people in industry.

Two of the main aims of the project have therefore been achieved:

- teachers had been provided with in-service training in science, in areas which they felt were important (implementing practical and investigative work), and this had had a lasting effect on the majority of teachers' classroom practice
- teachers and children were motivated by the links between science and industry. Children expressed their enthusiasm during interviews, and teachers saw this motivation affecting the children's approach to the science during the classroom sessions. Many of the teachers were motivated sufficiently to repeat the industry-linked science activities with another class of children.

6.3   Discussion of the summary

6.3.1 Changes in children's views

Children's original perception of industry was often a large mill-style 'factory' or warehouses which housed large numbers of noisy machines and people working on production lines in inhospitable and dangerous environments. They described a factory taking the 'ingredients' and mixing, heating and cooling them until they had the finished product which was boxed up and transported to shops and supermarkets in lorries. Science had very little to do with the whole process, and the vast majority of jobs did not require scientific knowledge.

Changes to these views varied considerably from child to child. Some children expressed global changes to their thinking, describing an industry that was completely different to their original perception, whilst others described specific new ideas - such as knowledge of a new job, or a different piece of safety wear.

There is broad overlap between the areas of learning in which the teachers felt the children had made gains, and those measured by the research. Children's awareness of the 'existence' of industry was demonstrated via the many ways in which children described and drew new images of the workplace and the processes involved.

Children expressed their new knowledge of the link between science and industry in three ways:

- they realised, after the intervention, that scientists worked in industry, and children frequently wanted to be scientists or 'testers'
- they realised that they could ask people from industry or visit industry to find out scientific information relating to the products a company manufactured
- they appreciated the importance of scientific tests in industry to determine the most appropriate processes, ascertain the quality of the product, and discover new products and processes.

Children were motivated by the nature of the sessions, stating that they enjoyed the vast majority of the activities, and particularly those which had a combination of the following characteristics:

- provided opportunities for learning something new
- were challenging, but not too difficult
- had achievable outcomes
- offered active participation
- opportunities to use simple scientific equipment (such as thermometers, funnels, stopclocks and pipettes).

These last two characteristics reflect the areas of science teaching in which teachers had implemented new ideas (section 6.2.2). The use of science activities in which children plan and carry out science experiments independently, was seen by the teachers to be possible, even with classes of thirty or more children.

6.3.2 Changes in teachers' views

50% of teachers were initially not confident to describe the chemical industry, but the majority made some attempt to do so. These descriptions were predominantly in terms of the site locations, major or local company names, pollution, accidents, and risks. Only 7% of teachers referred to the research and development work of the chemical industry. When asked about the effect of the chemical industry on their daily lives, teachers appreciated that this input was high, and that their limited knowledge came predominantly from media images. One third of these teachers hoped that this project might redress this balance.

Prior to the intervention, most of the teachers who taught about industry, did so in relation to the geography curriculum, and particularly concerned themselves with pollution. Half of the teachers made no links with industry at all. Science was linked to industry by only 11% of teachers, who covered aspects of pollution, nuclear power, and the building industry.

Therefore, during the classroom sessions, teachers hoped that knowledge would be gained (by themselves and by their classes) of industry and of science, and the links between the two. Prior to the intervention, equal numbers of teachers had hoped to gain knowledge of science and industry (30% in each case), whereas far more teachers felt they had achieved this afterwards, with 66% citing learning about industry, and 41% learning about science. Prior to the intervention, teachers were not specific about the nature of the knowledge they hoped to gain, but after the intervention, teachers felt their learning was in teaching about science and industry.

6.3.3 One year after the intervention

The industrial context for the science activities, and the presence of an experienced person to deliver them, were felt to be the main strengths of the classroom sessions. The context provided motivation and a purpose for children to do science. This, combined with the opportunity to see the project officer deliver the sessions, motivated teachers to repeat the same activities. 78% of the teachers interviewed one year after intervention either had repeated or planned to repeat the activities in the second year of their curriculum cycle. This repetition of activities was by far the most common way in which industry-links had been maintained by the teachers.

Teachers felt more confident and able to teach practical and investigative aspects of science, and 53% of the same teachers interviewed a year later, had made use of classroom strategies and ideas to teach practical science more effectively. 48% of the children's learning outcomes in science cited by the teachers related to investigative learning. Teachers described this practical and investigative work as particularly important areas of the primary science curriculum, and they proved to be important areas in which to provide support and learning opportunities for the children and the teachers.

6.3.4 Limitations of the research

It should be acknowledged that the sample size for some areas of the research was low:

- Only 17 teachers were interviewed one year after the intervention. Also, data were collected from children immediately after the intervention, thus ascertaining the short term effects. The longitudinal study, described in section 6.4.5, will overcome these limitations, by collecting further data from these teachers and children.

- The sample size of all teachers involved in this research phase was only 44. A questionnaire, informed by this research, could be used to collect data from teachers involved in future phases of the project. This would allow further analysis of the views of teachers, using a greater sample size.

It should be reiterated that the researcher was also the advisory teacher delivering the classroom activities. The data were thus validated rigorously, to attain the highest level of objectivity possible.

6.4   The way forward

6.4.1 Benefits of industrial sponsorship

We need to find chemical and allied companies to sponsor future phases of this project, making use of the model which has been developed during this first phase. The research has shown that the profile of the chemical industry has been raised in the minds of young children and their teachers.

The project model is one of intensive intervention in primary schools. The combination of the intervention design and the investment of the schools' and the project officer's time has proven to be successful, and possible with support from the chemical industry.

Reasons for companies to support such educational projects (Stephenson & Wingfield, 1998) are to:

- support recruitment
- support the community as a good neighbour
- improve the company profile within the community
- improve understanding of the chemical industry as a whole
- provide professional development for company personnel.

Children certainly became aware of the wide range of exciting job opportunities within the chemical industry, from the forklift truck driver to the research scientist and engineer. They also viewed companies they visited as part of their own lives and their community. Children gained a more accurate picture of the chemical industry as a whole, and appreciated the relationship between the industrial workplace, the science they carried out in school, and the products they used every day.

Little data were collected on the professional development of company personnel, though many received training on conducting effective site visits, thus improving their skills of communicating with young people and their awareness of the knowledge these young people bring with them on a visit.

6.4.2 Project continuation

The project model incorporates all the desirable kinds of industrial support expressed by teachers, other than providing the school with direct financial support. These elements are:

-        provision of high quality written materials that support the science curriculum
-        training for teachers on science-industry links
-        provision of science resources and apparatus
-        industrial visits or visitors into schools.

The model has proven to be successful, with minor modifications being necessary. These modifications relate primarily to areas in which weaknesses were found, or in which teacher implementation had not had a lasting effect after the intervention, and would include:

-        beginning classroom sessions late September[17]
-        flexibility of pace during the sessions, to meet the needs of each class
-        training for project officers, to ensure that activities were offered at an appropriate conceptual level for the children
-        inclusion of all the staff in each school participating in the project.

The final suggestion relates to the limited way in which the classroom activities were shared with other members of staff, as has been experienced with other primary science training initiatives, such as the 20-day courses (Harland & Kinder, 1992). Where teachers had left the school, the headteachers interviewed knew little about any continuation of the project, and whether anyone was using the activity packs, or indeed whether the packs remained in the school. Modifications to overcome this in future phases could be to:

-        plan for whole school (or whole Key Stage) involvement in the project, OR
-        offer introductory training to the whole staff, and continuing advice on subsequent sessions.

Implementing either of these ideas would involve the development of sets of activities for younger children, which had the desirable characteristics listed above. These could be adapted from existing packs produced by the Chemical Industry Education Centre.

6.4.3 Site visits

In future phases, companies will be strongly encouraged to adapt their visits to meet the needs of the children and the curriculum they are studying. This encouragement would take the form of training offered by the Chemical Industry Education Centre (CIEC) to help sites make the necessary changes. Ineffective site visits were those which had not made such adaptations (and had not received training from the project officer), and children were left with a reinforced negative image of industry. Similarly, teachers left the company with no motivation to make future industrial links. Training would endeavour to overcome these negative views.

To encourage teachers to sustain links with a company they have visited during the project, teachers would be actively involved in the process of arranging the initial visit to the site. They could also be offered Chemical Industry Education Centre teaching and learning packs, with additional advice from the project officer on how best to maintain these links. It may be possible to arrange training for teachers from several of the project schools, possibly providing training at the start of an academic year for all the teachers due to participate during the subsequent three terms.

Site visits will not always be possible. Indeed, if sites have not been able or willing to adapt site visits for the children, a visit may not be desirable. On these occasions, it would be beneficial for children to see a video, which has been designed specifically for primary-aged children. It should show a wide range of industrial images and the industry's links with classroom science. These images could be used during the classroom sessions to reinforce the connections between

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[17] This allows teachers to establish relationships and ground rules with their classes before another adult intervenes.

school science and the industrial workplace. Images could include:

- appropriate industrial processes
- scientific research carried out
- applications of the scientific research
- people involved in science-related work in the industry.

6.4.4 Additional support for teachers

The research data will also be used, along with the experience gained from the classroom practice and activities, to develop an in-service training package for teachers. This package will focus on supporting the teaching of science, but will also incorporate advice on planning and carrying out industrial visits. The package will be in the form of written notes, possibly a video, and will provide training activities which could be used by a whole staff, by individual teachers or by cluster groups. The progression of activities will:

- allow a flexible approach to the pack's use
- enable an activity to be used in isolation
- enable activities to be used in a series of short training sessions or during a longer training day.

In this way, the project outcomes will be utilised to reach the wider audience of teachers, rather than only those who are able to participate in further phases of the project. The package can also be used during future phases of the Children Challenging Industry project, to enhance the 'multi-layered' strategy advocated by John (1992), and which is already part of the Children Challenging Industry approach.

6.4.5 Further research

A longitudinal study will follow up the views of children and teachers five years after the intervention, to ascertain any longer-lasting effects of the project. This kind of study on changes in children's industrial understanding has been called for by Ross (1994), who points out that studies have generally sampled different age ranges of children rather than follow one cohort. The focus of the study with the teachers would be on the incorporation of the industry-linked activities into the school curriculum and any industry liaison that has resulted from the project. With the children, the focus would be on finding out what they remembered of the classroom sessions and site visits and whether they had retained any of the more accurate views of industry that were measured immediately after the project intervention.

Teaching and learning resources and activities

Through carrying out practical activities, watching appropriate videos, seeing industrial equipment, and watching demonstrations, children learn about the following:

A Pinch of Salt

Industrial story: rock salt is mined and pumped from below ground. It is used as a de-icer in winter. Salt solution can be chemically changed to provide many basic ingredients for the chemical industry.

Science: an investigative approach is adopted, and children learn about melting, dissolving, evaporation, filtration, crystals, corrosion, effect of salt water on plants, electrolysis (simple introduction).

Farming Tales

Industrial story: environmental scientists carry out the final stage of testing a pesticide by spraying on a field and monitoring its effect on animal populations.

Science: animal identification, animal habitats, conditions needed for plant growth, food chains, natural materials (soils).

Noisebusters

Industrial story: ear defenders are often worn by people working on industrial sites, as a protection from the noise.

Science: sound and sound insulation, materials.

Plastics Playtime

Industrial story: plastics are made on industrial sites. The focus is on expanding and moulding polystyrene. The origin of plastics as oil is touched upon.

Science: materials - identification, properties (heat insulation, sound insulation, shock absorption), fitness for purpose, how materials can be changed.

Water for Industry

Industrial story: water is transported by pipeline from a reservoir to an industrial site, used as cooling water and returned to the river.

Science: materials (for a water pipeline and sealants), filtration, heat exchange and acids/alkalis.

Science & Industry Project

Chemical Industry Education, University of York

in partnership with

Thomas Swan & Co. Ltd, Consett

Proposal for continuing involvement in the project

This form should be returned, no later than .... to:

        Joy Parvin
        Chemical Industry Education Centre
        Department of Chemistry
        FREEPOST
        York
        YO1 1TP.

We would like to be considred for continuing involvement in the Science & Industry Project in the summer term of 1998. We would like to propose the following ways of taking part and extending the project.

Name: ....

Position: ....

School: ....

Address: ....

        ....

        ....

Telephone number (include. STD): ....

The project officer can work in the school for three half-day sessions. The officer will work with one class, which must have some Y5 or Y6 children. The sessions can be used in several ways.

1. Please write the number of different sessions you would like to have (i.e. 2 classroom sessions and 1 staff meeting), or write alternative ideas in the space provided.

Classroom sessions	☐	Staff meeting	☐
Planning sessions with other staff*	☐	Parents meeting	☐

    *   If several classes are working on the project, the project officer can spend time planning sessions and 'trouble-shooting' with these teachers.

Alternative ideas

2. Will the science co-ordinator be involved in the project?   Yes/No
    Please describe the nature of his/her input:

3. The sessions will make use of a CIEC resource, as in the previous sessions. Please tick the resource you would like to use during re-visits (a catalogue is enclosed which provides a summary of each resource):

A Pinch of Salt	☐
Plastics Playtime	☐
Water for Industry	☐

    Please give your reasons for choosing this resource:

4a. Please tick the box to indicate the number of classes that will be involved.
    0:        ☐   (As all sessions will be with staff/parents. Go to question 7.)
    1:        ☐
    More: ☐   Please specify number of classes ☐

4b. Please state, for each class, the year groups and their proportions:

Class name/no.	No. of Y4 children	No. of Y4 children	No. of Y5 children

4c. If more than one class is to be involved in the project, how will the class teachers work together on the project?

5. Please suggest ways in which the teacher could have an active role in the classroom sessions:

6. Would you be interested in a suitable site visit (if possible)?   Yes/No
If so, please describe the role you would wish to have in planning the visit:

7. Please use the space below to describe any additional ideas you have for enhancing the project.

Signature: ....   Date: ....

Location of the participating schools in County Durham

type of location	number of schools	name of location
cities	3 schools	Durham
towns	14 schools	Barnard Castle
		Consett
		Darlington
		Easington Colliery
		Newton Aycliffe
		Peterlee
		Stanley
villages	21 schools	Aycliffe
		Bishopton
		Bournmoor
		Cockfield
		Dipton
		Ebchester
		Escomb
		Esh
		Esh Winning
		Forest of Teesdale
		Gainford
		Hunwick
		Rookhope
		Spennymoor
		Tanfield
		Trimdon
		Ushaw Moor
		West Auckland
		West Rainton
		Wingate
		Witton Gilbert

Information on schools participating in the project

location	school code	number on roll	number in class	year groups in class
city schools	S25	352	30	5
	S26	480	35	5
	S29	210	33	4
town schools	S1	140	31 (29)	5,6 (3,4,5)
	S2	176	33	5,6
	S3	400	30	5
	S4	164	21 (26)	6 (6)
	S7	560	27	5
	S8	195	34	6
	S9	171	32	5,6
	S10	160	34 (36)	5,6 (6)
	S14	150	37 (33)	5,6 (5,6)
	S21	225	30 (30)	5 (6)
	S27	355	31	5
	S32	250	26	5
	S34	230	36	5
	S36	240	29	5
village schools	S5	75	23	5,6
	S6	160	34 (31)	5,6 (6)
	S11	260	28	6
	S12	170	29	5,6
	S13	97	33	5,6
	S15	212	24	5,6
	S16	180	31	6
	S17	90	25	5,6
	S18	135	22	4,5
	S19	127	25	5,6
	S20	120	25	5,6
	S22	155	19	6
	S23	247	25	6
	S24	60	27	3,4,5,6
	S28	115	28	5,6
	S30	95	30	4,5
	S31	150	28	5
	S33	130	30	5,6
	S35	63	24	4,5,6
	S37	27	18	3,4,5,6
	S38	26	16	3,4,5,6

( ) denotes statistics for a second class participating from that school.

Interview schedule
Teachers (pre-intervention)

- How comfortable do you feel describing 'industry'? (ask to describe)

  - would you feel equally comfortable describing the 'chemical industry'?
  - how do you feel the chemical industry affects your daily life?
  - which products of the chemical industry are you aware of?
  - what are your local/nearest chemical companies?

- How would you describe the risks attached to the chemical industry?

  - for those working there?
  - for those living near?
  - for the environment?
  - are these acceptable risks?
  - are your answers applicable to all areas of the chemical industry?
  - from where do your views originate?

  - what about the risks attached to local industry?

- Do you or would you use science resources sponsored or developed by the chemical industry? Why?

- What do you think are the benefits of this project?

  - for the children?
  - for you?
  - for Thomas Swan?
  - what are the desired messages?
  - are there any disadvantages?

- Do you cover aspects of industry in the curriculum at present? If so, where (subjects)? How?

- What are your views on the primary science curriculum?

  - what are the most important scientific ideas for primary children to learn?
  - other than this project, how can the chemical industry effectively support this teaching?

Interview schedule

Teachers (post-intervention)

- How do you feel these sessions went?

  - how were they different to your own science activities?
  - what were the strengths of the sessions?
  - which aspects of the sessions were you not happy with?
  - did the project support science as you had hoped?
  - how do you think the children responded?

- How would you summarise the aspects of industry covered in the sessions?

  - were too many areas covered? which would you omit?
  - were any important aspects missed?

- What were the main learning outcomes?

  - in science?
  - in other areas?
  - about the chemical industry?
  - did you learn anything new about the chemical industry?

- Would you use industrial contexts for teaching science again? How?

  - resources developed by industry?
  - other resources using industrial contexts?
  - contact or visit or local industry?

- What do you think the value of your involvement in the project has been?

  - has the time commitment been worthwhile?
  - would you be interested in further involvement next year?
  - would you want to make any changes to the involvement you have had?

Teacher intervies (1 years on)

(a) teacher use of CIEC packs

- have you used the pack again? How?
- you were offered a second resource pack, did you take one? Why/why not?
- how have you made use of this pack?
- have other staff made use of either pack? How?

(b) general industrial links

- have any industrial links been initiated? (describe nature and success *or* why not?)
- have you contacted any other industry-linked organisations, such as DBEE?
- what are the school's aims for industrial links now?
- do you now have a staff policy on industry links?

(c) further involvement

- did the sessions provide support for developing your science teaching? How/why not?
- after your involvement last year, you put together a proposal for further input, why did you choose this nature of involvement? Who was involved in deciding on this nature of input?

OR

- after your involvement last year, you expressed interest in receiving further input, why did you decide not to put forward a proposal?

Interview schedule
Children (pre-intervention)

Range of objects as stimulus, such as:

• household bleach (safely contained!)
• junior aspirin
• washing up liquid
• yogurt pot
• table salt
• Mars bar wrapper

Using 1-2 of these objects, one at a time, ask children:

❑　How would you describe this (or the contents) to a 6-year old child?

❑　What is it made from?

❑　Imagine we didn't have any (plastic, washing-up liquid, etc.), how would your life be different?

❑　What could we use instead of it?

❑　Would this be better or not?

❑　How do you think it (the material/product) is made?

❑　Where do you think it (the material/product) is made?

❑　Can you describe what you think the factory (or whichever place is mentioned by children) is like?

❑　Where do you get your ideas - how do they get into your head?

❑　What sort of people do you think work there? What jobs do they do?

❑　What do you think they wear for their job? Why?

❑　If you were working in this factory, what do you think it would be like?

❑　Which job do you think you would like to do?

❑　Are there any local factories that make any of these things?

Interview schedule

Children (post-intervention)

Write activity titles on cards, for the rest of the group to see, and spread them out on the table:

❑   Which of these activities have interested you a lot?

❑   Which were not interesting?

❑   What would you like to find out more about? How could you do this?

The objects discussed in the first interview provide the stimulus for the next set of questions:

❑   Which of these things do you think you know more about?

❑   Last time I talked to you, you told me about the place that this is made. Can you now tell me anything else about this place?

       - appearance, sounds and smells; how it is made, etc.
       - any other jobs that might be done in this factory?
       - anything new about the things people wear?

❑   The activities we have done have all involved science tests and investigations. Are these sorts of tests important in the factory where (X) is made? How?

❑   What job might you like to do in this place? Why?

❑   What might you have to learn more about so you can do this job?

❑   If you were in charge of this place, what would you think is important?

❑   Why do people own these places?

Children's questionnaire 1

Please tick the right boxes:

girl ☐   boy ☐   year 5 ☐   year 6 ☐

These things are made from plastics:

yogurt — yogurt pot
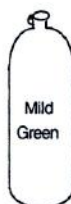
Mild Green — washing-up liquid bottle
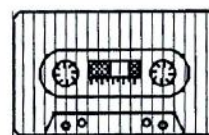
cassette tape

All of the questions below are about making plastics.

1. List the things that you think are needed to make a plastic: →

    Ingredients

2a. Tick one of the boxes to finish the sentence.

    If there were no plastics, my life would be:

    better   ☐

    the same   ☐

    worse   ☐

2b. How do you think life would be different (better or worse) or the same?

    _____

    _____

    _____

    _____

    _____

3. Fill in the table below about things you think we could use instead of plastics.

What could be used instead of plastics	Is this as good as plastics?	Reason why

5a. Circle the words which describe how you think plastics are made. Add any words you think are missing.

mixing	moulding	dissolving
heating	cooling	grinding
squashing	cleaning	sieving
draining		

5b. Number the words you have chosen in the order that they are done. For example, if you think 'cooling' happens first, number this circle '1'.

6. At what kind of place are plastics made?

_____

111

7. Draw two pictures: one of the inside and one of the outside of the place where plastics are made.

a. Outside
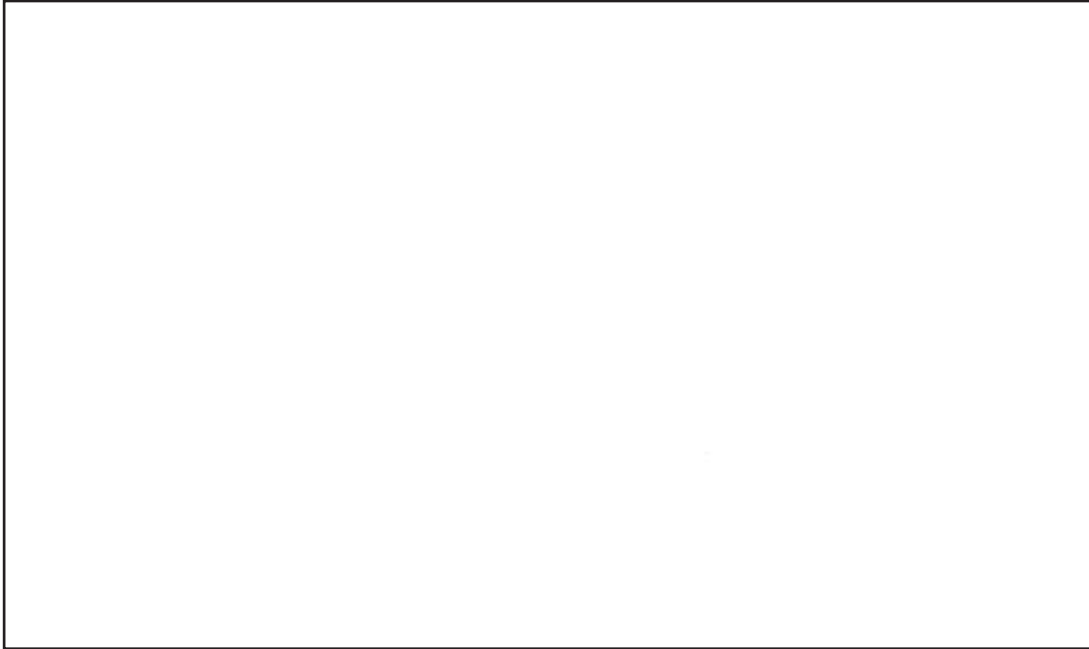
b. Inside
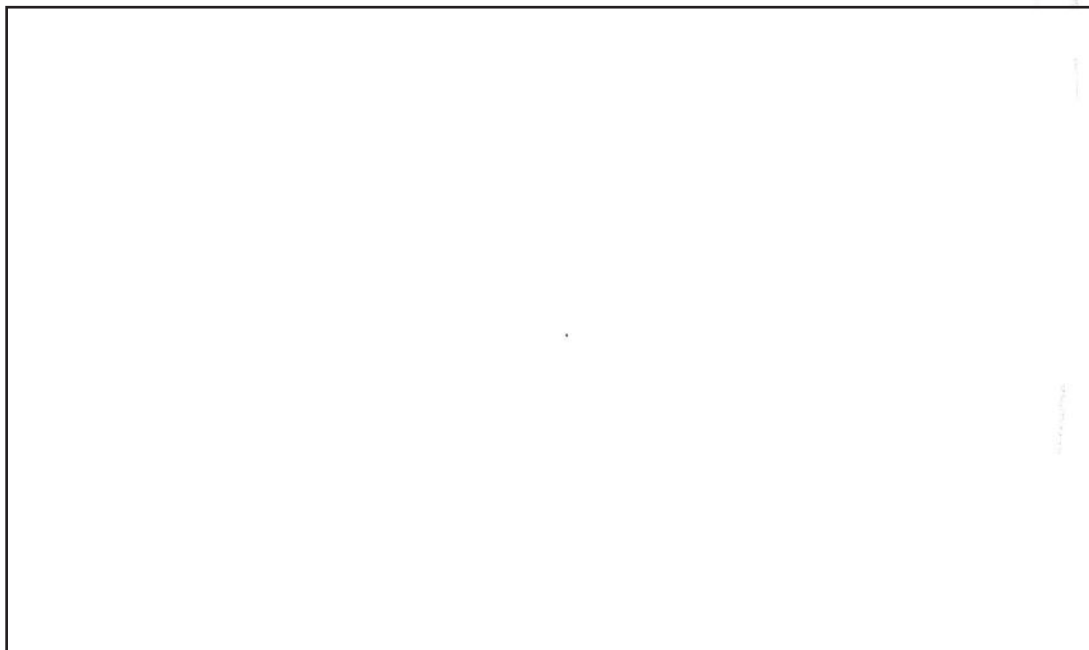
8. What else do you think this place will be like?

Tick one box on each line.

many people	☐	or	few people	☐
many machines	☐	or	few machines	☐
light	☐	or	dark	☐
quiet	☐	or	noisy	☐
large	☐	or	small	☐
clean	☐	or	dirty	☐
nice smells	☐	or	horrible smells	☐
safe	☐	or	dangerous	☐
hot	☐	or	cold	☐

Write about other things that you think the place will be like:

_____

_____

_____

9. Where do the ideas about this place come from - how do they get into your head?

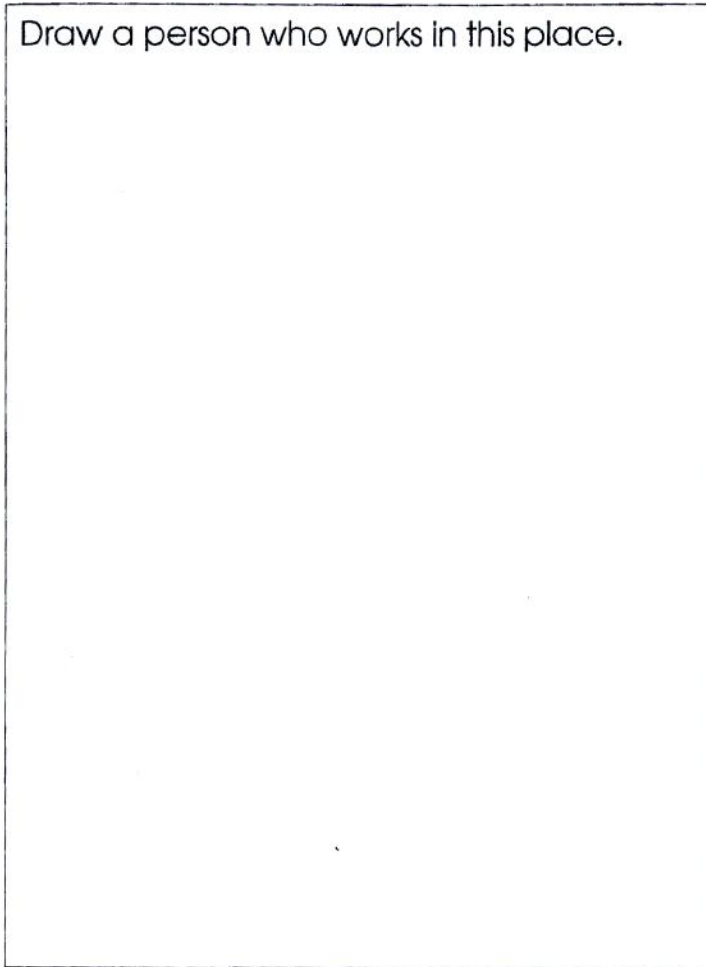|		
From Mum or Dad?	Yes ☐	No ☐
From books?	Yes ☐	No ☐
Seeing inside a factory?	Yes ☐	No ☐
Seeing the outside of a factory?	Yes ☐	No ☐
From the television?	Yes ☐	No ☐

Which programmes? _____

If you get your ideas from somwhere else, write them here:
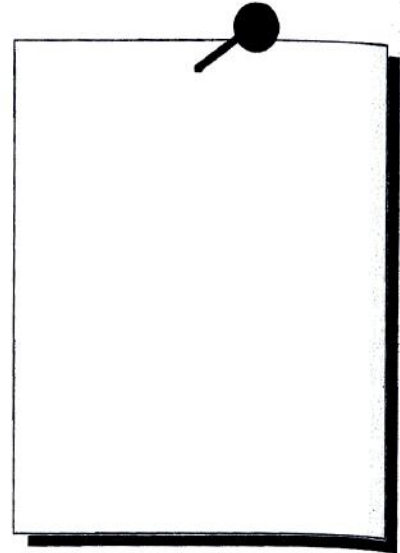
_____

10. | Draw a person who works in this place.

What is this person's job?

_____

_____

List other jobs that are done in this place:

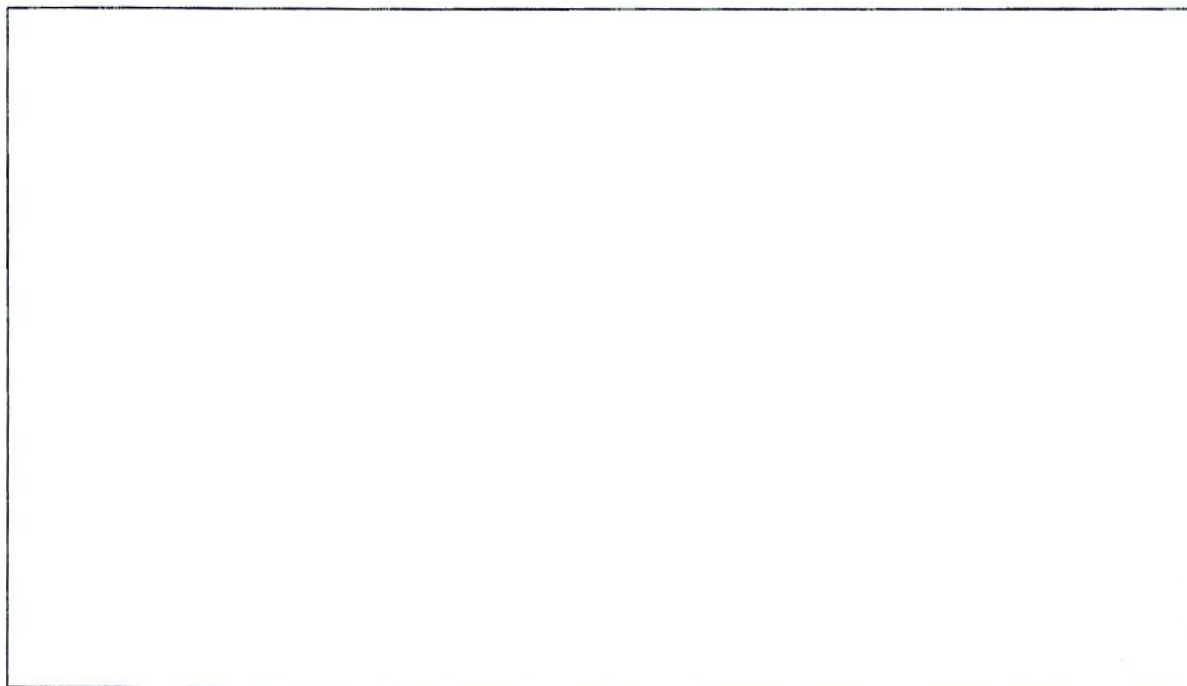11a. Which job would you like to do at this place? _____

_____

11b. Why? _____

_____

11c. Circle the words which describe what you think it would be like to do the job you have described in question 11a.
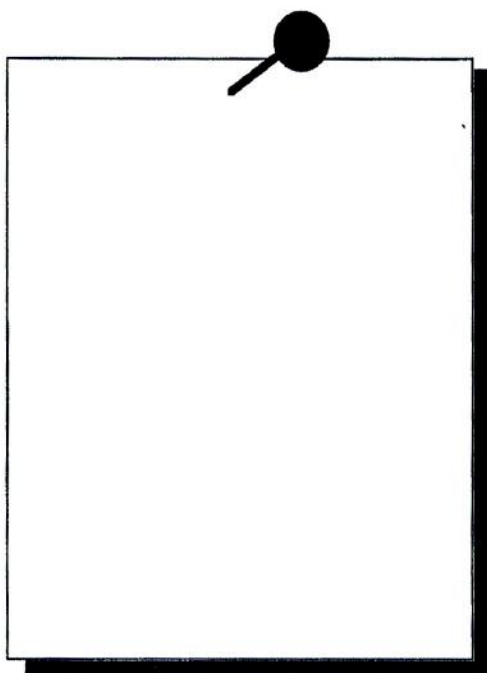Add words which you think are missing.

easy	hard	fun
exciting	boring	

Chemicals

Draw some examples of chemicals below:

List some words that describe what chemicals are:

Children's questionnaire 2

Please tick the right boxes:

girl ☐   boy ☐   year 5 ☐   year 6 ☐

1a. Tick the activities that interested you a lot.
Cross the activities that did not interest you.
Remember: You do not have to tick or cross every box.

1. Feely bag game   ☐

2. Identify four plastics (float & sink, and crease tests)   ☐

3. Making plastics video   ☐

4. Expanding polystyrene   ☐

5. Materials for packaging investigation   ☐

6. Design and make a parcel   ☐

7. Recycling information (if covered)   ☐

8. Site visit (if applicable)   ☐

1b. Write the number of each activity you found interesting next to the
reason why.
Add more reasons if you want to.

I learned something new.		I was surprised by what happened.	
I enjoyed doing the tests.		I liked using lots of different things.	
We all had a job to do.		It was fun.	
I enjoyed the challenge.		I enjoyed seeing what happened.	
It was easy.			

1c. Write the number of each activity you did not find interesting next to the reason why.

Add more reasons if you want to.

It didn't always work. [ ]

It took too long for something to happen. [ ]

I did not have to do much. [ ]

I already knew what would happen. [ ]

It was boring. [ ]

It was too short. [ ]

It was too difficult. [ ]

It was too easy. [ ]

2. Would you like to know more about plastics?

Yes ☐   No ☐

If you would, what would you like to know?

_____

_____

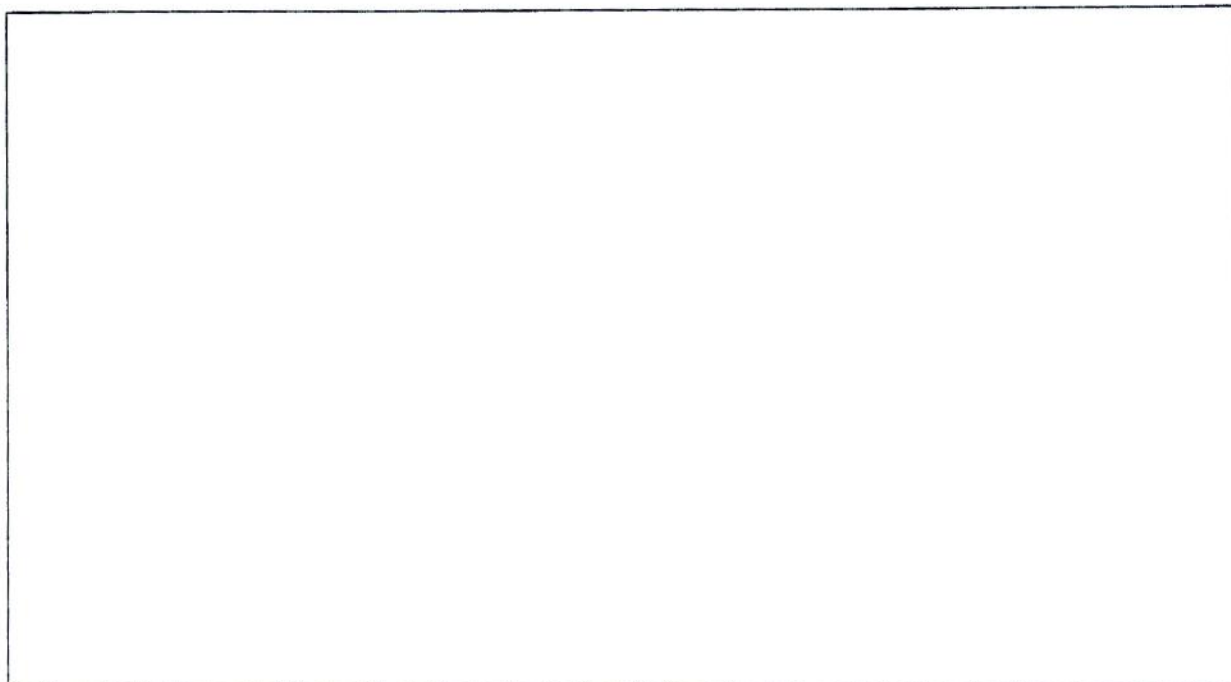How could you find out for yourself?

_____

_____

3. You have done lots of science tests and investigations. Do you think these are important in the plastics factory?
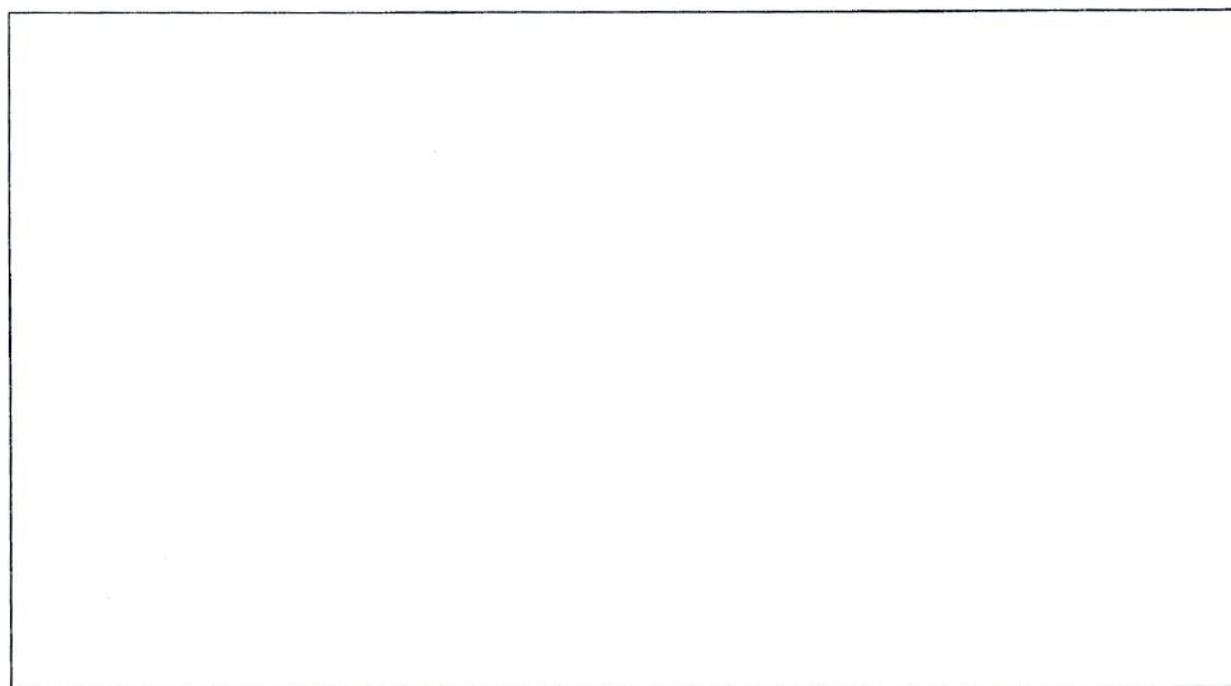
Yes ☐   No ☐

Why?

4. In the last questionnaire you drew pictures of the place where plastics were made. Draw two more pictures, that tell me more about the inside and outside of this place.

a. Outside.

b. Inside.

5. If there are other things that are different about the factory that you were not able to draw (like sounds, smells, light, people, other areas), write them here:

6. Are plastics made in the way you expected?

   Yes ☐   No ☐   If not, what did you find out?
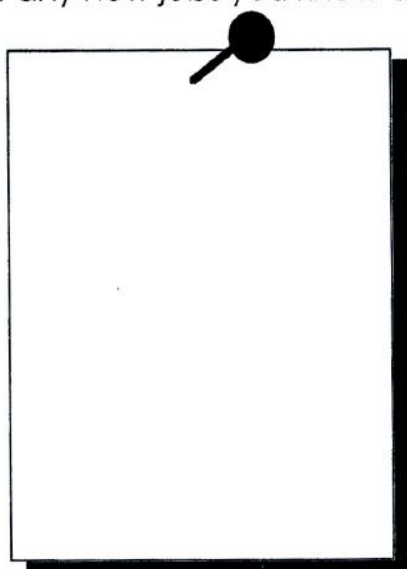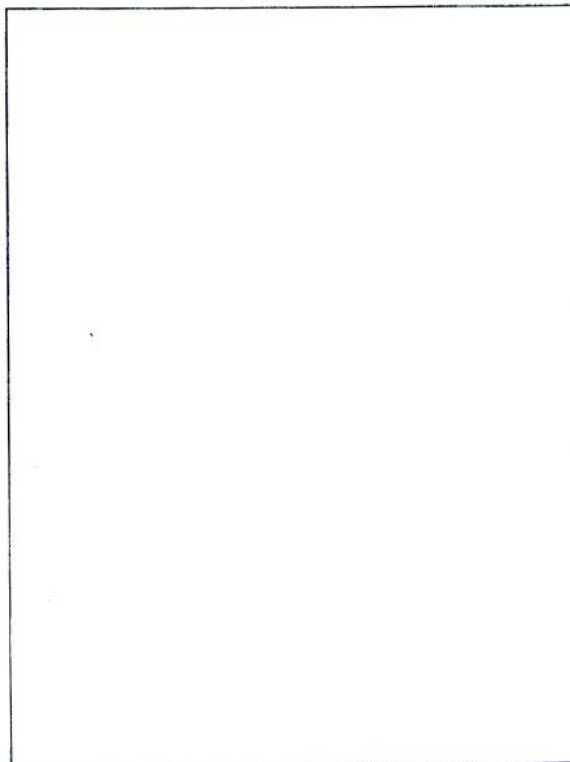
   _____

   _____

   _____

7. Last time, you drew a picture of someone who worked in a plastics factory. Draw another picture below.

   If this person is doing a different job to your last drawing, write what it is:

   _____

8. List any new jobs you know about:

9. If you would like to do a different job to the one you mentioned last time, write it here:

   _____

Children's ideas about the composition of products

	plastics	washing up liquid	Mars wrapper (incl. inks & glue)	tablets	bleach	Baby Bio
number of children & groups asked	88	20	17	6	10	2
acids & chemicals	16	5	4	4	8	2
	18%	25%	24%	67%	80%	100%
solids (powder)	3	3	0	6	2	2
	3%	15%	0%	100%	20%	100%
liquids	17	11	0	1	5	0
	19%	55%	0%	17%	50%	0%
gases	6	1	0	2	0	0
	7%	5%	0%	33%	0%	0%
water	16	16	4	1	3	2
	18%	80%	24%	17%	30%	100%
colouring	5	7	13	1	1	2
	6%	35%	76%	17%	10%	100%
from plants	5	3	4	3	2	1
	6%	15%	24%	50%	20%	50%
from animals	2	1	1	2	0	0
	2%	5%	6%	33%	0%	0%
food related	1	0	2	2	1	0
	1%	0%	12%	33%	10%	0%
materials*	25	0	6	0	0	0
	28%	0%	35%	0%	0%	0%
oil(s)	10	2	1	1	0	0
	11%	10%	6%	17%	0%	0%
don't know	26	0	10	2	3	0
	30%	0%	59%	33%	30%	0%
other	8	9	2	0	3	0
	9%	45%	12%	0%	30%	0%

* 'materials' include paper, card, plastic, metal, glass, fibre glass, wax, tar sand, plaster, rubber.

Definition of the UK chemical industry

(as described by the Careers and Occupational Information Centre)

The chemical industry is one of Britain's largest manufacturing industries and its highests-value exporter. Its products include plastics, paints, medicines, fertilisers, adhesives, pesticides, herbicides, inks, dyes, polishes and cosmetics.

The industry includes firms that:

refine feedstocks such as oil and natural gas to make base chemicals
create more sophisticated chemicals from thee base chemicals for industrial use
mix together chemicals to make finished products such as paints.

Process plant is found mainly in the first two types of firm.

Source@ Chemical Industry Edyucation Centre, (1098) Your Future, CIEC: University of York

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