

This item was submitted to [Loughborough's Research Repository](#) by the author.
Items in Figshare are protected by copyright, with all rights reserved, unless otherwise indicated.

Children designing: progression and development in Design and Technology at Key Stages 1 and 2

PLEASE CITE THE PUBLISHED VERSION

PUBLISHER

© Loughborough University

LICENCE

CC BY-NC-ND 4.0

REPOSITORY RECORD

Baynes, Ken. 2019. "Children Designing: Progression and Development in Design and Technology at Key Stages 1 and 2". figshare. <https://hdl.handle.net/2134/1688>.

CHILDREN DESIGNING

Learning Design: Occasional Paper No. 1

Ken Baynes



Department of Design and Technology
Loughborough University of Technology

Learning Design: Occasional Papers

THE SERIES

This is the first in a new series of occasional publications, Learning Design, which sets out to explore and explain the learning process in Design at all levels of education.

It is directed particularly at teachers who wish to base their work on a deeper understanding of the nature of 'design intelligence' and the dynamics of teaching and learning in the area.

This first publication analyses development and progression in Primary Design and Technology. Although it uses the National Curriculum framework as a starting point, the intention is to probe beyond this framework to relate it to larger issues of method and philosophy. The second title will look more closely at Imaging and Modelling and explain some strategies for teaching the key skills and knowledge at various stages of education. The third publication will discuss the relationship between Art and Design and Design and Technology, highlighting the shared 'design language' of form and the importance of bridging the often separate worlds of Art and Science.

Loughborough University of Technology
Department of Design and Technology

CHILDREN DESIGNING

Progression and Development in Design and Technology
at Key Stages 1 and 2

Ken Baynes



CHILDREN DESIGNING

The material in this publication is the copyright of the author

This edition:

© Loughborough University of Technology, 1992

ISBN 0 9518299 2 0

First edition, 1992

Designed and printed by Audio-Visual Services,
Loughborough University

Except where otherwise stated all photographs are by
Krycia Brochocka

Page v by Celia Lillywhite; page 4 by Lawrence Gresswell

The drawings on the title page and page iii are by Primary
school children in West Glamorgan. They were done as
part of the Art and the Built Environment project.

Further information about this series of
publications is available from:

Loughborough University of Technology
Department of Design and Technology
Loughborough
Leicestershire LE11 3TU

Telephone: 01509 263171
Fax: 01509 610813

CONTENTS

	Page
Introduction	1
1 Before School	5
2 Identifying Needs and Opportunities	11
3 Generating a Design	19
4 Planning and Making	27
5 Evaluating	39
6 Conclusion	42
7 References	inside back cover



THE AUTHOR

KEN BAYNES ARCA, FCSD

Visiting Professor, Department of Design and Technology, Loughborough University; partner, Brochocka Baynes, educational design consultants

Ken Baynes was trained as a painter and craftsman in stained glass but has spent the whole of his professional life working as a designer, educator and writer. At the centre of his work have been two main themes: the use of exhibitions as a medium for entertainment and education; and the attempt to develop better strategies for teaching and learning about art and design in Primary and Secondary schools. He was head of the Design Education Unit at the Royal College of Art and his most recent exhibitions include the ART of LEGO and The Art Machine. During its tour of the UK the ART of LEGO was seen by 1.4 million people. In addition to his work for Brochocka Baynes and Loughborough University, he is Education Consultant to the Design Dimension Project and is on the Advisory Board of design education bodies in Illinois and New York. He has been the scriptwriter and presenter for the Design Matters television series on Channel 4 where he was involved in creating 27 programmes dealing with every aspect of design. With Krysia Brochocka he is joint editor of the Nelson Design and Technology Resource and a member of the Education Committee of the Design Museum.





INTRODUCTION

The editors decided to begin this series at the Primary Phase for two reasons:

- 1 The early years are fundamental to the development of design capability;
- 2 The introduction of National Curriculum Design and Technology has made it particularly important for teachers in the primary phase to understand more about the developmental pattern of children's intelligence in the area.

It is widely accepted that Primary age children have the ability to design things. National Curriculum Design and Technology sees the planned development of this ability as central to its aims. It goes so far as to use a process model of design activity to structure the four Attainment Targets. It is through design activity that children are expected to learn the knowledge and skills set out in the Programme of Study.

One result of this is that 'design projects' have become a normal part of classroom activity in Primary schools. Many teachers have welcomed this. The idea of 'project-based learning' is familiar and full of potential. However, there is a danger that these design projects will be little more than conventional projects plus making. To go beyond this it is necessary to have a deeper understanding of what we might call 'design intelligence' - that is, the particular ways in which children and adults think and act when they are designing.

It is the aim of the present publication to make a first contribution to this area of enquiry.

The discussion is structured around the four Attainment Targets for Design and Technology. The approach has been adopted because this particular set of Quads has become totally familiar to Primary teachers. The idea that designing involves: Identifying Needs and Opportunities; Generating a Design; Planning and Making; and Evaluating has been enshrined by Act of Parliament as 'Design and Technology Capability'. Fortunately many useful things can be said using this framework. But it is also necessary to repeat the familiar caveats. The processes involved in designing are not linear, they do not always start from human needs and they do not always proceed in an orderly way. They are reiterative, spiralling back on themselves, proceeding by incremental change and occasional flashes of insight. Wherever possible, these reservations have been woven into the text.

It is also important to acknowledge that this four Attainment Target structure is likely to change. As I write, National Curriculum Technology is under review. However, the material in this book in no way depends on the existing structure. It is simply that the structure provides a convenient and familiar framework for the discussion.

One of the baffling elements in the existing National Curriculum Orders for Technology is the lack of a logical connection between the Attainment Targets and the Programme of Study. For the purposes of the present discussion, we have attempted to make at least some connection. We have taken up the idea coming from a number of LEAs (notably Leeds and Somerset) where threads of activity have been identified to tie the Programme of Study back into the ATs. So, in the case of AT1, Identifying Needs and Opportunities, we further identify Exploring and Investigating as a key related 'thread'.

We end up with the following structure:

AT1
IDENTIFYING NEEDS AND OPPORTUNITIES
Exploring and Investigating

AT2
GENERATING A DESIGN
Imaging, Modelling, Communicating and Developing Ideas

AT3
PLANNING AND MAKING
Energy, Systems and Mechanisms

AT4
EVALUATING
My own work and the work of others

Although this framework is helpful and familiar, it has one important drawback - it relates strongly to school and the structured learning experience of children. Much of the early development of design capability happens outside school, where the experience of growing up and playing in a designed world are amongst the major formative influences.

It was Maxim Gorki who wrote: 'Play is children's way of perceiving the world they have been called upon to change'. For Design and Technology, nothing could be more to the point. Designing is about shaping the future. It invites us to make the imaginative leap from present reality into future possibilities. Play is the child's major imaginative arena. Design and play are linked together.

I begin, therefore, with an opening Chapter, Before School, which attempts to place school-based learning in a broader developmental perspective. In subsequent chapters, the attempt is made to maintain connections between the world of play, the world of school and the world of professional design activity. It seems to me that the more we can illuminate these connections, the better we shall understand the nature of designing.

Ken Baynes
April, 1992.



1 BEFORE SCHOOL

Although children don't begin their 'official' education until they are five years old, the fact is that it is precisely during these first five years that children develop most rapidly. Physical and mental growth begin astonishingly quickly but the pace gradually slackens. Children actually reach a mid-point of development between four and five years old. By the time a child is four, 50% of intelligence will have developed, leaving only 30% for the years between four and eight and a further 20% up to seventeen. [1]

The importance of a child's experiences and development during these early years cannot be over-estimated. Learning begins at the moment of birth and even the youngest children are keen and enthusiastic investigators of the strange but exciting world into which they have suddenly been plunged. At once they begin exploration, using their senses to find things out and learning how other people respond to their sounds and movements.

What each child is really trying to discover is knowledge and understanding about themselves, their relationships with others and how the world works. They can only achieve this through the images, materials, stories, conversations and activities that they experience. In terms of design capability, it is shaped absolutely fundamentally by the experience of growing up in a world that has been designed.

Every child is born with the capability to take pleasure in learning and influencing the world around them. One of their most important and basic impulses is to enjoy finding things out either alone, or with other children and adults. It is a feeling that needs reinforcement and the reassurance of success. It is striking that small children persist even if the reality of learning proves difficult and requires effort. The end result of 'knowing' makes it worthwhile. These are the first steps towards the tenacity and creative thought that the child will need in order to cope with life by taking control of their own world and, in fact, shaping the future.

In case this sounds terribly difficult to achieve, it is helpful to realise that, in play, every child has a ready made way of finding out about life. Jean Piaget wrote: 'Play teaches children to master the world'.

If we reflect for a moment on the things children do when they are playing, it is easy to see why the activity is so important. It is also easy to see how it relates to design and technology capability. Let us take three very familiar types of play:

Role-playing Here the child pretends to be somebody else. It may be a familiar role, Mummy, for example, or it may be a more remote figure - a fireman or shopkeeper. This can be a solitary game or it can be played in a group. However it is played, it allows the children taking part to act out their knowledge of the adult world and to extend it by the use of their imaginations. The children have to work together to bring the situation alive and they have to use words and props in a way that will keep the game moving along. The play helps in the development of many of the qualities which psychologists believe to be essential for the growth of intelligence, language and what they call 'socialization', or more simply being able to enjoy getting along with other people. But crucially it explores the purposeful relationship between people and the places and things they make and use: in other words, design.

Building things During their play, children make an extraordinary variety of things. They are good at allowing one thing to represent another. A large cardboard box is a house one minute, a car the next. The things they make are a source of satisfaction in themselves but they are more important for the games they make possible. The car can be driven. It can become an ice-cream

van. It can then become a bus to be loaded up with Teddy Bears going to the seaside. This kind of play depends on the remarkable manual and imaginative skills which children have. Again, it encourages them to realise that people use all kinds of things - tools, vehicles, buildings - to help them do the things that need to be done.

Hide and seek We may guess that this is a very old game indeed. The pleasures of hiding and finding go very deep. As a form of play, it helps children to work together and to understand the purpose or rules but it also makes them aware of the surroundings in which the game is being played. It brings a heightened awareness of spaces, enclosures, perspectives and vistas.

In fact, psychologists have categorized the functions of play in a number of different ways. I particularly like the approach of the Australian educationalist, John Gabriel, [2] who sees play as encouraging children to continue to practise the skills that good parents quite naturally and un-selfconsciously helps their baby to practise as he or she grows up. These include:

Sensory skills
Exploratory skills
Manipulative skills
Emotional skills
Identification skills
Social skills

Of course, children do not separate these things out. They experience play as a whole. But it is useful to look at them separately when trying to understand what play is about and how it relates to design.

Sensory skills Much play in the first two years is about the acquisition of sensory experience. Looking, hearing, feeling, tasting and moving are important features of infant activity. Babies delight in looking at brightly coloured and moving things: the bath sponge or a plastic rattle are objects to be held and so enjoyed through the sense of touch. Everything gets put into baby's mouth. A one-year old will feel and stroke an unfamiliar thing even if it is a person!

Toddlers love the experience of running and rolling. They are gradually learning how to understand space and to experience the pleasure and excitement of moving. Riding a swing or the more organised exertion of dancing or Ring-a-roses are tremendously satisfying experiences for this age group. Moving about in the world, reveals its physical and aesthetic characteristics.

Exploratory skills Touching, tasting and the other elements in sensory experience are exploratory but the desire to explore becomes more deliberate and organised as babies develop. A toddler will want to search out unfamiliar objects - especially those that are forbidden or said to be dangerous. Their sense of danger is much less acute than their curiosity!

A two-year old is fascinated by all the things that are in the world and wants to try them all out - but just a little of each. Watch children of this age in the garden. They wander around, looking into everything. 'Let me do it', they say and grab the trowel for a moment before going on to try out the spade and tip up the wheelbarrow.

The activities sometimes seem pointless to adults because they are disjointed and don't seem to accomplish anything. However, what they really represent is a long-drawn out exploration of the physical world.

Manipulative skills Exploration grows into more organised and controlled attempts to work with tools and equipment. Before they are two, children join in housework



and want to operate the controls of the TV or video player. But it takes a while before skills in building, balancing and construction fully emerge.

When a variety of manipulative skills are used together, children have the experience of 'mastering' an aspect of the world. Riding a tricycle provides a good example. At two it is hard work even to push a tricycle and grown-ups will be needed to provide the motive power. At three, riding round the garden is easy. At four, it is possible to ride along the pavement and control speed so as to keep pace with someone else's rate of progress.

As they grow up, children attain mastery of a remarkably varied range of tools and equipment. They learn to paint and draw, cut-out and construct, build sandcastles, eat with grown-up cutlery and use swings and see-saws.

It is clear not only that children take great pleasure in mastering these skills, but that using the skills opens up new worlds of play and activity including those fundamental to designing and making.

Emotional skills Play engages the emotions. It is exciting, funny, exhilarating. Sometimes it involves pain and disappointment. Role play enables emotions to be experienced in a way which can make them less threatening.

Even so, there is sometimes an element in play that is frightening in a rather special way. Chasing games and games where a parent pretends to be a 'scary' lion are examples of play where an element of fear is actually enjoyable.

Children can be aggressive to their toys, punishing them for bad behaviour. Psychologists have coined the term 'displacement behaviour' for the situation where an expression of strong feeling is diverted from one person to another who, as it were, acts as a stand-in. Children can make good use of toys in this way, making a doll or teddy stand-in for their own feelings of 'badness' or inadequacy, getting rid of fear, anger and frustration in the process. This is a part of developing an understanding of the symbolic significance of places and objects, where emotion and meaning can play an equal part with function.

Identification skills Skills in handling emotions can be extended into identifying with or relating to the situations and experiences of other people. A four-year old watching a cartoon film will suddenly say: 'I'm the black puppy and you're the brown puppy'. Children want to model themselves on people they admire or like (real or fictional) and will often mimic them very effectively.

In early years it can be very simple acting out. Telephoning, powdering the face, carrying Daddy's huge umbrella or wearing Mummy's shoes. By four, there is much more elaboration and new interest in the roles of people outside the family. Dressing-up and playing a part become very important as children become more aware of the world's variety and want to find out what it might be like to be an adult. Once again, the interaction between people, places and things is an essential element in the game of acting out.

Social skills The focus now shifts to the experience that children gain from playing together. To begin with, babies play with a range of toys or objects in activities initiated by their grown-ups. Later, toddlers are very self-absorbed and possessive but they soon enjoy playing alongside other children. They also get pleasure from simply watching older children play. It is only gradually that real cooperative play develops, however - generally after the age of four.

It is easy to see that this long build-up towards playing with other children must be related to the gradual widening of the child's horizons, socially and environmentally. It is also easy to

appreciate the vital importance of the process for the child's future happiness. The ability to relate to other people, to respect their ideas and to be able to compromise with them are vital social skills that emerge through play and through the example set by grown-ups. Clearly they are also intellectual skills central to the conception, resolution and realisation of proposals in the design field.

In talking about play in the pre-school years, it is interesting to notice that girls and boys show very little sex difference in their choice of games. By four boys certainly show a tendency towards replicas of technological things while girls lean towards domestic objects but they are not embarrassed to exchange these roles. Girls can enjoy locomotives and boys can work happily at arranging furniture in a dolls house.

What is significant is that, in all these areas of play, objects are important in supporting play by making it realistic and giving it a focus. Toys and play go together even if the toy is only an old lolly stick or a cardboard box. Evidently children have a very imaginative relationship with objects. Play needs play things to support it. It is not at all that education needs to introduce children to the idea that there is a creative relationship between people and the material world: quite the opposite because this is already an ever present reality in children's imaginative life.



2 IDENTIFYING NEEDS AND OPPORTUNITIES

All design and technology is an attempt to serve human needs, wants, and aspirations, however imperfectly. This is a hard thing to do because people differ from each other even in the way they see their most fundamental requirements. Every human society meets the basic needs of the people that make it up: should it fail to do so it ceases to exist. But human groups differ from each other in their values and attitudes almost as much as human individuals.

The great American anthropologist, Ruth Benedict, wrote about this extraordinary variety [3]. She showed that in one culture possessions might be valued as a symbol of status and power while in another they might be seen as trivial and unimportant. In one community competitiveness was encouraged, in another it was looked on with horror. Inter-personal attitudes to gender, family life and children varied from tenderness to extraordinary harshness. In an important book about why houses are the way they are, Amos Rapoport [4] points out that social customs and beliefs have as much influence on the form of our homes as the climate or building methods. What people believe as well as practicality shapes the buildings, tools, clothes, food and images that they produce.

In a striking paragraph, Rapoport puts the situation very clearly: '...the form the house takes depends on how "shelter", "dwelling", and "need" are defined by the group. This definition will be reflected in the different interpretations given to such concepts as "home", privacy and territoriality ... one could speak of [basic needs] in terms of the need to breathe, eat, drink, sleep, sit and love, but this tells us very little; what is important with regard to built form is the culturally defined way in which these needs are handled'.

It is this that helps to explain the 'diversity within unity' that marks the results of design and technological activity. For example, the vast majority of human groups make shelters and clothes but these shelters and clothes come in an extraordinary variety of shapes, sizes, colours and materials.

In the past, these differences existed between different cultures. Usually different cultures were geographically separate and within each culture there was a shared agreement about what clothes to wear, how to make tools and utensils, even about the way a house should be built. Today we live in a new situation: a society which can accurately be described as multi-cultural. This is not simply a matter of ethnic differences but also of class, education and social background. In any major town in Britain, we can see evidence of a variety of answers to the question: 'How do you want to live?'. And television brings into our homes images of other people's lives from all over the world. It will be important to develop a better understanding of the way these new perspectives influence the ideas and attitudes of young children.

For small children, it is their immediate world of family, relatives and friends that shapes their understanding of what people need. For them, an abstraction like 'the elderly' is seen through their own Granny and Grandpa or the lonely widower who lives in the scary old house at the corner of the street.

A concept such as 'Food' is not even what people in general have for tea (assuming a culture in which people in fact take a meal called tea) but 'what we have for tea' whether it is baked beans on toast or curried vegetables and nan bread.

So far I have emphasised the influence of values on people's understanding of their own and other people's needs. But of course function and practicality are also important. The things we use must satisfy us aesthetically and give us the sense that they 'belong' in our lives. However,

they must also do the job they are designed to do. Here it is useful to introduce the idea of 'criticality'. In any design activity, it is useful to ask what is the critical element? How far does the practical function of a thing determine its form? We can see at once that there is a continuum. In the case of a ship the practical function is very critical: in order to design a boat effectively it is necessary to understand something about why it floats and how it will move efficiently through the water. The practical function is the critical one: it determines the form of what is made and the technology used to make it work.

If, on the other hand, we take a piece of jewellery, then the symbolic or aesthetic function becomes critical. What the ring is supposed to say to us, what it means to us, determines the form of what is made.

These issues, which are of overwhelming importance in design, can be brought alive for young children through the careful use of questions:

'What does that person need to make their life more comfortable?'

'What does that person need to make their life more exciting?'

'What do you think this is really for?'

'How should this look?'

'What should this do?'

'Who do you think will use it or own it?'

'Will they like it?'

'Do we need to know more about the person who will use this?'

Exploring and Investigating

This last question brings into focus the Active, exploratory side of Identifying Needs and Opportunities. How do we find out what people need? Exploring and Investigating is common to many activities in the Primary classroom, so how do we recognise the kind of investigation that is appropriate to design?

To begin with, there are many common areas between Science, Number and Design and Technology. For example, what might be called 'The Basic Human Machine' needs to be well understood because all designs have to satisfy the physical requirements of people. The human machine can be directly studied by children either by observing and measuring themselves or - perhaps more fun - teacher, the caretaker, Mum and Dad. This kind of activity lays the basis of an area of work that will continue throughout education. Studying what people can do, how they use their capacities at work and in interacting with machines and environments, is the beginning of what designers and technologists call 'Human Factors' or 'Ergonomics': areas which have now become human sciences in their own right.

It is easy for six year olds to understand that the human machine needs:

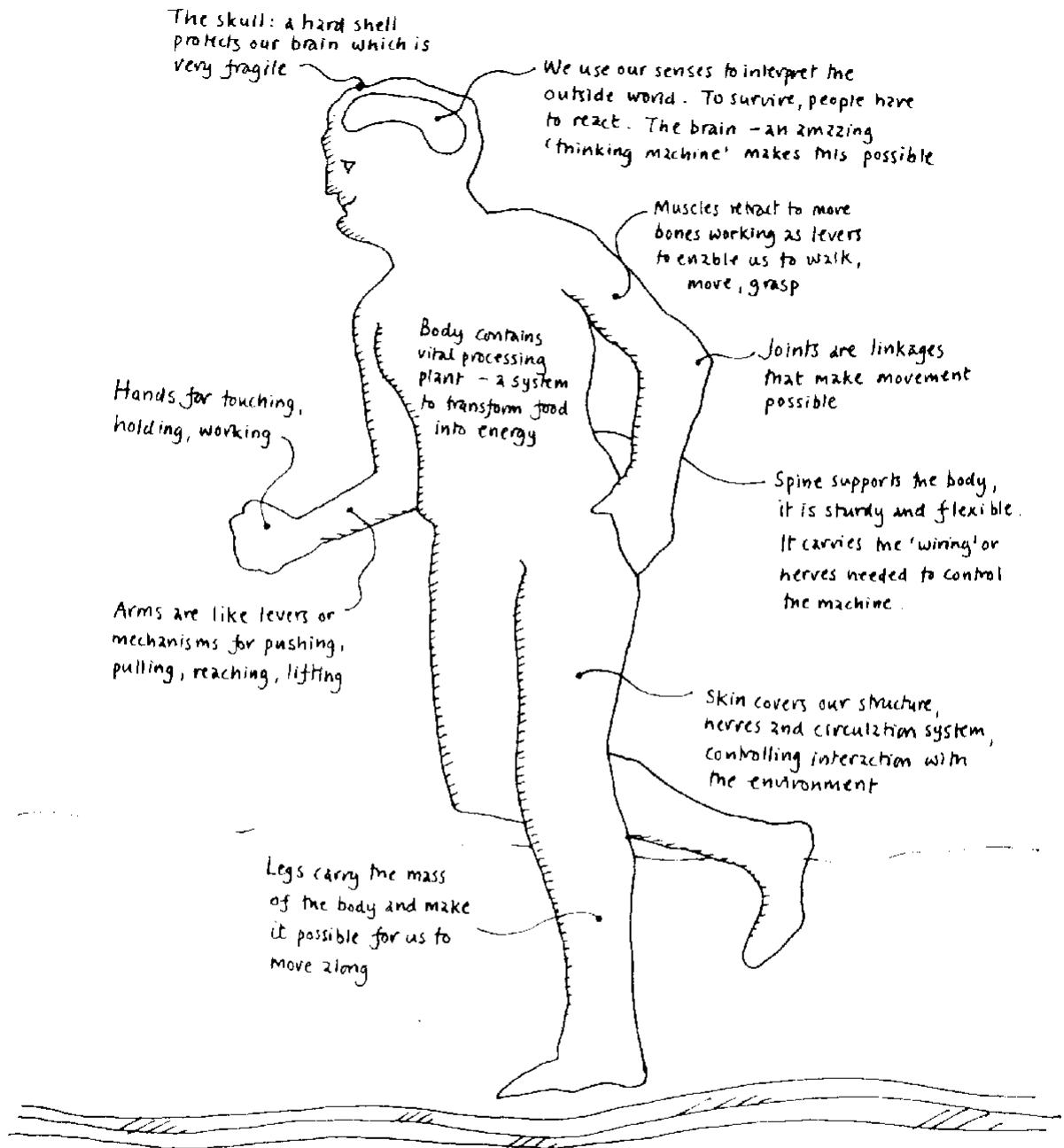
- fuel if it is to act and survive - food and water are essential to life and health
- temperature control - people can only stand a rather narrow range of climatic conditions. Excessive cold causes hypothermia, excessive heat causes hyperthermia. In extreme cases, either can be fatal.

By using its computer - the brain - the human machine can employ creativity to extend and multiply its own rather limited powers:

- tools, machines and vehicles can extend the limited power of human muscles
- books, words, music, computer programs, pictures and symbols can extend the limited power of the human mind.

These are exciting ideas for young children to explore through their own direct experience of growing up. Focusing them, making them a subject for discussion and activity, sums up the teacher's role at an early stage of development.

THE HUMAN MACHINE



DESIGN AND TECHNOLOGY HELP TO MEET THE PHYSICAL NEEDS OF 'THE HUMAN MACHINE'

- Fuel - food and water are needed
- Temperature controls - houses, clothes are needed
- More power - tools, vehicles, machines extend our power
- More thought - books, words, pictures, symbols extend thought

Exploring and Investigating: The Developmental Aspect

The ability to explore and investigate grows from the innate curiosity of human beings. Babies are not passive receivers, they reach out to discover the nature of the world into which they have been born.

Jean Piaget's great contribution to Science education has been to show that children gather, interpret and analyse information differently as they grow up. It is a journey from the concrete to the abstract, from total immersion in experience to the production of hypotheses to explain that experience in more fundamental ways. It is a journey from a world of haphazard events to a world organised through natural forces that operate in predictable ways. Away from subjective and towards objective modes of thought.

Design and Technology education needs to be alert to this form of progression in Science and to make use of it but also to recognise that designing also calls for a kind of investigation that is not simply scientific. For Design and Technology, the following points seem important:

- 1 The investigation and analysis of what people need and an understanding of likes and dislikes and cultural and social preferences. This is an area where qualitative and quantitative data interact and where moral and political issues come alive. (See Chart One) Five year olds are often well equipped in this respect, happily identifying with the Postman or Granny or even faraway people in the Amazon Rain Forest, while a sixteen year old may be hampered by cynicism and adult preferences and attitudes. In either case, the journey to be made is away from unexamined assumption towards the interpretation and sometimes the creation of evidence through enquiry and research (See Chart Two, page 23).
- 2 The investigation and analysis of what people have already created. A huge amount of knowledge about Design and Technology is latent in the every-day world of existing artefacts, systems and environments. There will be knowledge to be discovered in the form of things and the way they were made and about the values and ideas of the people who made them. From the developmental point of view, this is a storehouse of ideas that can steadily expand in size but children will need to learn the way to 'read' the made world in which they live. This kind of basic 'design awareness' is fundamental both to enjoying the results of design activity and to designing.
- 3 The investigation of the economic and industrial background to Design and Technology. Infants are quite capable of playing shops and so entering into the idea that goods and services exist in a world of markets and added value. Ten year olds can be self-conscious entrepreneurs. Sixteen year olds can have a good grasp of the role of manufacturing industry in wealth creation and of the fundamental financial constraints and opportunities that govern any business.

The main difference between exploring and investigating in Science and Design and Technology is that Science is generally pursuing knowledge for its own sake while Design and Technology has to use knowledge in order to take action.

From the developmental point of view, there are two aspects that require careful attention from the teacher if progression is to take place. These are:

- 1 Young children can find it difficult to wait to investigate and analyse before taking action.

Chart One

Some relationships between qualitative and quantitative data

Qualitative	Quantitative
<ul style="list-style-type: none">○ Granny says she is cross because she cannot reach the top shelf in the larder.	<ul style="list-style-type: none">○ Granny can reach this high.○ How many things does Granny keep on the top shelf?○ How often does Granny use the things she keeps on the top shelf?
<ul style="list-style-type: none">○ We need a mass of flowers because they make a great splash of colour in the middle of the school garden. It will look nice.	<ul style="list-style-type: none">○ We need x number of plants per square metre if the bed is going to look full.○ These plants bloom most of the Summer - these do not.
<ul style="list-style-type: none">○ I find that I'm uncomfortable sitting on this seat because it's too small for me.	<ul style="list-style-type: none">○ A bar chart showing how tall the children in the class are.○ How high off the ground are the seats in this class?
<ul style="list-style-type: none">○ People say that this bus shelter is good because it keeps all of us dry. But sometimes it seems awfully crowded and full up.	<ul style="list-style-type: none">○ Which direction does the wind come from on the greatest number of school days?○ What is the average number of people who wait for the bus on a school day?

- 2 It is difficult to maintain a balance between qualitative and quantitative information. As children move to the secondary stage and the first hints of specialisation emerge, it is appropriate for them to discover a preference for one or the other, but at earlier stages children need to appreciate the value and importance of both.

Infant teachers will want to make sure that they do not crush the excitement of making by too long drawn out a period of analysis. Often it will be better for analysis to follow on from the excitement of taking action. Equally, it will be important to recognise the importance of affective values in the motivation of small children. What they can feel for and respond to emotionally may be more significant than what they can measure.

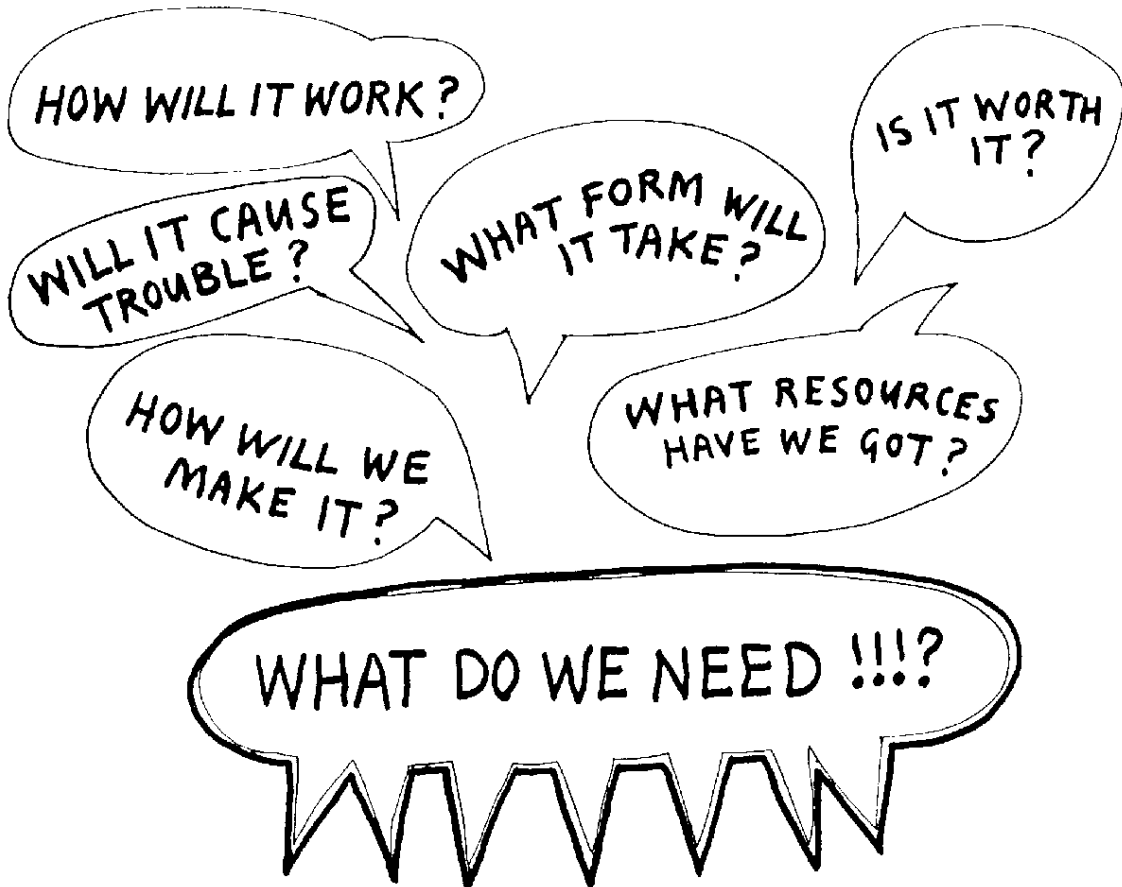
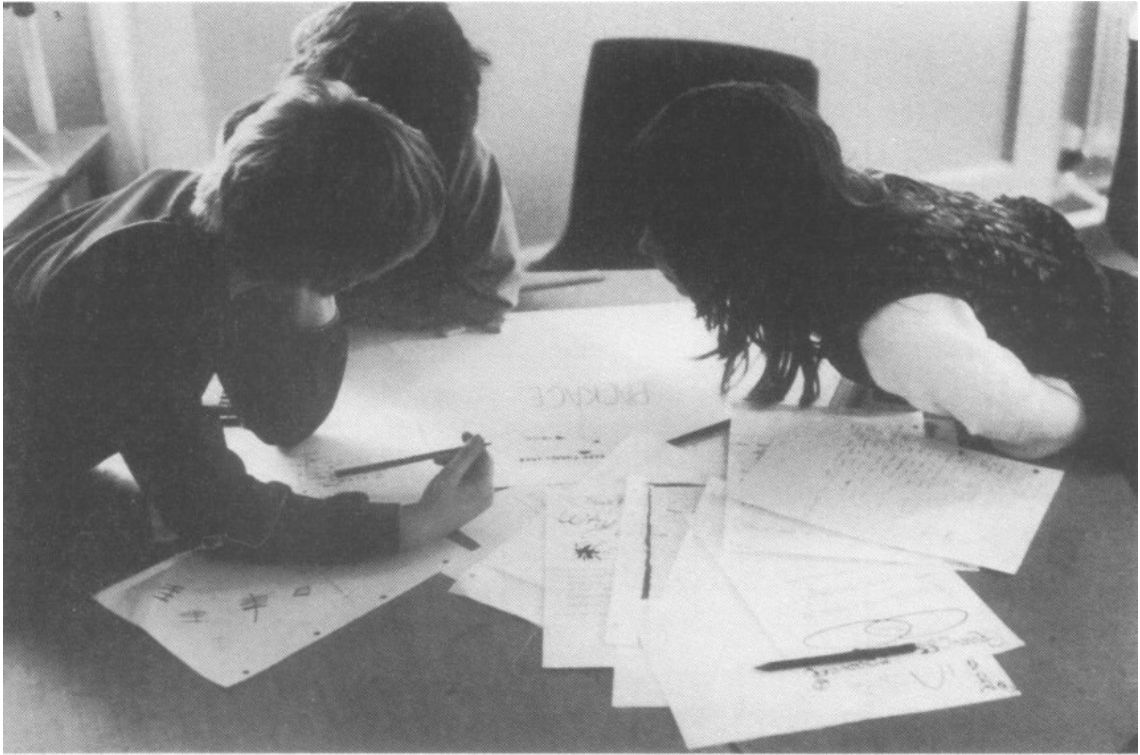


Chart Two

How can Primary age children find out what people need or identify opportunities for design activity?

- | | |
|---|---|
| ○ By asking them | ○ Simply asking people and remembering what is said can be extended by making very simple notes and even constructing a simple questionnaire with the help of the teacher. |
| | ○ Many Infant children are quite capable of making a tape recording in order to preserve and recall people's answers. |
| ○ By watching them | ○ Observing what people do and noting the difficulties they have in doing it. |
| | ○ The results of these observations can be talked about or simple drawings can be made to highlight the problem. Alternatively the difficulties can be 'made visible' by role play. |
| ○ By pretending to be them | ○ Children are better than adults at imagining they are in somebody else's situation. This can be extended into acting out a story which will bring alive the problems that these particular people face. |
| | ○ The effect of the proposed solutions can be acted out as well. |
| ○ By reflecting on what they need themselves | ○ We all use our own experience as the prime source of knowledge. Reflecting on what we need will help us to realise that other people have similar - but not identical - needs. |
| | ○ The teacher can encourage introspection by asking questions - 'Do you really like that colour?' 'Would that coat be too hot in winter?' 'What is a table really for?' |
| ○ By seeing what people need now and needed in the past | ○ People's needs are expressed clearly in the things they make to serve those needs. Looking at these things can help children to broaden their understanding of basic human needs and the extraordinary variety of ways different groups have provided for them. |
-



3 GENERATING A DESIGN

Design and Technology looks towards the future. Its job is to envisage what should be made. It attempts the difficult task of trying to 'see', and then to bring into existence, places, buildings, products and images that society believes it needs.

Design and Technology therefore depends for its existence on the extraordinary imaginative capacity of the human mind. Albert Einstein once said 'imagination is more important than knowledge' and for designers and technologists this is certainly true. Knowledge is of course important to underpin design activity, giving substance and realism to what is imagined, but without an imaginative spark Design and Technology is reduced to copying what has been made already.

Although we depend on the expertise of specialists to create and sustain the complex modern environment it would be a mistake to think they have a monopoly of imaginative skill. We all act as designers and technologists in our personal lives. The ability to design and to use technical knowledge is a universal attribute of people everywhere, as characteristic of human society as the use of language. The analogy with language is a good one. Just as we all use language but recognise that writers specialise in its use, so too with Design and Technology. It just happens that professional designers have developed their capacity to a particularly high level. (See Chart 3, overleaf)

When dealing with any aspect of human intelligence it is useful for teachers to be able to distinguish between the inevitable development of an ability and what can be done by educationalists to aid its growth. The analogy between language and Design and Technology is useful once again. Any baby growing up in a world where people are talking will learn the use of language. As the distinguished linguist, Noam Chomsky, puts it: humans have a 'language acquisition device'. Language is 'wired in' to the human mind. People are predisposed to learn to speak. However, recent work on perception and child behaviour shows that babies also learn to react intelligently to the world of objects and space and that they do this even before they can speak. What is more, they very soon take pleasure in making the environment conform to their wishes. They do this not only for survival but also in a spirit of playfulness. Humans have a 'wired-in' predisposition not only to speak but also to explore and change their environment.

At the centre of changing the environment is a specific mental power: the ability to 'image', or 'see in the mind's eye'. Recent psychological research suggests that it depends on the ability to form in the mind a realistic model of external reality. This model is not linguistic: it isn't in words, and it is much more than just a label for a concept. It can model all the properties of the physical world and relates directly to all our senses: sight, hearing, scent, touch and taste.

Human beings can share their imaginings with each other. They have created external equivalents for these internal models. Again, these are familiar things: drawings, plans, mathematical symbols, books, prototypes, computer programs. It is these models that make it possible to organise the social effort necessary to build or make something because they show us the character of what is proposed. Without them, the mental images would remain the private property of those that imagine them, socially ineffective and unable to inspire the collective effort necessary to bring them into real existence.

These externalised models also play a direct role in creative thinking. It is clear from recent work with architects, that all designers and technologists develop their design proposals in a dialogue between the internal images and the external models. Design activity consists of

Chart Three

Imagining the Future - Professionals, 'Everyday' Designers and Children

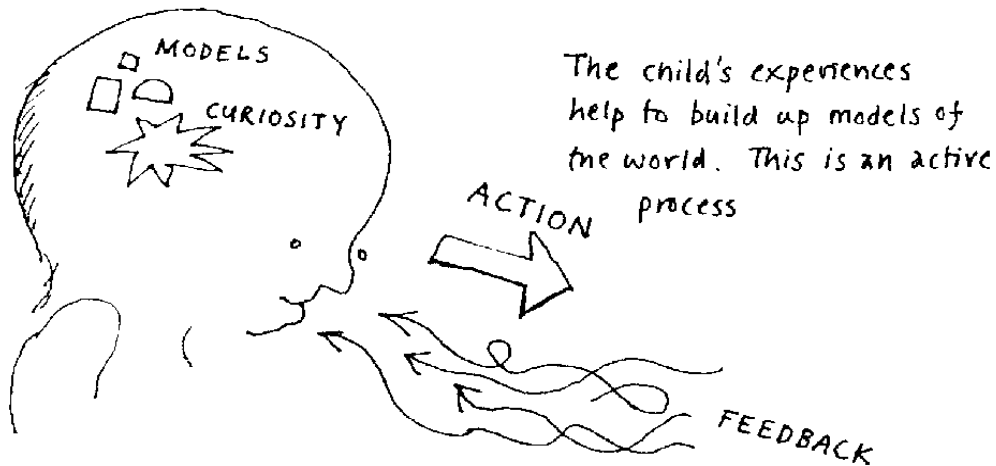
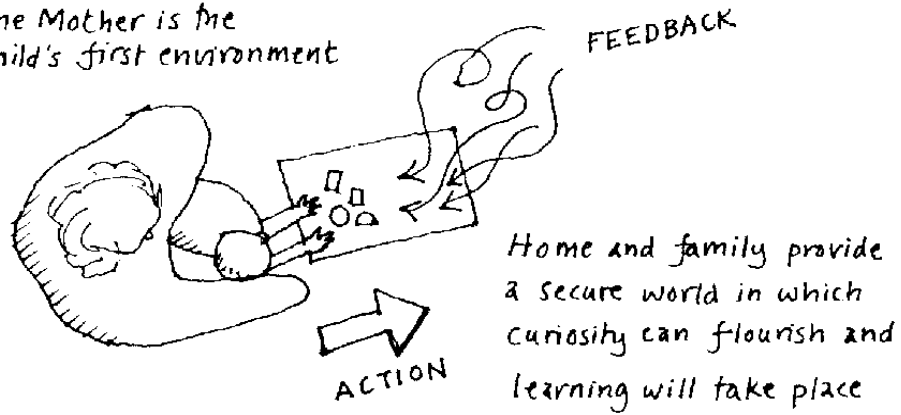
Typical Design and Technology Activity			
	By Professional Designers and Technologists	By Everyday Designers and Technologists	By Young Designers and Technologists
Working on interiors	Interior designers working for Marks & Spencer imagining the interior of a new store in Oxford St.	Local greengrocer imagining new ways of arranging his fruit display	Children imagining how to arrange the display of goods in the classroom shop
Working on machines	Locomotive engineers working as a group to improve the drive of a new electric engine by imagining different ways of organising the gears	A gardener imagining the relative merits of electric or petrol driven lawn mower when applied to the size, shape, and type of grass in the garden	Children imagining improvements to a LEGO vehicle to make it travel faster down a slope
Working on clothes	A fashion designer working on a new mass produced range of separates for the mid-30's market – imagining how designs will be liked or disliked	Adapting a dress or knitting pattern in the light of personal taste – imagining how the result will look at a Christmas party	Children imagining and making felt clothes for their Teddy – imagining how Teddy will like or dislike it. Telling a story about Teddy's reaction

proposing imagined solution after imagined solution. These are put to the test, refined and analysed through the medium of externalised model after externalised model. It is a repeating spiral process of thought made possible by the interaction between imaging and modelling.

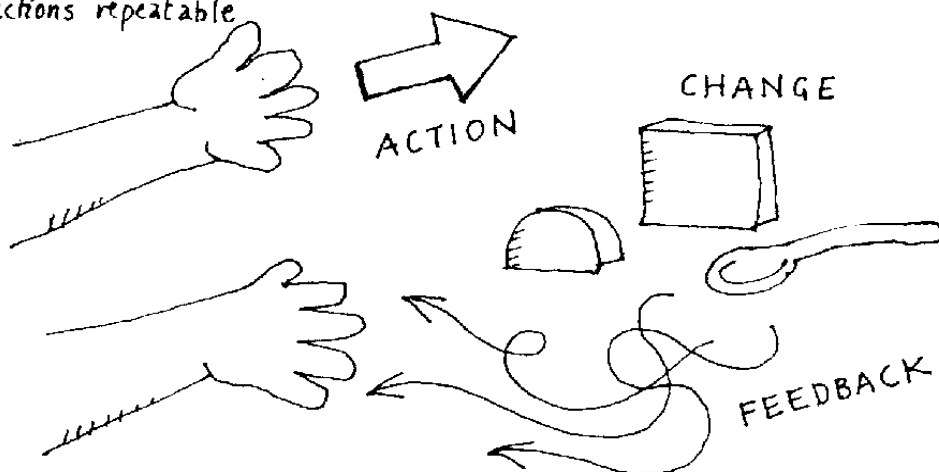
It may be felt that these are essentially adult ways of working and thinking but the idea of modelling is familiar to children and their mental development is closely bound up with the skilful use of models in play. In some ways, children are more adept at using models than adults. For infants, the division between model and reality is blurred and all children up to the age of thirteen can get thoroughly 'lost' in the world of the imagination represented by role-play, fantasy, toys, drawings and models. Many adult designers would give a lot to be able to enter the imagined future in such a wholehearted way!

THE CHILD'S IMMEDIATE 'WORLD OF LEARNING'

The Mother is the
child's first environment



Memory helps to make
actions repeatable



The child uses all senses to
engage with the environment
so as to control and change it.

Developmental Aspects

Imaging

The ability to image, to see 'in the mind's eye', is innate in human beings. These internal 'models' of external reality are the fundamental building blocks of thought. In young children, the ability to image is in place before school. 'Visual thinking' is not a problem for five year olds. Neither is imaging. The characteristic of this early stage is the intermixing of the fantastic with the familiar and the everyday. One aspect of growing up is to be able more and more to distinguish between what might actually be organised, built or made and what can be imagined but not made. The subtle thing is that this development towards 'realism' has to be achieved while also keeping the imagination alive. In Design and Technology, speculation is the controlled and deliberate use of imagination and this is something that can be developed through practice, learning and experience.

Children appear to pass through a number of reasonably well defined stages in this dialogue between imagination and reality. Up to the age of seven it is hardly useful to keep fantasy and reality apart. Familiar reality, the home and school, co-exist happily with a cast of story book characters. Between five and seven, children can wonder effectively both about reorganising the classroom and about how to stop Humpty Dumpty falling off his wall. The one would hardly seem ore 'real' than the other. A fifteen year old might still be willing to do both but would now see the Humpty Dumpty project as an entertaining way of introducing work that was 'really' about a tricky engineering problem.

In relation to imaging the developmental aims for Design and Technology would seem to be:

- 1 Gradually to differentiate between fantasy and an idea that might be realised in the real physical world
- 2 To keep the ability to speculate alive while providing it with a useful framework of knowledge and an awareness of constraints and limitations
- 3 To encourage the deliberate use and development of the ability to image and to create the motivation to use it to speculate about future environments, artefacts, systems and images
- 4 To encourage a deliberate interaction between internal imaging and external modelling.

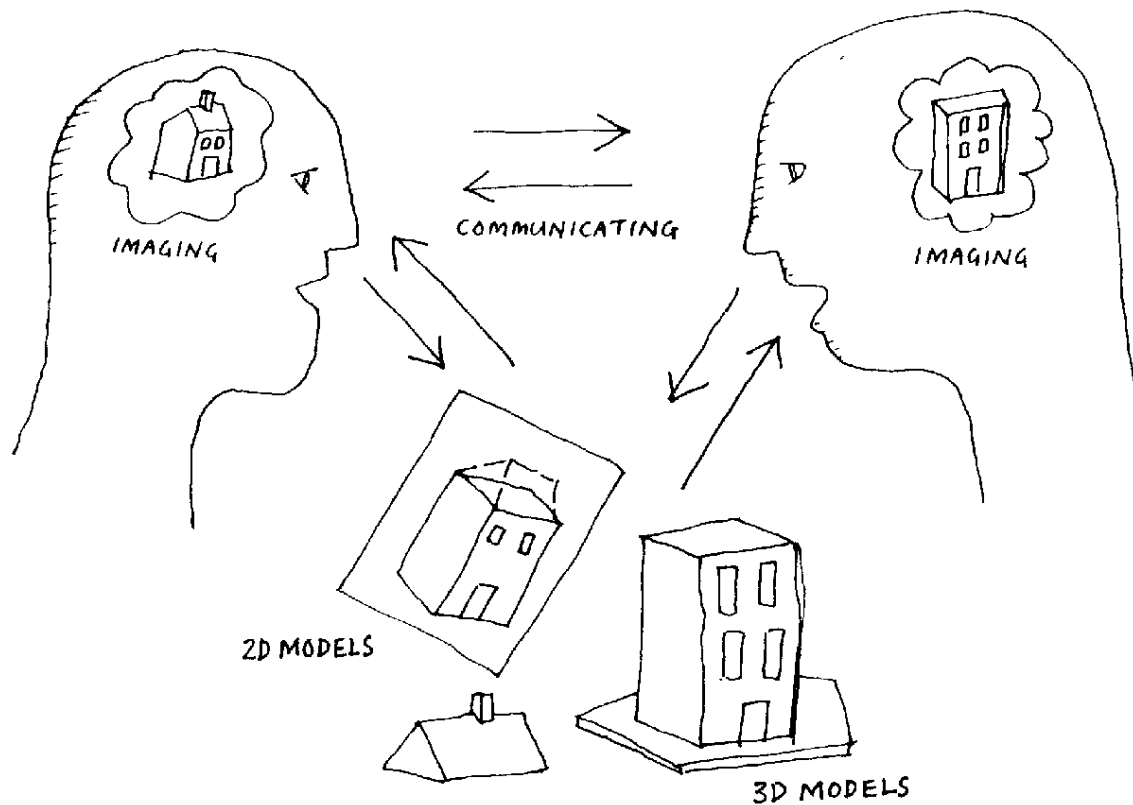
Modelling and Communicating

Small children have what appears to be limited abilities in communication. It takes time before they can speak; drawing and model-making develop gradually. But children can communicate effectively before they can speak and some of these communications express their pleasure and understanding of the physical world. They are also capable of demanding - and getting - changes in their surroundings. They can communicate well enough to express preferences about colours, clothes, food and toys.

Early children's 'models' representing the made world tend to be symbolic in character. Drawings and models work with a very narrow code: one model may have different meanings at different times and even all at the same time.

Five year olds take great pleasure in externalising their ideas but, in their Design and Technology work, modelling, communication and outcome tend to be one and the same thing. Their designs operate on different levels at the same time and the difference between a 'model'

IMAGING, MODELLING & COMMUNICATING



People use imaging to visualise or 'see in the mind's eye'. They communicate about the things they have visualised by means of models – drawings, plans, prototypes, roughs.

Designers use 'models' not only to communicate with other people but also to show their ideas to themselves. This is fundamental to the process of developing ideas.

standing for an idea and the idea itself is essentially blurred. Proposing and making are locked together.

The long-term developmental aim in Design and Technology education must be to pull these ideas apart. But it is a long journey. By the time they are twelve, we could expect children to be capable of at least the following:

- 1 Represent their initial ideas in an appropriate form of model so as to show it to themselves and to share it with others
- 2 Develop the initial idea by using appropriate forms of modelling
- 3 Realise that communication with other people is difficult and be able to choose the best medium for a particular purpose. 'What have I got to say and how am I going to say it?' should become a question that the child asks - an answers - without prompting
- 4 Know of the existence of different kinds of models - for example, models that look like the thing they stand for and models that perform like the thing they stand for - and have some experience in using them
- 5 Know of the existence of different media and technologies for communication - print, audio-visual, electronic, multi-media (eg exhibitions) and have some experience in using them.

Developing Ideas

In developing ideas the five year old will leap quickly through to synthesis while the twelve year old can be expected to engage in a relatively extended activity, the pattern of which can be seen to have influenced the outcome.

The act of generating a design is perhaps the least well understood of the mental processes involved in Design and Technology. It is frequently glossed over. 'Put forward three ideas'. 'Choose an idea for development'. These are typical of the phraseology used to hide this highly creative phase of designing. It is true that the mechanism by which people have ideas, how a design resolution comes into the mind through imaging or modelling, remains somewhat mysterious. However, we do now know quite a lot about the sort of thing that designers and technologists are looking for. They will range from the one extreme of a resolution that depends on a change in human behaviour to the other where it is an artefact or environment that completely solves the problem. Most designs will require a combination of both of these. This interaction between changing things and changing what people do is something that even very young children are quite able to understand.

An ability that adult designers have is to focus on one part of a proposal whilst also being aware of its influence on the whole. They are able to live with parts of a proposal being unresolved while they work on it. They have confidence that their management of the project will enable them to eventually reach a fully detailed proposal. This is a sophisticated way of working and full confidence can only come through practice. Nonetheless, nine and ten year olds are capable of planning a programme of development work for themselves and their projects can approach a surprisingly high level of management. Even infants can be encouraged to discuss the best way of thinking about the work they are doing.

Outside school, nearly all design and technology development means working with other people. It is useful to reproduce this in schools but there are limitations to genuine teamwork amongst five year olds. They work alongside one another rather than together. Eleven and

twelve year olds, on the other hand, are excellent team members, highly competitive and also critical of the scope and value of each other's contribution to the whole.

Developing an idea effectively will often depend on skill in using the appropriate form of modelling. Children may be held back because they are not familiar with the form of model that is right for the idea they want to represent. However, they will need to be introduced to a form of the technique that matches their developing knowledge and skill. A technical drawing by a seven year old will not obey the rules of the British Standard but it will be, nonetheless, a technical drawing and have a close relationship with the underlying principles of technical drawing.



4 PLANNING AND MAKING

It is through the use of tools and materials that people are able to realise their design ideas. But this is not simply a matter of making exactly what has been imagined. The work of making can be a formative part of Design and Technology activity. This is because the ability to imagine something is not the same as the ability to make something although, of course, the two things are intimately connected. Making not only gives reality to imagination, it stimulates it. In making a thing, we find out more about what we imagined and, as a result, develop and refine it.

This process of development and refinement seems to be a fundamental necessity. It applies as much to organisations as to individuals. Large manufacturing companies make prototypes of their products before they begin mass production so that final modifications can be made as a result of this practical experience.

In the same way, a craftsperson will embark on a sequence of making having a general direction in mind. He or she will then be guided partly by the logic of tools and materials: the next piece grows directly out of the experience of planning and making the one before.

In the adult world, making is planned in an extraordinary variety of ways. In architecture for example, drawings and specifications are used to coordinate the work of many different specialists. In a large building scheme, the scheduling of these trades in an efficient way is a management task in itself. Making a building requires day-to-day organisation and trouble-shooting on the actual site. Building work is notorious for over-running schedules and budgets. The sheer scale of the resulting product, the tons of materials used and the small army of people and equipment needed to do the job, make it very hard indeed to predict exactly what will happen.

At the other end of the scale, an individual furniture maker may be in sole charge of designing and planning the making of a specially commissioned dining table and chairs. In a case like this, the relationship between imaging, modelling, planning and making is an intimate one. Drawings may be sketchy. Instead the designer will go straight from seeing 'in the mind's eye' to trying out ideas in the actual materials. Here, the intention will be to focus on the trickiest parts of the proposal. Exactly what joint will give stability and elegance? How can the figuring of the timber best be emphasised? It is typical of planning and making at this level that prototypes of parts or joints will be made before work begins on the finished products.

There is much in common between these adult processes and the experience of Planning and Making in schools. But there is one essential difference and it is an important one. Outside school, making is carried out by specialists. In our industrialised world, the division of labour has maximised skill and efficiency by encouraging people to become 'expert' in a narrow area. In traditional crafts, the same result was achieved by the fact that people would spend a lifetime in their particular trade. The skill of a master baker, for example, came from the repetitive work of twenty years experience.

For children, the situation is exactly the opposite. They are fascinated and excited by making things but their skill is rather strictly limited. There is on the one hand the straightforward question of manual dexterity, but on the other there is the demanding situation that throughout their school career they will be using new and unfamiliar tools, materials and processes.

Seen in this light, children's capacity to tackle new ways of making is quite extraordinary. In her book *Creative Play*, Dorothy Einon [5] discusses the importance of play with objects in developing the sophisticated coordination between hand and eye that we take so much for

granted. For small babies, learning to grasp is intellectually demanding but it is even more difficult to learn to let go. In the Pre-school years, it falls to parents to provide the raw materials with which children learn the basic dynamics of planning and making.

The Chart opposite shows how some of these games relate to later developments as children become more mature. It is based on material by John and Elizabeth Newson used in Dorothy Einon's book.

For Infant children these basic games of skill remain enjoyable and challenging. The educational way forward is to be found in channelling this delight in tools and materials so that it becomes more purposeful and more intentional.

Good work with Infants will look at tools and materials from a variety of points of view. The properties of materials, for example, strength or hardness, are dealt with both by Science and Design and Technology. By making deliberate use of these predictable properties children begin to be able to make things work. But the range of knowledge and experience about materials and making is not, and cannot be, completely covered by the idea of applying scientific principles. Practical, direct experience with tools and materials is one of the main sources of knowledge about how things can be made. Qualitative knowledge about materials comes from handling them and reflecting on their character and potential. Education needs to deal with the emotional and aesthetic significance of materials as well as their functional capability. Here Design and Technology links with Art.

Here are some of the questions that it may be useful to ask when children are considering their planning and making:

What is this material capable of doing?

What qualities does it have?

What tools or processes can be used to change it?

What materials can be combined to achieve the results we want?

How do we respond personally to this material?

How have people used this material in the past and how might they use it in the future?

How shall we use it in our own work and how can we learn more about it?

How can we use these tools and materials safely?

Planning and Making: The Developmental Aspect

Before they use their hands to make things, children employ them to explore the world through touch and to arrange it in ways that satisfy them. Much of this is a direct, concrete form of design and technological activity. Speculation and experience grow together from this manipulation of materials and artefacts. From the beginning, the direct use of the hand, and later of tools and materials, is more than a way of simply carrying ideas into production. It is also a way of having new ideas: it is part of the mental equipment that supports the imagination. It is important to maintain this imaginative, experimental element from 5 years old to sixteen whilst supplementing it with a growing resource of knowledge about specific methods, tools and techniques.

Chart Four

The value of early games related to making

Game	Value	Later Development
<p>first 6 months</p> <p>Musical mittens</p> <p>Playing with a mitten on one hand that has two tiny bells sewn to it</p>	<p>Promotes hand/eye coordination</p>	<p>Developing hand/eye coordination is basic to all making skills. It continues throughout Primary and Secondary school and is taken to a high level by craftspeople of all kinds</p>
<p>first 6 months</p> <p>Feelers</p> <p>Playing with a great variety of objects. Hard, soft, firm, squashy, silky, coarse, cold, warm, wet, dry, furry, smooth</p>	<p>Promotes awareness of objects and heightens awareness of the qualities of materials</p>	<p>An awareness of the qualities of objects and materials underpins all designing and making</p>
<p>first 6 months</p> <p>Strike</p> <p>Hitting things, for example plastic toy hammer on pots, pans and tins</p>	<p>More learning about cause and effect and controlling the tool</p>	<p>Even at the Infant stage, simple practice at hammering nails into wood helps children to improve control over 'adult size' tools and materials</p>
<p>1 year</p> <p>Sand games</p> <p>Sandpit with appropriate tools and equipment</p>	<p>Discovering the character and potential of a material. Hand/eye coordination. Basic technological experiences: pouring sand to move a 'sand wheel'</p>	<p>Each material has its own character and potential. Sand and water are both accessible and fun but widening our knowledge of materials can be a lifelong process.</p>
<p>18 months</p> <p>Wet paint</p> <p>Copying the process of decorating using a bucket of water and paintbrush</p>	<p>Learning by role play. Cause and effect. Hand/eye coordination. Control</p>	<p>Many making processes can only be effectively learnt by copying some- body who 'knows how to do it'. We can always add to our repertoire of skills in this way.</p>



Children's manual skill develops relatively slowly and then not at a consistent pace. At times it is clear that their ability to image will outrun their ability to model or make. However, children are able to value their own products even above those that have been manufactured in a fully adult way. By the age of fourteen, however, many children will be approaching quite sophisticated levels of manual skill in areas which particularly attract them and where they have had a sufficient amount of practice.

It is useful to realise that children of any age will seldom be involved in making a finished product in the industrial sense. What they are producing as the outcome of their work is more aptly to be called a prototype, a finished model, a sample piece, finished artwork or a developed proposal. In many cases, of course, these will involve achieving a very high quality of finish and the use of developed craft skill. They are not in any sense 'roughs'. In some contexts, it would actually be impossible to make the proposed outcomes with school resources.

This is not to say that there will never be a physical product, three dimensional and 'real'. Often a child's 'prototype' will be exactly that. Nor is it to say that children need not encounter and master the intractable problems of working in resistant materials and wrestling with making devices that work. These activities should grow in harmony with children's physical and mental development.

It is to say, however, that much making in Design and Technology will be speculative, attempting to solve problems or to extend aesthetic possibilities.

For Infants, it is vital that the direct, concrete experience of materials remains the foundation of their work in Design and Technology and, indeed, Art. At this stage, their engagement with the tactile qualities of clay, the vivid colours of paint or the excitement of cutting, shaping and glueing card are as important as anything they might actually design using these materials. The doing is all. In encouraging the doing, the Infant teacher is making a solid and indispensable investment in the future. Wide experience at this stage will bring immense rewards later on when children may begin to doubt their competence in making. By then tools and materials should have become old friends, familiar through much use, fun and success.

Making is likely to occur throughout a Design and Technology project. At the start, children will be using paper, card, wood, plasticine and similar materials to represent their first ideas. Even before that, they may need to use their model-making skills to explore the present situation. A project to re-design a part of the local High Street could well begin from the children making a model of how it actually is at the moment. Here evaluating and making would be welded together. In most extended projects, particularly with children aged 7 and over, there will be a logical progression in making from quick, sometimes rough, 'three dimensional sketches' towards more finished prototypes and products made from actual materials.

Energy, Systems and Mechanisms

Energy, systems and mechanisms deal with some of the most basic knowledge needed to make things work. What we can see of them in schools is only the tip of a vast iceberg of technological thinking that has made the modern world possible.

The dynamics of the industrial revolution grew out of the intellectual ferment of the three centuries before 1800. During this period science developed the beginnings of objective knowledge about the physical world. Early engineers used this knowledge to advance techniques for both the use of energy and the creation of new and useful materials. It was the discovery of how to harness heat energy by the use of steam power that broke the social and economic mould and helped people to realise that technological innovation had commercial and

social value. Sweeping changes began to shape the idea of 'progress' linking the concept of technological innovation with essentially European and north American ideas of individualism, democracy and self-determination.

Technology, Science and commerce were the motive power that pushed innovation forward during the Nineteenth Century. In the course of a hundred years designers and technologists invented the modern urban environment. By 1900, the basis had been laid for the civil engineering technologies that still support the infrastructure of all great cities. Chemical and electrical engineering were emerging as the main growth points for the future. In the Twentieth Century, the search for sources of energy has culminated in atomic power but, balancing this, our concern for the environment is encouraging us to look again at the renewable resources of wind, sunlight and tides.

The second half of the Twentieth Century has seen the beginnings of a second industrial revolution. Scientists and technologists realised that what created the first was not only mechanisation but also the human imagination that lay behind mechanisation. They began to look for ways of mechanising the handling of information so as to extend the power of the human brain in the same way that hand tools and steam power extended the power of human muscles. The result is computer technology and it has proved a very powerful tool. Its facility in calculation means that it has invaded and strengthened existing technological processes in fields as different as shipbuilding, printing, knitting, banking and chemical engineering and has begun to take over the control of many production processes that were previously performed by people.

Information technology has even extended the possibilities for the imagination by incredibly increasing the mathematical power at the disposal of the human mind. Today it seems to be biotechnology that is moving to the centre of the stage as the possibility emerges of understanding and therefore using and controlling fundamental biological processes. It is certain that information technology and biotechnology will have a powerful influence on the way we live our lives in the Twenty-first century.

Now we are faced with a growing catalogue of unwanted and unforeseen side effects stemming from the link between unrestricted technological development and commercial pressure. Problems of pollution, the destruction of natural resources and the greenhouse effect can all be traced back to specific applications of new technologies. The need for a wide general understanding of technology and its potential has never been so urgent.

Environmental problems on a global scale are, of course, a long way from the experiential roots of children's work in Technology. Here it is the real delight that children take in making things work that is most striking. It is in actually handling machines and systems that technology comes alive for five year olds. It may well be asked if there is any sensible connection to be made between these large but often remote social issues and the direct experience of making a LEGO brick robot controlled by the program of the school's computer. In fact, there probably is. These early direct technological experiences in which children make technology their own are a powerful way to demystify technology. One of the weaknesses that has characterised much technology teaching in the past, has been its divorce from any consideration of human needs. Seen out of context, making things work can be fun but it does not contribute much to a broad understanding of the social significance of technology. Placing the learning of technological ideas in the framework of a series of design projects makes sure that these social and environmental links will be made.

It is one thing to acknowledge the importance of technology but rather more difficult to select out the specific elements which young children can understand and use. This problem will be explored in more detail in a later publication.





Links with Science

In this technological area, there is a very close connection between Science and Design and Technology. The relevant part of the Science Curriculum concentrates on two fundamental technological concepts: Forces and Energy. In Design and Technology, we are concerned with the application of these concepts in making things work and controlling their performance.

When the two sets of ideas are brought together they immediately begin to spark off imaginative approaches because they support and complement one another.

It is not hard for small children to realise that power is needed to make things work. However, infants may have considerable difficulty in relating any kind of theoretical framework to their direct experience. As will also be the case in using materials, children will frequently be using energy or mechanisms without fully understanding the theory behind them.

Questions can be used to prompt an understanding of the link between Science and Technology:

Why does this tower stand up (or fall down)? Can I stop it wobbling by changing its shape?

Why does this model go faster downhill? Can I control its acceleration? Will it go faster if it is heavier or if the wheels turn more easily or both?

How long will it take this model train to stop when the electricity is turned off?

How can I control this buzzer more precisely?

How is thread made? Why is one kind of thread stronger than another? How can we test them to find out?

Systems

There is no doubt that the term 'System' is unfamiliar in Primary schools. It may be helpful to distinguish between three different kinds of systems:

Human Systems How people organise themselves to carry out the business of society. A milk round would be an example of this or, at a different level, the British form of parliamentary government. Primary schools are full of human systems that are immediately visible to the children. How is the week organised? How is the rubbish cleared up and collected? Who does what in the life of the school?

Physical Systems How artefacts work together or how the parts of an artefact or environment interact with each other. A transport system consists of roads and vehicles but these also consist of systems: the drainage system under the roads for example, the lubrication system of a motor car or lorry.

Communication Systems How activities are informed and controlled by the flow of ideas and information. These can range from complex computer control programs to simple instruction manuals or simply a note left out everyday for the milkman.

In most situations there will be a close linkage between these three types of systems. In Design and Technology there will nearly always be:

A Physical system to support a Human system (e.g. the telephone system) which supports a great variety of more general Human systems (e.g. ordering; getting information about bus

times; calling the emergency services) and which needs Communication systems (e.g. telephone directories; directory enquiries) to explain it and make it usable.

Energy, Systems and Mechanisms: Developmental Aspects

All children in Britain grow up in a world where Energy, Systems and Mechanisms are an evident part of everyday life. The dependence of people on technology is not foreign to them in any way. Before coming to school, they will be likely to have experienced artefacts as complex as television sets and washing machines, to have used battery and pedal power, to have played computer games and ridden in cars, buses and probably aeroplanes. In their play, boys and girls will have played the role of a pilot or a truck driver and they will have arranged and re-arranged their own toys in imitation of the systems they see around them. Children come to school with wide knowledge of what technology can do, but with much less knowledge of how it does it.

This balance is very clear in their Design and Technology work. 'This plane', they say at six, 'will fly to the Moon'. How? 'By magic rocket'. What the ingredients of a magic rocket might be, seem less important to them than the magic of moon flight which, of course, they know (and we know) is possible.

The task for teachers is a subtle one. They have to preserve this wide and sometimes fantastic vision of technological potential because it is the basis of imagination and innovation. But at the same time they have to introduce children to knowledge about the limitations that physical reality imposes on everything that is made. In Primary school there is a clearly defined moment, around the age of eight or nine, when it suddenly becomes of paramount importance that things made should work 'properly'. Before that it hardly matters to the pupil if a kite will fly - making it is enough. It flies in the mind at least. But after eight or nine a kite that does not fly is not a kite at all.

Fortunately this pattern of development works well for the teacher. It is possible to begin to introduce simple Scientific investigations and making things work using construction kits from the very beginning. This will be direct experience. The scope for understanding grows in harmony with manual skill so that eventually the ability to make things work matches the ability to understand why they work.

So far as Systems are concerned, there is no doubt that small children have difficulty with the idea of a system in the abstract. They are much more at home with a physical system they can see and touch or with the people who actually make a human system work. It is only at Key Stage 2 that the Programme of Study begins to demand the ability to think about and model systems such as simple circuits using abstract symbols. Before that direct manipulation of systems will be sufficient and fascinating.



5 EVALUATING

In its efforts to improve the quality of architecture in Britain, the Royal Fine Art Commission speaks of 'raising the quality of demand'. By this they mean that people who know more about buildings and are more aware of their surroundings will ask for higher standards from developers, architects and politicians. This idea of improving quality through widespread awareness of Design and Technology has deep roots. Henry Cole wrote about it in the Nineteenth Century when he founded the first publicly funded art schools and argued for the establishment of municipal museums and art galleries. William Morris took up the theme and more recently it has fallen to the Design Council to make the same point.

In National Curriculum terms, the argument is that we will not get better Artefacts, Systems and Environments until children (and adults) take a more critical, well-informed attitude to the made world.

The ability to evaluate is thus central to education in Design and Technology. Being able to evaluate depends on a steady growth in knowledge and experience. The knowledge involved is about 'why things are the way they are'. The experience comes from direct, personal study of the things that have been designed and made by ourselves and other people.

In the Schools Council's Art and the Built Environment project [6], an attempt was made to set out a series of logical steps linking direct, personal study through to design activity and making. In fact, it is equally possible to work outwards from our own design activity. What we can say is that a study of things that have been made will help us in our own design and technology work but, equally, that our own design and technology work will help us to understand things that have been made.

In the adult world, a big investment is made in Evaluation by companies and government departments. This is largely because making mistakes in design and technology can be very expensive in both economic and human terms. One of the most costly series of errors since 1945 has been in the form and quality of public housing. High rise blocks proved to be a poor design solution for unforeseen social reasons. The industrialised building systems used to construct them were a failure because the technology employed was not sufficiently well-trying.

We are used to thinking of evaluation as coming at the end of a sequence of work. But the example of high rise flats focuses our attention on the fact that in Design and Technology it is equally important to evaluate during a project. If a product really is a disaster when it is made, this means that the design work has been badly done. When we take on the role of a designer, we also take on the responsibility for imagining, calculating, and evaluating the likely effects of our proposals.

Many of the models used by designers and technologists during the work of generating a design are attempts to evaluate the effects of their designs before production begins. The adult world of extended Evaluation may seem a long way from the direct and immediate experience of small children. However, it is entirely possible to build evaluation activities into children's project work. Teachers have always encouraged children to reflect on their experiences and so to develop the ability to learn from mistakes and successes.

In a Design and Technology project for Key Stage One, evaluating may take a number of forms:

- growth in vocabulary to talk and make judgements about their own work and the work of others

- awareness of the work of others in relation to their own ideas and proposals. Generally this will be based on familiar things but may also involve examples from other times and cultures
- 'critical dialogue' with their own ideas, proposals, plans and outcomes. The teacher can prompt this by suitable questioning. The 'dialogue' will use drawings and models as well as language
- discussions with other children
- trying ideas out in practice to see how they work
- 'fair tests' of materials to see if they are suitable
- discussion with teachers or visitors to the classroom
- discussions with people who use their outcomes.

All evaluation depends on the ability to make comparisons. These comparisons can be formal or informal and take place in many different ways. They will often begin from asking questions. Some typical questions might be:

How does my product compare with what I set out to do?

How reliable was the information I used in my project?

How well did I plan my project?

Was I able to keep to the plan? Which of my ideas would be the best one to take further?

How does my idea compare with that of other people?

Which proposal or product works best? Looks best? Which do I like best? Can I explain why?

Children can gradually learn the difference between Quantitative appraisal of what can be measured (for example, how much water is needed to make the water wheel turn?) and Qualitative appraisal of feelings and responses (for example, does this room make people feel happy or sad?) Here the questioning will link up with the work they may already have done on identifying Needs and Opportunities.

Evaluating : Developmental Aspects

The roots of skill in evaluation are to be found in children's likes and dislikes. These begin to emerge remarkably early: certainly before the growth of language. It is the long-term job of the teacher to go beyond these personal preferences and to make preference more self-conscious, subtle and informed.

The ability to evaluate grows with skill and knowledge and, as we have seen, has two distinct branches. There is first the ability to appreciate, analyse and debate what others have done. In Design and Technology, this means gradually developing an historical and cultural perspective and becoming aware of the issues and results of current work. The second is the ability to analyse, criticise and learn from the child's own activity in Design and Technology. This will require at least some ability in the sophisticated art of observing oneself and as one grows up it begins to call for a degree of objectivity.

It is clear that young children have difficulty in fully distinguishing themselves and their perceptions from the world around them. A five year old's critical faculties will be bound up in direct, concrete experience. A seven year old, on the other hand, can fully recognise that people have many different views and values and that these are worth listening to. He or she can also plan simple objective testing procedures and draw conclusions from the results. At twelve, near

adult standard may be reached in some areas, particularly where the individual child has strong interest and motivation but all children are able to grasp the broad principles and issues involved.

In everyday experience, nearly all design and Technology activity starts from an evaluation, however informal. The feeling that something is 'not quite right' with the garden or that the kitchen 'just doesn't work' means that we have made some kind of evaluation of our existing situation and would like to do something about it. This is a good starting point for children: making an evaluation of something familiar and important to them provides strong motivation for improving it.

Another approach to starting from evaluation is to begin by analysing and criticising a group of existing products before going on to try and improve them. These might be small artefacts like toys or tools, or it might be interesting to evaluate an environment - perhaps the local leisure centre or the school playground.

Skill in evaluating is an aspect of personal development that grows with continuous practice. It depends on making careful observations, having a personal standpoint and balancing this by respect for the opinions of others.

We have come a long way since the days when adult design activity was taken as the model for school activity. But there still exists a considerable amount of practice that reflects the belief that young children only have minimal design and technology capability. As I hope I have shown, exactly the reverse is the case. Every child entering the Reception class **MUST** have this capability. Not only is it innate in human beings, the lessons built into the process of growing up ensure that it will develop in the pre-school years.

This is of a piece with the changing picture of children's development. Today the proactive nature of a baby's relationship with its environment is well recognised. A number of researchers [7] have recently highlighted the intelligence and curiosity of four year olds. The basic argument behind all this work is that small children are not stupid. It is not their mental equipment that limits their ability but their lack of experience and rather limited physical development.

Ever since Margaret Donaldson's [8] pioneering work challenging Piaget's interpretation of children's capabilities, the trend has been to recognise afresh the intelligence of Pre-school and Primary children. Provided children feel 'at home' in a learning situation, their curiosity and intellect will push them forward to discover new meanings and to create things.

Design and Technology project work should be an ideal vehicle for children's educational development. Its essence is open, active learning. It will be important to see this very clearly in the future. At their own level, children working on their own design projects are operating on the borders of their experience. Not only are they attempting to understand 'why things are the way they are' but they are also confronting the existential challenge of attempting to shape the future.

We are thus faced with what seems to be a paradox. Children have innate capability in Design and Technology which develops because of the experience of growing up. What then is left for the teacher to do? The answer must be the same as in every other area of human development. It is the role of teaching to provide those experiences and knowledge that will encourage each person's development to be coherent and to reach its potential. Through good teaching the child can become self-consciously aware of his or her own design capacity and so be able to make deliberate use of it. Children can be helped to participate fully in their own material culture and to take part in changing it. But this can only be done efficiently 'with the grain' of human development and it is in this context that we need to improve our understanding of the pattern of design intelligence in young children. We need better knowledge of 'children designing'.

References

- 1 The evidence for this is spread through many different publications. What is generally agreed is that at the appropriate moment - a moment of 'readiness' - a particular development happens with striking rapidity. For example, an American researcher, M E Smith, studied the number of words used by children. The figures were: 3 at one year, 22 at eighteen months, 272 by two years. In no other period of one year will human beings achieve a ninety fold increase in vocabulary. (See M E Smith, 'An investigation into the development of one the sentence and the extent of vocabulary in young children'. University of Iowa Studies in Child Welfare, 1926, 3, No 5)

Tom Bower gives a vivid picture of the power and development of infant intelligence in: T Bower, A Primer of Infant Development. San Francisco, Freeman, 1977.
Howard Gardner gives a particularly accessible account of the intelligence of pre-school children in: Howard Gardner, The Unschooled Mind. New York, Basic Books, Harper/Collins, 1991.
- 2 John Gabriel, Children Growing Up: the development of children's personalities. London, University of London Press, 1964
- 3 Ruth Benedict. Patterns of Culture. London, Routledge and Kegan Paul, 1935
- 4 Amos Rapoport. House Form and Culture. Englewood Cliffs, 1969
- 5 Dorothy Einon. Creative Play. Harmondsworth, Penguin Books, 1985
- 6 Eileen Adams and Ken Baynes. Art and The Built Environment: study activities. York, Longman/Schools Council, 1982
- 7 for example: Barbara Tizzard and Martin Hughes, Young Children Learning. London, Fontana, 1984
- 8 Margaret Donaldson, Children's Minds. London, Fontana, 1978