Supporting science, design and technology in the early years
Supporting early learning

Series Editors: Vicky Hurst and Jenefer Joseph

The focus of this series is on improving the effectiveness of early education. Policy developments come and go, and difficult decisions are often forced on those with responsibility for young children's well-being. This series aims to help with these decisions by showing how developmental approaches to early education provide a sound and positive basis for learning.

Each book recognizes that children from birth to six years old have particular developmental needs. This applies just as much to the acquisition of subject knowledge, skills and understanding as to other educational goals such as social skills, attitudes and dispositions. The importance of providing a learning environment which is carefully planned to stimulate children's own active learning is also stressed.

Throughout the series, readers are encouraged to reflect on the education being offered to young children, through revisiting developmental principles and using them to analyse their observations of children. In this way, readers can evaluate ideas about the most effective ways of educating young children and develop strategies for approaching their practice in ways which offer every child a more appropriate education.

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Supporting science, design and technology in the early years

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Series editors’ preface

This book is one of a series which will be of interest to all those concerned with the care and education of children from birth to 6 years old – childminders, teachers and other professionals in schools, those who work in playgroups, private and community nurseries and similar institutions; governors, providers and managers. We also speak to parents and carers, whose involvement is probably the most influential of all for children’s learning and development.

Our focus is on improving the effectiveness of early education. Policy developments come and go, and difficult decisions are often forced on all those with responsibility for young children’s well-being. We aim to help with these decisions by showing how developmental approaches to young children’s education not only accord with our fundamental educational principles, but provide a positive and sound basis for learning.

Each book recognizes and demonstrates that children from birth to 6 years old have particular developmental learning needs, and that all those providing care and education for them would be wise to approach their work developmentally. This applies just as much to the acquisition of subject knowledge, skills and understanding, as to other educational goals such as social skills, attitudes and dispositions. In this series there are several volumes with a subject-based focus, and the main aim is to show how that can be introduced to young children within the framework of an integrated and developmentally appropriate curriculum, without losing its integrity as an area of knowledge in its own right. We also stress the importance of providing a learning environment which is carefully
planned for children’s own active learning. The present volume helps to dispel the anxieties which many practitioners have about their own expertise in, and understanding of science, design and technology. It will help to stimulate adults’ enthusiasm for these vital areas of learning, and offers many examples of practical ways of initiating young children into them.

Access for all children is fundamental to the provision of educational opportunity. We are concerned to emphasize anti-discriminatory approaches throughout, as well as the importance of recognizing that meeting special educational needs must be an integral purpose of curriculum development and planning. We see the role of play in learning as a central one, and one which also relates to all-round emotional, social and physical development. Play, along with other forms of active learning, is normally a natural point of access to the curriculum for each child at his or her particular stage and level of understanding. It is therefore an essential force in making for equal opportunities in learning, intrinsic as it is to all areas of development. We believe that these two aspects, play and equal opportunities, are so important that we not only highlight them in each volume in this series, but also include separate volumes on them as well.

Throughout this series, we encourage readers to reflect on the education being offered to young children, through revisiting the developmental principles which most practitioners hold, and using them to analyse their observations of the children. In this way, readers can evaluate ideas about the most effective ways of educating young children, and develop strategies for approaching their practice in ways which exemplify their fundamental educational beliefs, and offer every child a more appropriate education.

The authors of each book in the series subscribe to the following set of principles for a developmental curriculum:

Principles for a developmental curriculum

- Each child is an individual and should be respected and treated as such.
- The early years are a period of development in their own right, and education of young children should be seen as a specialism with its own valid criteria of appropriate practice.
- The role of the educator of young children is to engage actively with what most concerns the child, and to support learning through these preoccupations.
- The educator has a responsibility to foster positive attitudes in children to both self and others, and to counter negative messages which children may have received.
• Each child’s cultural and linguistic endowment is seen as the fundamental medium of learning.
• An anti-discriminatory approach is the basis of all respect-worthy education, and is essential as a criterion for a developmentally appropriate curriculum (DAC).
• All children should be offered equal opportunities to progress and develop, and should have equal access to good quality provision. The concepts of multiculturalism and anti-racism are intrinsic to this whole educational approach.
• Partnership with parents should be given priority as the most effective means of ensuring coherence and continuity in children’s experiences, and in the curriculum offered to them.
• A democratic perspective permeates education of good quality and is the basis of transactions between people.

Vicky Hurst and Jenefer Joseph
Introduction

The first time we saw Patrick was on the photo of the scan . . . the next time was when he arrived – seven weeks early (Fran had to have an emergency Caesarean). He seemed healthy and didn’t need to go in an incubator but after a few days at home he was back in hospital for an operation. He was constantly monitored by a computer – which was operated by touching the screen.

Within the first few weeks of his life Patrick had experienced many forms of technology. Even before his birth his parents and grandparents had been able to see him as a result of a technological process. Our interactions with technology and science are both profound and lifelong. Every part of life is affected by the results of scientific investigation and the products of technology. Our earliest sensory experiences involve touching, tasting, smelling, listening to, or looking at the products of scientific and technological activity. Our natural inclinations to explore and to try things out play a profound role in our early learning. Food technologies are immediately significant to the very young child; they eat processed food products and food that is cooked at home. It may even be prepared in a food processor or microwave oven. As parents we act as food technologists, we adapt and combine food products to suit our children’s tastes. Proportions are often systematically varied and tested. Experiments are conducted. When we place a mobile above a baby’s cot the stimulus that we are offering triggers off a conscious process of interaction with technology that will develop throughout the child’s life.
Before long children begin to play with toys which may have moving parts and mechanisms; these toys will be made of a variety of materials including plastic or fabric or wood. They begin to learn about the properties that these materials possess: Are they soft and smooth? Are they flexible? Are they strong? Even when children are sleeping they will experience and be influenced by the technological products around them: their cot, their mattress, their quilt. Many parents have been concerned to read scientific reports that relate the risk of cot death syndrome to various qualities of these commercial products.

Once consideration is made of the impact of science and technology on our lives, and with the everyday as well as the extraordinary uses we make of technology, it becomes evident that all people are the beneficiaries of science and technology. We are all users of technology but this is not in a purely passive way. When we choose a toothbrush we consider its design features; we have evaluated the one that we have been using; considered how well it fits the hand and the mouth; the hardness of the bristles, the size of the toothbrush head. We evaluate the feel, the handling qualities and effectiveness of it as a product and of its usefulness in application. Things like toothbrushes are made, the products of someone’s technical skill in designing and making and they are evaluated, used, explored through each of our senses.

We all use science and technology and we are all practising scientists and technologists as well. We all try to provide explanations for things that we experience, we measure things at times and we try things out. However modestly, from time to time, we also design or adapt and make things, whether these are food products, the occasional item of clothing or a bookshelf. We may design and construct a new layout for our garden, and we are even more often responsible for the interior decoration, layout and choice of furniture in our homes. If we are to encourage young children to grow up to be good at these things we must start by trying to see the world through their eyes and support them in their own inquiries and projects. Increasingly we can broaden their horizons and show them that with our support there is so much more that they can achieve, and that they can look forward to achieving independently in the future.

This book provides a novel approach to supporting young children’s learning in science and design and technology. We know that the approach is effective from our own experience but the general approach may be unfamiliar to some of our readers. For this reason some theoretical explanations are necessary. In the interests of avoiding interruptions in what we consider to be an essentially practical text, many extended explanations have been restricted to appendixes. However, some broad introductory comments are necessary and it is to these that we now turn.
Design and technology: encouraging children to make things

The broad aims and provisions for teaching design and technology in the UK were defined for the first time in the National Curriculum; the subject was devised with an emphasis upon the development of children’s practical capability. Children therefore design, make and evaluate their own products in primary school classrooms throughout the country. The areas of knowledge and experience that are outlined in the curriculum documents cover the use of food and textiles, construction kits, making things from wood and other construction materials and communicating ideas through the use of drawings and other media. These are areas of experience that are familiar, for the most part, to those working with young children. In fact, as far as the early years curriculum is concerned, we might consider the foundations of these design and technology educational practices to have been set over a period of two centuries by the pioneers of the kindergarten and nursery education movement.

Comenius, in the seventeenth century, and Pestalozzi, Froebel, and Owen in the nineteenth century all extolled the virtues of young children being industrious. They encouraged educators to provide opportunities for infants to make things. Froebel’s proposals, as far back as 1829, included the suggestion that children should spend each afternoon in crafts that included the making of wooden kitchen utensils, weaving, the use of pasteboard to make stars, wheels, boxes, napkin rings and lamp shades. He also suggested that children might be encouraged to whittle boats, windmills and water wheels, and that they should model with clay and flexible wire. For Froebel, education in manual skills served to develop the whole child; his concern was much more than merely vocational. Froebel believed that craft provided a means of expression and a powerful means to develop habits of thought that included: ‘success, a calm sense of power, a firm conviction of mastership, which are so essential to fullness of life’ (Frobel 1887: 37).

In different ways, Maria Montessori, Jean Piaget and John Dewey all took this emphasis upon craft even further and also argued that classification, and the power to distinguish between qualities and attributes, actually provided the foundations of intelligence: ‘To be able to distinguish, classify and catalogue external things on the basis of a secure order already established in the mind, this is at once intelligence and culture’ (Montessori 1912: 205). As we shall see, sorting and classification play a major part in science education, and they also have a major role to play in design and technology. In integrating design education with the craft tradition, design and technology educators placed a new emphasis upon the ‘evaluation’ of technological products. The implications of this will be
explained more fully in the next chapter. For the time being it is enough to
note that this provides a part of our justification for adopting an integrated
approach to supporting science, design and technology.

The integrated approach to science and design and technology
education

Evaluation plays a part in both science and design and technology. We
have found that it is often appropriate to subject the products of both chil-
dren’s and adults’ design and technology to forms of scientific evaluation.
Scientific investigations and explanations also provide the stimulus for
many designing and making activities. Many adults found their own sci-
ence education alienating and this provided us with yet another reason for
adopting the integrated approach. In providing guidance and illustrations
of good practice in science education we have made every effort to ensure
that the relevance is clear. As Hurst and Joseph (1998: 14) put it: ‘Children
learn best in social contexts, when they are interacting in meaningful ways
with their peers or with adults’.

Design and technology often provide the most relevant social contexts
for understanding science. The integrated approach is also consistent with
the School Curriculum and Assessment Authority (SCAA) Desirable Out-
comes for Children’s Learning (1996) that are discussed in depth in Chapter
5. Perhaps even more importantly, the integrated approach that we have
taken is consistent with an academic tradition that in recent years has been
having an influence on all sectors of education. As a curriculum subject,
science, technology and society (STS) has sought to introduce an approach
to science education that emphasizes a study of the nature of science and
technology and of the social effects of technological change. In a survey
identifying the opinions of their members regarding the direction of future
developments within science education, the Association for Science Edu-
cation (ASE) has also found that most teachers now feel that the subject
should be set within a more holistic curriculum framework that empha-
sizes ‘relevance’ (ASE 1998). It may be that in future years we will there-
fore see greater integration throughout the school curriculum.

Science education in the early years

We often talk of children as ‘natural scientists’ (Bentley and Watts 1994),
and of their natural inclination to ‘spontaneously wonder’ (Donaldson
1992) about things:
From the very earliest days in its life, a child develops beliefs about the things that happen in its surroundings. The baby lets go of the rattle and it falls to the ground; it does it again and the pattern repeats itself. It pushes a ball and it goes on rolling across the floor. In this way, sets of expectations are established which enable the child to begin to make predictions. Initially these are isolated and independent of one another. However, as the child grows older, all its experiences of pushing, pulling, lifting, throwing and feeling and seeing things stimulate the development of more generalised sets of expectations and the ability to make predictions about a wider range of experiences. By the time the child receives formal teaching in science it has already constructed a set of beliefs about a wide range of natural phenomena.

(Driver 1985: 2)

As Driver (1985) goes on to suggest, we now know that some of the beliefs that children develop turn out to differ markedly from accepted scientific knowledge and that young children’s views are often difficult to change. This has important consequences for science educational approaches that are based on the notion of children finding things out for themselves, for ‘discovery’ learning. Left entirely to their own devices, children will learn about the world around them, but the trouble is they will often learn to understand it in idiosyncratic (and less useful) ways. A few very common examples may illustrate the point:

- Children often consider that a vacuum ‘sucks’, yet a ‘vacuum’, that is by definition ‘nothing’ can clearly be doing nothing;
- When children put their hands in cold water or stand barefoot on a tiled floor they will refer to the cold coming ‘into’ them rather than to the heat escaping from them;
- Children believe that heavy things fall faster;
- They believe that things float simply because they are ‘light’;
- They fail to recognize that they can see because light is reflected from the things around them and that this enters their eyes, they imagine something comes from their eyes to sense the things around them.

It may be many years later, in adolescence or adulthood, that we come across a better scientific explanation for these things. Many adults never come across them.

The scientific beliefs that individual children build up on their own and the science that is constructed by professional scientists is qualitatively different. When we accept the scientific knowledge that is produced by professional scientists we do so because we know that the ideas have been
communicated throughout the scientific community and they have been subjected to rigorous testing. ‘Established’ scientific knowledge is the product of a collective and collaborative historical enterprise. When we refer to science as a ‘discipline’ we also draw attention to the fact that it constitutes an intellectual enterprise that has a distinct set of rules and that these rules are normally (or properly) adhered to by that particular academic community we know as ‘scientists’. For a child (or for anyone else) to think ‘scientifically’ means to obey these rules, to keep an open mind, to respect yet always to critically evaluate evidence, and to participate in a community that encourages the free exchange of information, critical peer review and testing. This latter point is crucial because, as Driver et al. (1996: 44) have put it: ‘Scientific knowledge is the product of a community, not of an individual. Findings reported by an individual must survive an institutional checking and testing mechanism, before being accepted as knowledge’.

All of this can be carried out to good effect in infant classrooms and preschool settings. The National Curriculum for science in primary schools has been developed to teach children some of the key ideas at the same time as developing their investigative skills. The central task of a science education is therefore to give children an appreciation of the historical accomplishments of the scientific community and an introduction to the scientific practices that provide the means by which they are achieved. In the early years this is best achieved by providing young children with practical ‘hands-on’ experiences, and drawing their attention to some of the scientific theories that are available to explain these experiences. It is also achieved by answering their questions and telling them stories about significant developments and discoveries. To do this well, we need to build up our repertoire of appropriate stories and develop our knowledge of everyday phenomena. Science provides us with explanations for a broad range of phenomena that is of interest to young children: Why is the sky blue? What happens to the tadpoles? How does a torch work? Where does all of the water go to after it goes down to the sea? Science also provides the means by which predictions can be made: What will happen when you mix vinegar and baking powder together? What happens when you squash a plastic bottle full of air under water? What will the moon look like tomorrow night?

In addition to passing on the best explanations available we also need to help children understand how it was that these ideas came to be discovered. The best way of doing this is to carry out some investigations with the children ourselves. As Black (1993: 10) put it, in his general discussion of primary school science learning programmes: ‘A first essential is that students should come to understand science and to understand how
science is made by being engaged in doing it’. As we shall see, this book takes the view that this work can also be developed in any home, nursery or other preschool setting and that it is most usefully presented to young children as ‘playing the scientist game’.

Playing the scientist game

It has often been assumed that the central aim of science education is to teach children as much as possible about what scientists have learnt. A similar view could be taken in design and technology where the subject would then be limited to teaching children about the products of influential schools of design, and about particular techniques and technologies. While all of these certainly have a place in science and design and technology education it is now widely agreed that the central focus of both subjects should be on the development of practical capability. Children should therefore be systematically introduced to the ‘craft skills’ of the scientist and those of the design technologist.

Children should therefore be introduced to these particular ways of working and thinking and apply them to their own investigations and problems at an early stage. Just as portrait or landscape painters need to learn techniques and technicalities to practise their art effectively, and just as they will benefit from studying the paintings of others, so the scientist and the design technologist gain from similarly focused tuition in their own fields. The point is that these focused activities are not the ends in themselves, they are merely the means by which children are given their first appreciation and are later more formally introduced to each of these ‘craft’ communities. As Robin Millar (1989: 60) has suggested:

In teaching children science, we are helping them to internalise the procedures and standards of the scientific community. We are assisting the child to construct for herself a mental representation of the scientific ways of working and judging.

Millar (1989: 60) cites Lawrence Stenhouse (1978) to argue for a model of teaching in which ‘the teacher guides the learner towards an appreciation of the standards of judgment inherent in a discipline, through a process of day-to-day correction and critical comment on the learner’s work’.

The most important personal skill for a scientist is the skill of reasoning. More accurately, it is the skill of identifying mistaken reasoning. We can all reason incorrectly easily enough. Aristotle thought that a heavier object would fall to the ground faster than a light one. It won’t, but the fact that he got it wrong doesn’t mean that he was stupid – far from it. Aristotle
would have been quick to correct himself if he had carried out a systematic study. Galileo is often credited as being the first to make the necessary measurements, but it is important to recognize that that was all that it took. Galileo may or may not have been the first to make the measurements, but his spectacular demonstration on the leaning tower of Pisa certainly popularized the idea. It made history! Let’s take a more mundane example from a school PE lesson involving 4 and 5-year-olds:

To the tune of ‘The Sorcerer’s Apprentice’ the group of infants were jumping, feet together, around the school hall imitating ‘magical brushes’ that were sweeping away the water. As the children began to tire one child, Sarah, suddenly exclaimed; ‘It’s not fair Brahmajit can jump further because he has longer legs!’ The teacher stopped the class and repeated what Sarah had said. She then lined the children up in order of their height. Each in turn was asked to jump and the children were invited to judge which children jumped farthest. It certainly looked as though Sarah’s hypothesis was correct. The teacher had encouraged the children to make systematic observations, to organize the observations into an orderly array so that any pattern would be easier to see. However misleading the evidence here, the teacher was demonstrating some rigorous scientific reasoning. She could have left it at that but she had doubts and decided to persevere to test the hypothesis further, and this demonstrated her real commitment to science education. On the way back to the classroom, she took two of the children into the library and showed them where the books on sport were located; she asked them to collect together all the picture of famous athletes they could find.

When the children were dressed they sat on the carpet in front of the teacher and were invited to look closely at the pictures in the books. Which athletes were the jumpers? Which athletes had the longest legs? Again the evidence seemed to show that Sarah’s hypothesis was correct. The teacher suggested that the children should test the hypothesis further and asked the children how they might each measure the length of their legs and the distance they could jump. The teacher emphasized the fact that everyone would have to measure their legs and jumps in the same way or the test would not be ‘fair’. The methods were agreed and over the following week the children, in pairs, measured their legs. A sheet of sugar paper was first pinned to the wall and each took their turn in drawing around each other’s right leg. They then cut out the silhouette of their leg and wrote their name upon it. The teacher supervised the arrangement of the legs on a wall display. By the end of the week the lower part of the wall was covered...
with the leg silhouettes. They were arranged in order of height and just before the children went into the hall for their PE lesson the teacher asked them how they thought they would be arranged if each were put in order of distance they could jump. The children agreed that, if the hypothesis was correct, the legs would be in the same order. The teacher pinned a thread across the tops of the legs to show the gradual curve upwards.

In the hall the children chalked lines, jumped and counted the decimetre divisions on their meter measuring sticks. One child complained that his partner was cheating because he put his toe instead of his heel on the line. Again the teacher stopped all of the children to discuss how they might be sure to make the test fair. After a few minutes each paper ‘leg’ had a number written on it and the teacher lined the children up according to the number and length of their jump before returning to the classroom. Still in order the children lined up against the wall and pinned their leg in its place. When they stood back they could see that the gradual incline had given way to unevenness and that the pattern was gone. The children concluded that the hypothesis was wrong. So why were some of the children able to jump further than others? One of the suggestions was that some children had stronger legs and the teacher therefore arranged some bathroom scales against a wall so that the children could measure the strength of their ‘leg pushes’ over the following week.

When the teacher decided to continue to test the generalization that had been made (that longer legs meant longer jumps) she was demonstrating to the children a fundamental principle of the scientific enterprise. She was demonstrating that no generalization should be allowed to stand unless it is repeatedly tested by newer and newer experiments and more and more accurate forms of measurement. While Sarah may have been a little disappointed that her hypothesis was ultimately proved incorrect, it had become the property of the whole class before it was found wanting. The children did not, in fact, seem disappointed at all, but were rather excited to find themselves testing yet another hypothesis (prediction) that they had identified so soon.

To take another example, this time drawn from a professional development package produced at the Manchester Metropolitan University (Abbott et al. 1996), a younger group of nursery children were playing the scientist game in the context of a ‘ladybird hunt’. A number of the activities within the nursery had been centred around the topic of living things and patterns in nature so that when one of the children said they had seen a ladybird in a raised flower bed this was seen as an excellent
opportunity. Before the first group of children embarked upon the ladybird hunt, a member of the nursery staff spent a few minutes showing them some of the centre’s reference books that featured ladybirds. As she talked to the children she seemed genuinely curious about the insects and this encouraged the children to take an interest too. They looked at the pictures and talked about the spots and the wings and the wing covers. They also talked about how they should always take care of living things. There was an air of anticipation and excitement before they embarked outside. The video then shows the children inspecting the foliage in the flower beds and hedgerows and then returning with some specimens to the centre. In the preliminary discussions, outside on the hunt, and back in the centre a lot of questions were asked:

- What colours are they?
- How many spots do they have?
- Are they hiding?
- Where shall we find them?
- What do they eat?
- What does it feel like?
- Will it fly away?
- How many legs has it got?
- What shape is its body?

The children looked at the ladybirds through their magnifying glasses. They counted their spots with the help of the adult and they allowed them to crawl across their hands, and watched them fly. The children were then given the opportunity to make their own model ladybirds out of red and black playdough. This activity was chosen specifically to encourage the children’s visual perception. The video then shows how the children returned to the hunt quite spontaneously in their free play and were clearly very much engaged in the topic for some time afterwards.

In both of the above cases, the investigative processes that were followed by the teacher can be represented in a simple diagrammatic form that has been found helpful in planning. The same approach is employed to support teachers in developing design and technology activities. The planning diagrams are provided in Chapter 4. The major difference between the two investigations cited above was in the degree of support and role modelling provided by the educator. In the first case the teacher was able to develop the investigation in collaboration with the children. In the latter case there was a need to provide more support and to demonstrate by their own actions and discussion what it was to look at things scientifically. All of the investigations and designing and making activities
that we provide need to be matched to the children’s capabilities in this way and Chapters 5 and 6 will therefore focus on the curriculum, resourcing, assessment, progression and continuity. Before we go on to these areas of concern for curriculum planning and development an effort will be made to show how science and design and technology education relate to the broader concerns of teaching and learning in early childhood. Chapter 1 will begin by developing many of the ideas introduced in this chapter. It will be argued that a good deal of both science and design and technology education should build upon existing practice. Chapter 2 is concerned with developing practices that are responsive to the differing needs of children. Issues relate to culture, gender, bilingualism, physical difference and the children’s differing emotional needs. In Chapter 3 the literature on early childhood play and development will be reviewed to identify the role to be played by adults in supporting the child’s scientific and design and technological development.

Notes

1 If you feel at all unsure about the answers to any of the questions that are referred to on this page or at any other point in the book, you shouldn’t be in any way concerned about it. When we started to teach science we didn’t know how to explain many of these things either. We believe it was the quality of our own science education that needed to be questioned. Suitable explanations are provided in Appendix 1, and Appendix 2 provides a range of other reference sources that you may find useful in dealing with children’s questions.

2 The activity is included as a video case study in the resource pack which includes a number of other useful studies related to the six key areas of the School Curriculum and Assessment Authority (SCAA) Desirable Outcomes for Children’s Learning on Starting Compulsory Schooling (SCAA 1996).