An Evaluation of the Impact of INPUT on the Education of Able Primary Children

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Abstract

This paper will consider whether highly able pupils and their teachers see INPUT as valuable. It will also examine the content and methodology employed in sessions to examine whether this approach has particular value for able pupils.

Introduction

INPUT was launched in 1986 as Industry North Project: Understanding Technology with the aim:

> 'to make young people and their teachers more aware of the challenge of engineering and career opportunities available in industry.' (Marsh, 1996: 1)

The objectives of the project were to 'develop the next generation of highly qualified science and technology personnel by helping young people become aware of:

- the importance of science and technology in modern society and the contribution which it makes to raising our standards of living
- the creativity, imagination and ingenuity which science and engineering can foster
- the self confidence which can develop through solving real engineering problems
- the wide range of stimulating and rewarding career opportunities and personal challenges which science and engineering can provide.' (Marsh, 1996: 1-2)

The INPUT project is managed nationally through the Oxford Trust and on a regional basis mainly by local Science and Technology Regional Organisations, and Educational Business Partnerships. These organisations bring engineering and business expertise into the classroom, which gives children insight into the world of industry. Schools contact the local organisation when they want to organise an INPUT session. The activities are planned by the organiser in conjunction with the class teacher and are linked to the National Curriculum. One of the key features of the days is that children frequently come into contact with real engineers. These might be the organisers or where possible, engineers from the local community. This broadens children's concept of what engineering really is.

INPUT sessions for pupils of all ages are organised on a day or half day basis where pupils have to solve technological problems, e.g. building a metre high tower from paper tubes and placing a light circuit at the top of it. During the sessions, pupils work towards a presentation of their final designs. The aim is that all achieve a high level of success. One of the key points is that visiting teachers are able to observe a number of activities running successfully with pupils and are able to take back valuable ideas to the classroom. Further tasks and projects, which can run at school, are available for encouraging innovation at all ages (Marsh, 1996, 1997a, 1997b).

Evidence shows that these sessions are greatly enjoyed by pupils and their teachers, and go some way towards encouraging a greater interest in science and engineering (Marsh, 1996). The award of three major national prizes for attracting talent into engineering and science confirms the value of INPUT (Marsh, 1996). The Gatsby Foundation, who sponsor INPUT, are now in the process of evaluating the Project nationally. As part of this national evaluation, we were asked to examine the impact of INPUT on able children in primary schools. This section of the pupil population has been chosen as the focus since one of the aims of the project generally is to encourage a higher profile and greater interest in science and engineering amongst the most academically able pupils in schools.

> 'By presenting the challenge of engineering through open-ended, hands-on technical problems, more of our able, innovative young people are attracted to careers in engineering.' (Marsh, 1996: 1-2)

The activities observed on the three INPUT days evaluated included the design and construction of a self-righting buoy with a light, a bridge, a polydome, a stream-lined car, the Millennium wheel and a tower from materials readily available in a primary school. For example, the self-righting buoy was made from a soft drink can and the polydome was constructed from tubes made out of A4 paper.

Background

Characteristics of able children

Porter (1999: 33) has summarised current research views by defining able children as:

> '...those who have the capacity to learn at a pace and level of complexity that is significantly advanced of their age peers in any domain or domains... Talented behaviours are performances that are quantitatively or qualitatively exceptional compared with age mates.'

The domains that are related to INPUT are science and technology and their interrelationship in engineering. The pupil who is the highly able scientist is generally the one who 'asks perceptive, provocative questions and brings background knowledge

to their science work.'(Dudley LEA, 1998: 91) The specific characteristics of able children in relation to science might include:

- 'a natural curiosity about the world and the way things work
- an enjoyment of hypothesising
- an ability to express scientific knowledge and understanding logically and coherently
- using scientific vocabulary accurately and appropriately
- an ability to transfer knowledge and understanding from one situation to another
- an ability to spot and describe patterns in results
- being innovative in experimental design and/or in the collecting and recording of data.' (Coates and Wilson, 2001: 92)

Pupils who are seen to be highly able in design and technology tend to have 'creative ideas and can develop them successfully ... persevering with the problems encountered...' (Dudley LEA, 1998: 132). Other more specific characteristics related to design and technology have been defined by Lewin (1999: 10) as including:

- 'seeing the same as everyone else and thinking something different
- knowledge and understanding of design and technology
- high spatial sense
- good practical and mechanical ability
- mathematical and scientific ability
- good knowledge of materials, structures, mechanisms and electronics.'

No one pupil will necessarily have all of these characteristics, either from the science or technology lists, but they are indicators for future high calibre engineers. As science is a core subject in the National Curriculum, with more teaching time than design and technology, there is an increased likelihood that teachers will be able to identify able scientists in their classes.

The National Curriculum

The National Curriculum for 2000 outlines clear aims for primary children which are in sympathy with the philosophy of INPUT and the needs of able children. It should 'enable pupils to think creatively and critically and to solve problems.' (DfEE and QCA, 1999: 11)

There is obviously a close relationship between science and design and technology. Pupils use scientific methods to test and develop their ideas. This scientific knowledge can be used in technology to help solve problems. Children might use their knowledge of forces and friction to produce a streamlined train or of electricity to produce a circuit for a light at the top of a tower.

Developing a curriculum specifically for able children

Montgomery in her evidence to the House of Commons Education and Employment Committee (House of Commons, 1999) suggested that teachers should change their teaching for able children from a 'competence based' to a 'cognitive based' curriculum.

> 'This would ensure children developed "cognitive skills" such as thinking, planning, organisation, problem solving and creativity, and reflecting upon and monitoring their learning.' (House of Commons, 1999: xliii)

There are two major ways we can develop the curriculum to challenge able pupils with a cognitive emphasis: the product based curricula and the process based curricula (Montgomery, 1995). The first model concentrates on content and concepts to be learnt. The emphasis is mainly on increasing the depth of study through extension work within a limited range of activities. Children can be accelerated through the work so those able primary age children are taught the secondary school curriculum. This way of creating sufficient challenge for able children is seen as a particular problem for primary teachers, especially in areas of the curriculum where they lack confidence or specific expertise, or the resources are not available.

In a process based model, higher level abilities and talents are identified, and these are used as the basis for enrichment work where the emphasis is on experiencing a range of activities and using and applying concepts learned (George, 1997). The education of highly able children would be 'broader and more intense' (Freeman *et al*, 1995: 84). The process based model emphasises the teaching of problem solving and investigations, the use of higher order thinking (Montgomery, 1995) and social interactional approaches. With problem solving, the focus is on knowledge, skills and concept acquisition through enquiry based learning (Eyre, 1997).

> 'Problem solving is an effective way of challenging able children. Their interest is often gained by posing a question that is intriguing and sustained by the motivation to puzzle something out.' (Clark and Callow, 1998: 32)

Able children are seen to be capable of using higher order thinking (Bloom, 1956) when attempting to solve problems and in their creative thinking. Enriching the curriculum using a social interactional approach introduces tasks that require teamwork and the possibility for different views to emerge. It encourages flexible thinking and creativity within the group. The highly able children would be working together as a group within the class since they will 'benefit academically and socially from spending some time learning alongside other children of similar ability levels to themselves.' (Porter, 1999: 179) Examination of INPUT challenges and tasks (Marsh, 1996, 1997a; Marsh 1997b) shows that they provide a process based education, which should be beneficial to able children in particular.

Method of enquiry

The research sought to examine and gain an understanding whether, and if so how, INPUT sessions could benefit able children. It was conducted in the natural settings of the schools and a case study research approach was adopted. Hitchcock and Hughes (1995) state that a case study should focus on a particular actor or groups of actors and their perceptions, and the concern is with the 'rich and vivid description of events' within the case. The major focus of such a study will be on what things happen, how they happen and why. Data has been collected from a range of sources and perspectives as this allows for triangulation and helps to establish validity and corroborate findings (see Denscombe, 1998; Robson, 1999). This approach gives an insight into how INPUT caters for highly able pupils. As Denscombe (1998: 39) expresses it, the study tries to capture the 'complex reality under scrutiny'.

It is important to consider ethical issues in this type of research as it examines teachers' fundamental beliefs and the children with whom they work. The INPUT organisers and teacher colleagues were all appraised of the objectives of the research before they became involved. The children in each class were also informed about the researchers' visits, but this was couched in terms related to them, their classrooms and their work. As children were a focus of this research, permission from schools to proceed was sought at every stage. The Organisers of the INPUT sessions, researchers and teachers took great care to put the children at their ease in order to ensure that the settings of the INPUT sessions were as natural as possible. As the study was focusing on INPUT and able children, it was necessary to group the able pupils together in order that the researchers could identify the able pupils and to enable them to make observations effectively. Obviously, the way the pupils are grouped may affect the nature of the INPUT experience and the outcome as teamwork is very much a feature of INPUT sessions. It was considered that placing the able pupils in the one group would facilitate data collection. The teachers said that for a special activity like INPUT, the pupils would not normally be placed in ability groups, rather children prefer to work with their friends. The effect of ability grouping was therefore considered in this research.

Data was collected using a variety of research instruments. Semi-structured interview schedules were devised to obtain data from INPUT organisers, the class teachers and the able children themselves. A semi-structured interview format was selected because it would give the opportunity to develop questioning further to clarify ideas and points raised. The key research question to be addressed was whether the content and methodology employed in INPUT sessions have particular value for able children. Data from the perspectives of the pupils, teachers and organisers were collected and analysed to try to come to an answer to this question. A qualitative approach was adopted due to the small number of schools involved which necessitates a case study approach rather than a numerical analysis.

Unstructured observational techniques were used to obtain data during the INPUT sessions. Detailed unstructured written observations were made on the way sessions were introduced and concluded, the way the able children engaged with the challenges and the roles of adult helpers and organisers during the sessions. The presence of researchers in the classroom might have led to the Hawthorne effect (Denscombe, 1998) where teacher and children act in atypical ways, but as INPUT sessions are not part of the typical day this was thought to be negligible. All pupils appeared to be very much at their ease and well used to visiting adults in the classroom. Documents written by the national co-ordinator for INPUT and briefing notes and task sheets were also examined.

Due to the scale and timing of the project, it was only possible to attend INPUT days at three different schools. These days were conducted by two different Organisers: a third Organiser was interviewed for the survey. At two of the schools, one group of four able children was observed (at one school the group was all male and at the other it was half male and half female). At the third school, two groups of four able children had been identified (one all male and one all female

group). Overall, six classes of children were observed, including 16 able children, and five class teachers were interviewed. As INPUT caters for schools across the whole country, this was necessarily a small scale project. However, it was hoped that it would provide some insight into the role of INPUT in educating able children.

Data analysis and interpretation

What do INPUT Organisers and class teachers understand by able children?

Although INPUT is specifically concerned with being accessible to children of all ability ranges, it clearly has much to offer the able child. Class teachers were simply asked to identify groups of able children without any guidance on what was understood by the term 'able', although they did know that the children would be involved in solving technological problems. Teachers identified able children by their performance in the core curriculum subjects, in particular mathematics and science. Two groups of teachers also added that these children were able technologists. The organisers of sessions generally defined able children through their ability in these academic subjects as well. Other features identified by all teachers were that the children were analytical and logical thinkers, highly motivated, willing to take risks and rise to the challenges presented. Two organisers mentioned the ability of able children to think independently and one noted that they could make conceptual leaps. Two teachers said that the children that they had identified had performed well in similar problem solving situations, while a second group noted that able children could effectively use prior knowledge in their problem solving. It was also recognised by one group of teachers that INPUT activities might 'throw up' other children who might not be recognised as 'able' in the classroom setting. This was supported by one of the Organisers who considered that there was not always a clear connection between children's technological ability and what is traditionally recognised as academic ability.

Observations of the groups of children identified tended to confirm that they were of high ability. This was generally made apparent through the way that they used prior science knowledge and understanding to help them tackle the tasks. They were also able to converse intelligently about the activities with adults and to justify their design choices scientifically. They appeared to be well focused, purposeful and capable of working with sustained effort. The task instruction sheets were always carefully read and they remained on task throughout the activities. Other groups did not read the instruction sheets as carefully, seeming to prefer to launch straight into the planning and designing. This links clearly with the definition Porter (1999) gives for able children. Their behaviour was qualitatively different and exceptional compared with other children.

There were, however, as predicted by Organisers, a few children identified as able, who may not have been as able in a technological setting as they were in the usual classroom curriculum. One group's design for the construction of a polydome structure, to support the maximum weight possible, used hexagons rather than triangles as a starting point; hence the final model was not a viable construction. The pupils' discussion suggested that it was designed for its decorative features, rather than for strength. This may suggest a lack of engagement with the design brief.

Criteria for selection of tasks and their suitability

Tasks had constraints built into them which included choice of materials, size, time and factors to simulate financial restraints. Thus,

> 'INPUT presents technical problems in a manner which stretches the imagination and challenges students in ways which may not be possible within the constraints of a normal school timetable. With the short time available for a project, the importance of design, planning and teamwork soon becomes clear.' (Marsh, 1996: 1-3)

The essential criteria for an INPUT course set out in the documentation are that:

- it is well planned
- it is based on challenging, open-ended, hands-on project work to solve real engineering problems
- it requires the application of mathematics, science and technology
- it presents opportunities to develop the young person's:
  - creativity, self confidence, understanding
  - problem solving skills, communication skills
  - ability to work in a team. (Marsh, 1996)

The National Curriculum sets out key skills that should be embedded in all subjects. These include communication, application of number, working with others, problem solving and the development of thinking skills (DfEE and QCA, 1999: 20). These would seem to

CURRICULUM

closely match the criteria set out for INPUT activities. In particular, the activities observed allowed able primary children to attain aspects of level 5 and 6 of the design and technology level descriptions. For example,

Level 5:

> 'They test and evaluate their products showing that they understand the situations in which their designs will have to function and are aware of resources as a constraint'

Level 6:

> 'They evaluate their products as they are being used and identify ways of improving them' (DfEE and QCA, 1999: 25).

The INPUT criteria also clearly seem to fit into the process based model of effective provision for challenging able children. Montgomery (1996) identified a number of cognitive process pedagogies, which provide appropriate curriculum enrichment for able children. These include real problem solving and investigative learning, and collaborative learning, all features of INPUT.

> 'These facilitate the development of higher order cognitive and metacognitive skills and offer challenge in all content areas.' (Montgomery, 1996: 25)

The tasks observed on the INPUT days generally seemed to fit these principles as well as the INPUT criteria.

The Organisers of the INPUT days emphasised that the tasks should be challenging, but achievable by all ability levels. They should be open-ended, not prescriptive, and 'challenge children's thinking'. The tasks should investigate different aspects of technology and science, allowing children to produce solutions that will develop their knowledge and understanding, and which are related to engineering in the wider world. By working to a limited time scale, this also had the potential to challenge the able child. This simulates the engineering and business world, and adds an extra dimension to the challenge. Another key criterion is selecting tasks which require children to work co-operatively as a team in order to produce the solution to the problem. One Organiser also emphasised the need for children 'to put together a verbal presentation about what they have done' at the end of the day.

An example of a task that fits the INPUT criteria well is the self-righting buoy (Marsh, 1996a: 8-3). The context of the task is an air-sea rescue plane needs to drop a marker buoy into the sea. The buoy has to meet the following specifications: light weight with no unnecessary solid or liquid ballast, self-righting from a totally inverted position, the light is on, and it must fit into a space 30cm x 12cm. In this task children were given two soft drink cans, plastic cups, masking tape and materials to make a simple circuit. The task enabled the presenter to challenge the children's thinking within a real life context. The Organiser's questioning was a key to stimulating this thinking. The children were exhibiting many of the characteristics set out by Coates and Wilson (2001). They had to use previous knowledge and understanding in a logical manner to solve the problem. The task led to a lot of discussion on balanced forces related to floating, the meaning of self-righting and how it might be achieved, and how to construct a simple circuit and keep it waterproof. Throughout, the children were using scientific vocabulary accurately and appropriately. To construct a successful model, the children had to work effectively as a team, continually sharing ideas and listening to other points of view. They had to transfer knowledge and understanding gained in a school science context to solving the INPUT problem. The able children did this really well and were seen to be very excited and engaged by this challenge. During this task, the able children were observed to be using the higher order thinking skills of analysis, synthesis and evaluation in order to devise their solutions. With some of the other groups of children, casual observations showed that it was more of a trial and error process.

A range of other INPUT tasks would also seem to meet the criteria for stimulating and developing able children's thinking. Observations of the groups of able children clearly indicated that they used their previous knowledge to develop their design ideas, e.g. they discussed the use of triangular structures when trying to create the strongest bridges, and streamlining and aerodynamics when designing the car shape. Groups spent a lot of time discussing the problem before drawing up designs. A feature of each group was that they listened carefully to other children's ideas. They shared ideas and evaluated their models as they progressed, changing the designs after testing.

The able children really enjoyed the activities and talked about them as being 'a big challenge'. The challenge was perceived in two ways, in terms of the time constraint and the actual tasks themselves. They liked the activities because, 'it gets your brain working and wakes you up in the morning' and 'they're fun to build and sort out the problems'. The tasks made the children develop their thinking when analysing the problems and evaluating the outcomes. One

child pointed out, 'You think about the obvious, you think about ways to improve it.' He/she then went on to describe clearly the reasoning behind the group's design of a self-righting buoy and the background knowledge associated with balanced forces that they had used in the development of their solution to the problem. A second child said, '...you might have a problem and you might find a way of solving the problem and you could perhaps use that in another sort of problem.' The majority of children appreciated the open nature of the tasks. One child picked out the bridge construction task as the most enjoyable because, 'There were more ways to do the bridge, so you could compare and say 'well this would be better' where the polydome, you had to use triangles, so you didn't really have much choice.' A second child thought the bridge was more fun 'because it was more realistic' as it involved calculating the cost of materials. The bridge task was more open ended as the children could build their own design from the wood, card and thread provided. It had to be as strong as possible to span a given gap. The pupils were also able to exchange some of their materials with the Organiser who enjoyed 'driving a hard bargain'. Thus they gained some insight into the commercial factors which operate in the real world. They could not just damage their materials and ask for more. The Organiser even deliberately 'short-changed' one group out of a few strips of sticking tape during one exchange to see how alert they were to the possibilities of fraudulent trading. Such touches obviously heightened the enjoyment and effectiveness of INPUT sessions. When they were told they had been short-changed they really laughed. One able child did, however, think that some of the challenges 'can be a bit much, a bit difficult'. He/she thought they should be more specific like the buoy challenge. The tasks also allowed the children to utilise knowledge gained from previous experience or teaching, or from other tasks tackled during the day. For example, one child explained that, 'We thought of other bridges that we've seen, and based our designs on them... and came up with the idea that a triangle was a very strong shape...' Another stated that they had, 'used knowledge gained in the morning in different circumstances, but using the same base'.

One of the aims of INPUT days is to interest able pupils in engineering, and this seems to have been achieved, at least in the short term. As one child explained, 'It's giving you another idea of a different sort of job you can do... if you're doing these sort of days, it opens your eyes to engineering'. When asked if engineers work in the way they did during the INPUT day, one child said, 'I think the basis would be the same. They would use plans and they would have a budget'. One child was even heard to exclaim, 'I'm an engineer' as she worked on a task. It may be worthwhile to carry out a longer term study on young adults who had attended INPUT days when they were children, in order to ascertain whether INPUT is achieving its longer term goal of attracting more young people into engineering.

The effect of grouping children for INPUT sessions

Normally teachers and organisers view INPUT days as special activity days where children are arranged into groups, which are sometimes designated by the teacher and sometimes by the children themselves. These groups generally tend to be of mixed ability and single sex friendship groups. As one presenter said, 'mixed ability groups seem to work better somehow'. All of the teachers said that they would have used mixed ability groups were they to have done the activity themselves.

One Organiser considered that when able children were grouped together 'they're all vying to be number one'. This view was echoed by a second Organiser who thought that able children, 'tend to be more argumentative and less receptive to other people ... so if there is a group break up it is much more likely to be because an able child does not want to accept' the views of other group members. Mixed ability groups were seen by one organiser to make the beneficial effects of the session more apparent. Moreover, mixed ability groups were seen to have social benefits, as all children were able to succeed with the activities. The Organisers thought that INPUT gives children the opportunity to develop their self-esteem by presenting challenges which are different from those in the normal classroom setting. The children who excelled in the INPUT activities were often not those identified as able in terms of their academic ability. This observation was supported at the INPUT days where the most successful models for each task were identified and awarded a small prize. The able groups did not 'win' any of the four challenges for best designs on either of the two days, although they came second or third in two tasks. This suggests that Organisers were correct in surmising that children who are 'able' in the traditional curriculum may not necessarily be as 'able' in technology. Alternatively, it may be related to the criteria use to judge the final products. If some of the thought processes involved in the manufacture of the final design were

incorporated into the judging process, the able children may have scored more highly. Interestingly, the only mixed-sex group won two of the four challenges on one INPUT day.

Some organisers were therefore uneasy about grouping the able children together. This view, however, contrasts with research (Porter, 1999) findings which, indicate that when children are in ability groups and instruction is more complex their achievement, attitudes to learning, social skills and self-esteem are improved. The self-esteem and achievements of the less able have also been shown not to be reduced (Carter, 1986 cited in Porter, 1999).

Teachers also supported the view that children should be in mixed ability groups for the INPUT activities. One teacher thought that as the children were not being assessed, it was appropriate for them to be in friendship groups. Another argument for mixed ability grouping was that the teacher liked the 'low ability children to work with high ability children to learn from their peers'. However, one teacher also commented that it, 'does enable children good to be together as they do discuss better, whereas they tend to be just leaders if they've got less able children' in the group. Moreover, 'the advantage (of ability groups) was ... that they all got to work with someone on their level and ... were not frustrated with behaviour issues in other groups because in mixed ability groups sometimes there can be behavioural issues'

When questioned, able children generally claimed to prefer to work in ability groups. However, working in ability groups was occasionally observed to create an adverse pressure to succeed, which may have detracted from the enjoyment of the day. In real engineering situations, contracts go to the firms with the 'best' designs; hence one INPUT organiser simulated this situation by awarding small prizes to the groups which created the best solutions for the INPUT tasks. In general, the children greatly enjoyed this, particularly the presentation of awards session at the end of the day. One able group, however, was anxious about 'winning' because they felt that it would be 'expected of them'. They discussed how it 'would be good if we win'. The perceived expectations appeared to worry them and they gave the impression that they may have enjoyed themselves more in mixed ability groups where they could relax more. This tension was observed throughout the day.

Interviews with the children, including the group just mentioned, however, indicated that they really enjoyed working in their own ability groups. 'It's best really to just work in a team somewhere where no one can disturb you.' They were concerned that children with less ability might not fit in with their groups of similar abilities. As one child indicated, 'We are all of the same ability, so we were all coming up with ideas, where if one of us hadn't been clever they would have just been sitting there and not coming up and helping'. All of them agreed that they had worked as a team with 'hardly any arguing'. They thought the people in their group were 'all of our standard' and so they 'worked hard together'. One child, when summarising why they liked working in these groups said, 'Because we have the same sort of ideas but then we base them on different things, and we have different little changes to them, and ... because we'll probably come up with different ideas and if we sort of merge them together then it's quite interesting to see what it comes up with.' This would indicate that the children clearly think that the INPUT sessions offer them the opportunities which are set out in the documentation as criteria for the projects.

Have able children benefited from these tasks?

All teachers agreed that the able children had greatly benefited from the INPUT activities. One group of teachers even commented that, 'In our opinion, the INPUT sessions are geared to the more able children'. They went on to say that the able children enjoyed the challenges more because they are open-ended, whereas less able children were often seen to need much more help. The activities in this context would fit into the definition of enrichment activities given by George (1997) as those which provide experiences and activities beyond the regular curriculum. INPUT sessions were seen by teachers to be, 'challenges that they (able children) should be given ... where they don't fail necessarily, but where they do struggle a bit, because they go through primary school and they don't ever fail'. This is supported by Adey (1992) who stated,

> '...if anything of intellectual worth is to be gained by students from science, activities must be intellectually demanding, but ... the demand must be managed so that it challenges without leaving students struggling helplessly.' (Adey, 1992: 140)

The House of Commons Education and Employment Committee (1999) indicated:

> 'Highly able primary school children need to be sufficiently challenged. Partly, this will be achieved through appropriate teaching and expectations of pupils.' (p.iv)

INPUT activities would seem to fit these criteria as the tasks involved real world

problems, which the highly able children found to be stimulating and motivating. One of the key factors in building pupils' confidence is an environment which is safe and nurturing, where children can discuss their ideas freely with their teachers (Clark and Callow, 1998). The children's thoughts discussed in the previous section reveal how they enjoyed working on the challenges with other children of a similar ability level and were keen and motivated to work out solutions to the tasks.

In a normal classroom setting, a second group of teachers commented that able children were particularly good at individual work, but not so good at group work. 'So I think that it was a good thing for them to discuss with other children at their level'. The children were seen to be able to set themselves clear parameters of what they could and could not do.

The role of adult helpers in INPUT sessions

Adult supervision is obviously necessary during INPUT sessions to ensure the safety of the children and to provide a certain amount of practical assistance. The role of the INPUT team, teachers and Neighbourhood Engineers is outlined in Marsh (1996). One Organiser stressed that the helpers were not to show the pupils how to solve the challenges. Montgomery (1996) suggested three ways for teachers/ helpers to support children in their problem solving:

- 'Describe with interest what the child is doing.
- Ask the child what s/he is doing.
- Support the (problem solving) process when necessary.' (Montgomery, 1996: 101)

Observation of sessions clearly showed that the majority of helpers supported the children actively in these ways. In one session an engineer who was helping asked the pupils challenging questions about their design which stimulated a higher level of thinking. When interviewed about the session, the group of able children immediately commented on how beneficial this type of questioning was. They referred to it several times during the interview and it had clearly made an important impact on what they obtained from the session. One Organiser used questioning very effectively when introducing one of the challenges. Open ended questions provoked pupils' scientific thinking before they set about applying their knowledge and understanding to the task. Questioning obviously heightened pupils' awareness and enjoyment of the challenge and able pupils in particular, responded enthusiastically to this approach. Thinking skills in highly able children can be enhanced by setting problems in unfamiliar contexts and using questions which force the child to use scientific thinking, and technological and science ideas (O'Brien, 1998). Thus appropriate questioning can enhance the value of INPUT days for able pupils, in particular.

Conclusions

This investigation showed that INPUT activities have the potential to challenge and stimulate able children in a primary school. They are sufficiently open-ended to extend and enrich the curriculum. INPUT activities, which are effectively implemented, appear to fit the criteria set out by Porter (1999) in her general curriculum guidance for able children. Thus they:

- 'encourage higher level thinking skills such as analysis, synthesis, evaluation and problem solving;
- allow children to pursue their own interests to a depth that satisfies them;
- involves less repetition and a faster pace than usual for their age;
- promote intellectual risk taking- that is creativity – and divergent thinking;
- offer a high degree of complexity and variety in their content, process and product.' (Porter, 1999: 173)

There needs to be an emphasis on the process of problem solving as well as on the final product, including children reviewing their solution and the means by which they came to this solution.

Group work is an effective way of helping children to develop and explore their ideas. It needs to be planned for in an active way. The INPUT sessions that were viewed achieved this. The INPUT Organisers and teachers involved all thought that children should be in mixed ability groups. This contrasted with children's ideas and research evidence which suggests that ability grouping within the class seems to have a beneficial effect on pupils in science (Sukhnandan and Lee, 1998). Placing able children in their own groups would allow Organisers to set starting points that are more challenging and complex. This could improve the achievements of these children even further.

Questions which are open rather than closed allowed children's thinking to develop. With some of the helpers it was apparent that this was happening during INPUT sessions. On other occasions, however, children were being directed by less experienced helpers.

Organisers might look to build in open ended questions in their planning and briefing sheets for helpers to facilitate the development of able children's thinking.

The chief drawback of this investigation was the number of INPUT days and activities which could be observed in the time available. However, it is likely that the findings would be repeated if a more extensive survey was carried out. There are close links between science and technology, particularly in the primary school. INPUT activities obviously allow children of all ability levels to apply scientific knowledge and understanding to solve technological problems. They are, however, particularly suitable for enriching the curriculum for able children.

Contacts

INPUT is sponsored by the Gatsby Foundation. If you would like to find out more about the project please contact John Allen at the Oxford Trust, Tel: 01865 728 953 or e-mail johna@oxtrust.org.uk

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