THE PLACE AND PERCEPTION OF

TECHNOLOGY IN THE CURRICULUM:

HISTORICAL DEVELOPMENTS UP TO 1997

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ANGLIA POLYTECHNIC UNIVERSITY

ABSTRACT

SCHOOL OF EDUCATION

DOCTOR OF PHILOSOPHY

THE PLACE AND PERCEPTION OF TECHNOLOGY IN THE CURRICULUM: HISTORICAL DEVELOPMENTS UP TO 1997

By STANLEY CHARLES OWERS
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Background: Technology was introduced with the 1988 Education Reform Act, and was the last subject to appear in the curriculum on a national footing, but it was not well defined. Without a conceptual framework for the subject, the role of technology could not be adequately appreciated. As part of the 1988 ERA, Economic and Industrial Understanding (EIU) was introduced as a cross-curricular theme against a background of two intangibles: (a) though technology was so recently introduced, the products and services of technology and industry have long been visible, and (b) although the first country to experience the Industrial Revolution, Britain has been in industrial decline for decades. Thus the declared general purpose of this research was based on the viewpoint that the educational system of *'the UK has consistently failed to respond appropriately to "technology"*, and to test the hypothesis that *'this failure has contributed to the problems associated with the place and perception of "technology" in the National Curriculum'.*

Goals: Specifically, the research explored: (a) the place of technology, (b) the perception of technology, and (c) a conceptual framework for technology for inclusion in the curriculum.

Methodology: Various groups were tested for their understanding of technology and EIU. Classroom exercises were conducted with student teachers and teachers. A-level students were tested using a 3-page questionnaire; a one-page schedule was used for recorded interviews with teachers, student teachers, parents, and A-level students. The research was informed also by iteration, and included the literature review.

Outcomes (a): The literature research confirmed that technology is as old as humankind. The foundations of technology resides in our imaginative capabilities as toolmakers. Humankind has always used tools, and recently technologies, as extensions of itself. Tools and technological evolution have been constant companions to the evolution of humankind. The underlying purpose has always been sustainment, and this applies with every type of nation whether hunter/gatherer or industrialised. For industrialised societies, as new tools

and technologies raised productivity and capability, the socio-economic community sustainment model became less dependent on the widespread use of craft skills, and more dependent on products from manufacturing industry whether locally produced or imported. However, there will always be a requirement for core craft skills, particularly in the fields of precision technology. The tool-making and tool-using activities of prehistoric times have been identified with 'industry' and 'manufacture'.

As graphs, the statistical data from the A-level student survey casts original light on causes for serious concern. In the context of getting a job, all students regarded Maths as important whether taking the subject or not. Students also regarded Maths as important in the context of Economic and Industrial Understanding. However, poor levels of creativity were perceived as allowable in the curriculum for the subject of Maths by students taking and not taking the subject. The statistical survey disclosed many other causes for serious concern, indicating a 'crisis' thesis.

Outcomes (b): An exploration of historical developments up to 1997, has disclosed that the status of technology was not representative of its crucial role at the core of society. As an intellectual subject, technology has many component parts including maths and science. Maths and science in the curriculum was resisted for many decades, particularly by the middle and upper classes. During the 19th Century, technical education was for the 'industrial classes' or 'the lower orders'. So there was a lack of social esteem associated with technical education and industry, and particularly among the opinion leaders of society. In society, technology occupies a largely unseen pivotal role; as we become more productive and capable, we become more dependent, but the opposition created by our value judgments, threatens the standard of living for our society. Before the formative years of education, other sources of stigma influenced the value judgments of our society. The roles of industry and technology have yet to be understood in the depth required to sustain ourselves as a society; in reality, the past is in the present.

Outcomes (c): Among many systemic barriers identified in this research, the lack of a consensual conceptual framework for technology emerges as critical. This research concludes with a conceptual framework for technology that underpins its pivotal role in society, and is recommended for inclusion in any future legislation. Future policy was never part of the remit of this research; the findings could not be anticipated. However, the research findings provide useful pointers for policy makers, and these are included.

Future developments: This research points to the need to re-map the statistical survey data to look for possible shifts in the vectors of direction and change. That work is now ongoing, informed by this thesis.

Chapter 1

Introduction

01.01 Preamble

The author's application for a post-graduate research degree was registered 1 April 1995; the proposed plan of work was approved as follows:

> The general purpose is based on the viewpoint that the educational system of *'the UK has consistently failed to respond appropriately to 'technology'* (hence our economic decline), and to test the hypothesis that *'this failure has contributed to the problems associated with the place and perception of 'technology' in the National Curriculum'.*

As a project, the research was prompted also by two apparent intangibles:

- technology was the last subject to be introduced on a national footing with the 1988 Education Reform Act, but we are surrounded by the products and services of technology.
- Britain was the first country to experience the Industrial Revolution, but it has been in relative industrial decline for many decades.

After the Education Reform Act of 1988, three sets of Orders were published for technology between 1989 and 1995; this surely was testimony to some of the difficulties that surrounded the subject after its introduction. None of the Orders provided a definition for 'design' or 'technology'. 'If you can't define something you have no formal rational way of knowing that it exists. Neither can you *really* tell anyone else what it is'—Pirsig (1991:206). These omissions from the Orders for D&T added considerably to the difficulties faced by teachers.

As the literature review got under way, some thought was given to how the process of inquiry should proceed, and chapter 2 summarises the investigation associated directly with defining and refining the research model to be adopted.

01.02 Methodology

Since none of the Orders for technology provided a definition of the subject, it was considered important to test what was understood by the name of the most recently introduced curriculum subject. However, DES (1989a:1) stated: 'but it [D&T] will also be an essential condition for the future prosperity of our business and industry.' 'In their approach to design and technology as a foundation subject', the DES (1989a:1-2) continued:

- 'to understand the significance of design and technology to the economy and to the quality of life.
- We have been particularly concerned to formulate a curriculum which meets the

requirements of the 21st Century. It must contribute to pupils' economic and careers awareness, …
- Our Terms of Reference described design and technology as an activity which goes across the curriculum, drawing on and linking with a wide range of subjects.'

Hence there was plenty of scope for research inquiry to address the two intangibles referred to above. Thus data-gathering instruments were required, and chapter 2 discusses their design rationale, their testing, and the groups for whom they were intended. The final research model chosen is presented in diagrammatic form.

There was one other outcome from the literature review, namely the need to understand the origins of technology, and this became the subject of chapter 3.

01.03 The origins of technology

Chapter 3 traces the origins of technology back to the imaginative tool-making skills of Stone Age humankind. With the first acts of stone tool-making, the human species made not one but two inventions that were crucial to its evolution and its technology; making tools for both immediate and future use implied further imaginative skills—Bronowski (1979:40).

Technology evolved as the means by which the human species developed a degree of freedom not shared by any other animals. The human species invented tools, used its imagination, and learning from experience. Humankind also used its hand/eye coordinated skills on the available stone materials, and learnt about the properties of the materials by which it was surrounded. This learning process was part of the burgeoning tool-culture.

Stone endured as the material of choice because it would accept a durable cutting edge. But there was a further important invention, namely 'social organisation', perceived as a great step towards cultural evolution. The cultural evolution that now separates us from our predecessors, started 10,000-12,000 years ago—Bronowski (1979:59). The concept of the 'cutting edge' was to become crucial to the way we now live as will be shown in this thesis—see also Smiles (1863:3).

Humankind enhanced its capability and productivity by the use of its elementary tools as extensions of itself, eventually learning to create 'extra produce' for the purposes of 'barter'. Barter was the beginning of trade; coins were not invented until 640 BC—Asimov (1990:36), and the tool-culture of humankind was at the core of this activity.

01.04 The evolution of technology up to the Industrial Revolution

From the earliest times, humans have learnt about the materials surrounding them. Their acquired knowledge has been used to enhance their ability to survive. Thought and action were inherent in preliterate societies—Usher (1954:59).

Chapter 4 reflects on the concept of invention as a key phenomenon in the evolution of humankind which is implicit in the development of technology, both historically and culturally, ever since the Stone Age. Typically, the process of invention encourages images of the 'hero inventor', but it should be seen as the product of 'social cumulation'—Usher (1954:68), or knowledge building on knowledge.

The earliest machine tool which applied the 'cutting edge' appears to have been the lathe, a most important development for humankind. Turned artifacts date from as early as 700 BC —Woodbury (1972d:20/21). By the 18th Century, the skills and techniques of precision had evolved with the instrument makers; they had a profound effect on the course of technological history—Rolt (1965:38). Their knowledge and skills provided scientists with instruments capable of accurate measurements to an extent previously unknown—Rolt (*ibid*), at the same time expanding the frontiers of the tool-culture.

The evolution of the lathe, and the process by which precision technology evolved as social cumulation is discussed; precision technology enabled cheap replaceable parts to be produced, and made mass production feasible.

01.05 Technology, Industry and Wealth Creation

Every society, whether 'native' or 'western industrialised', is dependent on tools to enhance productivity and/or capability in order to sustain itself. For a western industrialised society, the nature of that dependency is complex, encompassing tools, technology, materials, methods, organisations, industry and above all the application of imagination. Within this circle of dependency, the consumers have a role too, since they are looking for cheap good quality products and services.

Hence, there is a circular relationship in this dependency which is not easily perceived. However, the government is keen to promote understanding since a manufacturing industry that is competitive is a wealth creator for the state, and wealth creation is required to sustain ourselves as a society. These issues are discussed in chapter 5.

01.06 Technology and Culture

The word 'culture' is used in a variety of ways, and conveys different things to different people. Anthropologists use the term 'culture' when making reference to the particular ways of life of early indigenous peoples—Williams (1988:39). Social scientists use this word as a way of distinguishing or separating societies—Argyle (1976:78).

But the word is also used to lay claim to 'superior knowledge', or to distinguish between '"high" art (culture) and popular art and entertainment'—Williams (1988:92). So it becomes clear that the word 'culture' has a wide range of applications and meanings.

Some of the complexity inherent in the word 'culture' is developed in this chapter, but with the primary purpose of exposing technology as the utterly dependent system manifest in every human society. In every society, the technology of humankind has evolved alongside humankind, and is culture-specific.

01.07 Technology in Education - statutory considerations

The quality of esteem attributed to maths, science and industry during the formative years of the educational system are discussed. As the system of education evolved, there were many difficulties and competing priorities, including the design of courses of study.

Maths and science are components of technology, and manufacturing industry is totally dependent on a continuous stream of new and evolving technologies to remain competitive. The difficulties encountered with the development of education, and the value judgments of those times, became intrinsic parts of the processes that moulded the educational system, the courses of study, and the attitudes displayed towards industry, and technical education; in reality the past is in the present.

The government now seeks to encourage industry to be more competitive 'to deliver the wealth that we need for our public services, to provide good jobs for all our people and to maximise quality of life'—Beckett (1997:3). But for more than a century, UK governments provided statutory sanction for the disparagement of industry and technical education; these value judgments continue to inflict significant damage upon our ability to sustain ourselves as a society. There is no esteem attached to working in industry.

01.08 The perception of technology

In this chapter, the crucial place of technology in our lives is first recapitulated; and then the perceptions of technology are examined using evidence as follows:

- the origins of hostility towards industry and business,
- anecdotal evidence of a prejudicial culture from across society,
- evidence from three research exercises: (1) economic and industrial understanding with teachers and student teachers, (2) a survey of A-level students, and (3) evidence from transcribed recordings in response to questions on the meaning and influence of technology.

Humankind evolved because of its tool-making skills; humankind has always used tools, and much more recently technologies, as extensions of itself. The underlying purpose has always been sustainment, and this applies with every type of nation whether hunter/gatherer or industrialised. Tools and technological evolution have been constant companions to the evolution of humankind.

Technology is paramount in competitive industry; as an industrialised society, it is also paramount in our lives. But in our society, there has been a crucial failure to understand and value these pivotal relationships, and the tool-culture upon which we are utterly dependent. In the thread of technological continuity and progression, a law of prior dependency becomes evident as knowledge builds on knowledge, and is demonstrated as a model.

01.09 Summary and discussion

The discussion in this chapter traces the thread of technological continuity and progression as the generic creative system of humankind that has brought us from the Stone Age to the way we live now. All the research is subsequently reviewed.

Technology evolved out of the ability of the human species to design and make tools, and we use technologies as tools. The whole of the human species, without exception, uses tools as extensions of itself for the purposes of enhancing productivity and/or capability. While we are all tool-users, relatively few are tool- or technology-makers.

Through tool and technological prowess and entrepreneurial drive, Britain became the first society to experience the Industrial Revolution, substantially enhancing national prosperity. However, not only did the influential opinion leaders of the time not understand the process by which the wealth had been created, they disparaged the process. These value judgments still prevail; technology was the last subject to be introduced into the curriculum on a national basis, and at least a century too late. The UKs relative industrial decline continues.

01.10 Conclusions and Recommendations

The rationale for the research, as stated in the hypothesis, is recapitulated, and broken down into the four elements of inquiry. It is concluded that each of these elements has been proven.

For the recommendations, the metaphor of a ship's navigator becomes appropriate; before a new course can be charted, the navigator needs to know the direction from which s/he has come. Concerns about the direction pursued by our educational system and the need for educational reform have long excited strong comment, going back more than 130 years.

Basically, we need to confront our culture, and this can be done by changing the structure of the curriculum so that sustaining ourselves as a society, both economically and now environmentally, moves to the top of the agenda.

Chapter 2

Methodology

02.01 Introduction

The school curriculum is influenced by society—Lawton (1975:6). This is logical, since the influences extend to particular aspects of the way we live, particular kinds of knowledge to be learned, together with certain attitudes and values to be acquired. Collectively, this selection from our culture is deemed so important that its dissemination 'to the next generation is not left to chance in our society but is entrusted to specially-trained professionals (teachers) in elaborate and expensive institutions (schools)'—Lawton *(ibid).* Hence the National Curriculum.

By comparison with other curriculum subjects, the arrival of technology on a national basis was a relatively recent event. It may be assumed that this was because of pressure from society, but if so why? How important is it for us to understand the place and perception of technology in our society? Should it be a slice of our culture to be passed on through the National Curriculum? And has the subject been taken seriously? These among many other questions pointed to a number of parallel strands of research and inquiry.

First among these strands was a literature review as an on-going iterative discipline throughout the programme of research. Research and inquiry was required among groups representing teachers, student teachers, students and parents - they are all members of our society. Membership of our society also comprises a number of bodies outside education, including non-profit making professional technological organisations. They each have concerns about the course of technological development in their own specialist fields, and as a consequence have a point of view about the place of technology in our society.

Research and inquiry started with a methodological model that was changed in order to respond to experience and supervisory concerns. Both the initial and final models are described. Also explained are the experiences and supervisory concerns that brought about the final methodological model.

02.02 First methodological model

<u>02.02.01 Literature review</u>

This was required for two reasons: (1) to be informed about the perceptions of technology from earlier times up to the present, and (2) to determine whether there were references that could be used in points of argument and discussion when presenting my philosophy. The outcome will be evident.

02.02.02 What did students think about technology?

The plan was to conduct a survey of students to find out what they understood and thought about technology. For each group, the survey included a sample who were taking technology and a sample who were not - this was necessary to try and obtain a balanced perspective. The planned survey groups and methods were as follows:

- 6th Form students - negotiate with two Secondary schools, to conduct recorded interviews of five students taking technology and five students who were not - a total of 20 interviews. The interview schedule would seek to determine perceptions about the role of technology between those taking the subject and those who were not.

- 6th Form students - in order to discover whether regional variations existed in the perception of technology, send questionnaires to twenty secondary schools in Scotland, twenty in Wales, twenty in Northern Ireland, twenty in northern England and twenty in southern England. Each school would receive 10 copies of the questionnaire with a request that they are completed by five students taking technology, and five who were not - a total of 100 schools and 1000 questionnaires.

02.02.03 What did student teachers in training think about technology?

There were a number of different teacher training cohorts at the Department of Education, Anglia Polytechnic University. The plan was to negotiate with the college management in order to conduct recorded interviews of four students taking technology and four who were not taking technology, from each of five cohorts - a total of 20 interviews.

02.02.04 What did teachers think about technology?

The plan was to negotiate with 6 secondary schools with a view to conducting recorded interviews of two teachers responsible for delivering technology, and 2 other teachers with no responsibility for technology or science - a total of 24 interviewees.

02.02.05 What did parents understand about technology?

Conduct recorded interviews of a total of 12 parents who were professional engineers and therefore practising technologists, and 12 parents who worked in a non-technological capacity - a total of 24 interviews.

02.02.06 What was the 'empirical' view of technology?

As stated earlier, there were many professional organisations outside education that have an empirical point of view. The better known organisations include The Engineering Council, The Institution of Mechanical Engineers, The Institution of Electrical Engineers, and one of the oldest The Institution of Civil Engineers. A literature review of conference papers, journals and correspondence in these organisations should provide a test not only about the concerns held by people, but the depth of those concerns. Was there any mention of education, and in particular technological education?

02.03 Design of data gathering instruments

02.03.01 Rationale for designs of data gathering instruments

In order to start the research from a basis of confidence, it was necessary to pilot trial draft examples of the data gathering instruments. Hence other studies in similar areas of research were examined. The methodology and aims were considered in four research studies:

- Teenage Attitudes to Technology & Industry, Page and Nash, 1980,
- Student Attitudes to British Business, RSGB, 1989,
- Neighbourhood Engineers: An Evaluation, Bridges, 1991,
- Technology in the National Curriculum by Smithers, 1992.

As the report implies, Page *et al* concentrated on 'attitudes' and exclusively in the context of 'technology' and 'industry'. They used a good questionnaire, containing some 40 questions that were quite searching and highly appropriate. These questions were developed as part of an 'attitude scale', and details were included in the report. However, for this study the author wished to consider a different set of dimensions that were best captured in part by McCulloch *et al* (1985: 2), who stated:

> It is the cultural context … which determines whether innovations in the curriculum become established … some areas of the curriculum, … , being regarded as more worthwhile than others.

Hence it was necessary to try and discover the relative worth of technology by comparison with other National Curriculum subjects. Page's report also contained evidence of cultural bias, but there was no discussion about these issues. Indeed the researchers themselves may have exhibited some cultural bias in the evaluation and write-up of their data. But what is there to discover about culture?

As Page's report dealt with the issues of teenagers, the report by RSGB covered a study designed '… to be broadly representative of all undergraduates at universities and polytechnics throughout Great Britain'. No less than six aims were specified for this survey, and the list was headed by the requirement to assess 'students attitudes to, and preferences for, careers in business'. A total of 1013 undergraduates were questioned, and represented some 35 universities, 19 polytechnics and 2 colleges of technology. The questionnaire was different in concept. In particular it was designed as a schedule to be used by interviewers and contained a mixture of multiple choice questions, together with questions seeking spoken statements. The report dealt with the issues of career preferences, and so the concerns associated with 'some areas of the curriculum, … , being regarded as more worth-while than others,' were not considered.

There was a statutory requirement for the cross-curricular theme of economic and industrial understanding (EIU) which may not be realised. Since there is a strong bond between industry and technology, the questionnaire should test for EIU.

Lastly, Bridges (1991: 31) states:

> If the Engineering Council want as a priority to attempt to raise the status of engineering in the eyes of students, then the scheme must evolve so that the identity of the engineers as ENGINEERS as against 'employers' or 'industrialists' is given a higher profile.

Hence a question should be included about the relative standing of engineers in society.

In summary, the questionnaire should test in the following areas:

- What was the relative worth of technology against other curriculum subjects?
- Was there a cultural context?
- What was the perception of EIU?
- How were engineers regarded?

Where possible the schedule for interviews should similarly use these themes.

Two types of instruments were required: (1) a questionnaire designed for completion by 6th Form students, and (2) a schedule for use in recorded interviews.

Why choose 6th Form students? Difficulty was being experienced with technology as a recently introduced curriculum subject. 6th Form students would have had the longest exposure to the subject. Industry has to take the products of the educational system regardless of the difficulties being experienced by education, and A-level students were closest to employment or higher education.

<u>02.03.02 Design of the questionnaire</u>

This proceeded in parallel with the development of the data gathering methodology. Simultaneous designs were necessary since both aspects were informed by the questionnaire pilot trials. Before attempting to pilot trial the questionnaire, it was discussed in depth with colleagues in the College, and sent to a Senior Lecturer at 'The Centre for Technology in Education' at Chester, for further comment.

Subsequently, the questionnaire was put through a series of 3 separate pilot trials for use with schools in England, and modifications were incorporated after each stage. In addition, the questionnaire was sent to my adviser, and discussed with my second supervisor. It was also discussed with 9 of the 54 students who had completed it during the final pilot trial.

The pilot trials were conducted in stages with different schools. These were found after making contact with a total of ten schools as shown in Fig. 2.01.

Anglo-European School	King Edward VI Grammar School
Brentwood County High School	Palmer's Sixth Form College
Chelmsford County High School for Girls	Shenfield High School
Colchester County High School for Girls	St. Martin's School
Davenant Foundation School	The Hedley Walter School

Fig. 2.01 - Secondary schools considered for questionnaire pilot trials

This short list included some schools which had previously cooperated with ULTRALAB on projects of mutual benefit. Six of those schools offered Technology at A-level. One school agreed to accept 24 questionnaires for pilot trial, and subsequently decided not to complete the trial. In yet another of those schools, administrative changes were in-hand which concerned the subject of Technology to an extent that precluded the school for the time being. Only four of the ten schools offered A-level Technology and would assist with the development of questionnaire and data gathering methodology designs. Only three schools were required in order to complete and validate the design of the questionnaire.

During the initial telephone conversation with the Heads of Technology in these schools, it was significant that some of the teachers felt some obligation, either towards the Teacher Training College where they had qualified or to ULTRALAB. Trying to find goodwill was part of the planning strategy.

The programme to contact these schools on Technology questionnaire design issues began in July 1995. The questionnaire went through three stages of development. Each stage was the subject of a separate pilot trial. In total, some 110 copies of the questionnaire in different stages of development were returned during the pilot trials. The last pilot trial took place in February 1996, and concluded the questionnaire development programme.

As a data gathering instrument, the questionnaire ran into three pages with margins that preclude full-size display. Images that are 65% of the original size are shown in Figures 2.02, 2.03 and 2.4. The first page of the questionnaire is shown below.

6th Form Survey 1996

Please do not fold this form
Please do not use paper clips or staples on this form

Note 1: This form is designed to be completed by 6th Form Pupils
Note 2: Here is some information to help you complete this form:
- **Please answer each question or part of a question.**
- You indicate your answer by making a bold line — in one of the faint brackets marked from 1 to 9.
- Please use a black or blue ball-point pen or HB pencil.
- The brackets and numbers are faint so that the machine will 'read' only the marks you make on this form.
- Thank you for your help in this research. Here is an example of how to make your answer.

[1] [2] [3] [4] [5] [6] [7] [8] [9]

Part A. Please indicate whether you are female [1] or male [2]

Part B. In which year of your studies are you? First year [1] or Second year [2]

Part C. Please indicate which subjects you are taking at 'A' level.

C1.	Art:	[1]	C6.	Maths:	[5]
C2.	Design & Technology:	[2]	C7.	Modern Foreign Languages:	[6]
C3.	English:	[3]	C8.	Science:	[8]
C4.	Geography:	[4]	C9.	Other – please define:	[9]
C5.	History:	[5]		....	

Part D. How much interest do you have in each one of the following subjects at the moment:

D1. D& T:	low interest	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high interest
D2. English:	low interest	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high interest
D3. Maths:	low interest	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high interest
D4. Science:	low interest	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high interest

Part E. In your opinion, how difficult is each one of the following subjects: :

E1. D& T:	not difficult	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very difficult
E2. English:	not difficult	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very difficult
E3. Maths:	not difficult	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very difficult
E4. Science:	not difficult	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very difficult

Part F. For most people, when it comes to getting a job, how important do you consider each of the following curriculum subjects:

F1. D& T:	unimportant	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
F2. English:	unimportant	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
F3. Maths:	unimportant	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
F4. Science:	unimportant	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
F5. 2nd language	unimportant	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important

Fig. 2.02 - Questionnaire final design, page 1

Part G. Did you have teachers for each of the following cross-curricular themes at your school:

	Yes	Not sure	No
G1. Careers Education & Guidance:	[1]	[2]	[3]
G2. Education for Citizenship:	[1]	[2]	[3]
G3. Education for Economic and Industrial Understanding:	[1]	[2]	[3]
G4. Environmental Education:	[1]	[2]	[3]
G5. Health Education:	[1]	[2]	[3]

Part H. Do you think each of these cross-curricular themes should have a place in the National Curriculum:

	Yes	Not sure	No
H1. Careers Education & Guidance:	[1]	[2]	[3]
H2. Education for Citizenship:	[1]	[2]	[3]
H3. Education for Economic and Industrial Understanding:	[1]	[2]	[3]
H4. Environmental Education:	[1]	[2]	[3]
H5. Health Education:	[1]	[2]	[3]

Note: The letter 'I' has not been used. So the next letter is 'J'.

Part J. In the context of Economic & Industrial Understanding, how important do you consider each one of the following subjects:

J1. Art	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J2. D& T:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J3. English:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J4. Geography:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J5. History:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J6. Maths:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important
J7. Science:	not important	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very important

Part K. In our society, how much do you think the way we live now has been influenced by each of the following curriculum subjects:

K1. Art:	not influential	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very influential
K2. D& T:	not influential	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very influential
K3. English:	not influential	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very influential
K4. Maths:	not influential	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very influential
K5. Science:	not influential	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very influential

Fig. 2.03 - Questionnaire final design, page 2

Part L. In your opinion, how creative does the curriculum allow <u>you</u> to be in <u>each one of the following subjects</u>:

L1. Art	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative
L2. D& T:	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative
L3. English:	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative
L4. Maths:	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative
L5. Science:	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative
L6. 2nd language	not creative	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very creative

Part M. As a modern society, how dependent do <u>you</u> think we are on <u>each one of the following subjects</u>:

M1. Art	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
M2. D& T:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
M3. English:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
M4. Maths:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
M5. Science:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent

Part N. As a modern society, how dependent do you think we are on <u>each of the following</u>:

N1. Commerce:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
N2. Finance:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent
N3. Industry:	not dependent	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	very dependent

Part O. Here is a list of professional occupations. How do <u>you</u> personally see the standing of <u>each one in our society</u>?

O1. Accountant:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O2. Artist:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O3. Doctor (GP):	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O4. Engineer:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O5. Lawyer:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O6. Pilot (Civil):	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O7. Policeman:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O8. Politician:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing
O9. Teacher:	low standing	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	high standing

[Printer Offset 0.026" - 19.04.1996] [Form 5]

Fig. 2.04 - Questionnaire final design, page 3

These forms were designed using *Form*pro 1990 software, which produces formats to be read by an 'optical mark reader'. The Optical Mark Reader was a CD200 series made by

Data & Research Services plc. The rationale for the questions will become clear during the analysis of the data and the discussion.

02.03.03 Design of the schedule for interviews

A one-page schedule was designed with a common set of data gathering questions that could be used for all sub-groups. A sample appears in Fig. 2.05 below, and was intended for student teachers.

Subject: The place and perception of Technology

A schedule for interviewing student teachers in training

1. Personal details:

1.1 Gender?

1.2 Age?

1.3 Do you already hold post 18 qualifications?

1.4 What are your subject specialisms?

1.5 If you are a mature student, what was your previous job?
Has that experience been of benefit as a student teacher?

Note: Please be candid in your responses to the following questions. There will be no disclosure of source

2. Can you describe briefly what is meant by Technology?

3. Here is a list of cross-curricular themes. Have you heard of them? Which do you think should be in the National Curriculum?

4. What do you think is meant by Economic and Industrial Understanding (EIU)?

5. Here is a list of National Curriculum subjects. Do you think EIU has relevance in any of of these subjects, and if so which ones?

6. Can you see much evidence of Technology around you?

7. Do you think there are ways in which you personally have benefited from Technology?

8. Do you think our society has benefited from Technology?

9. Do you think our society is dependent on Technology?
Sub-question: Where on a scale of 1 to 9 would you place any dependency? 1 is low and and 9 is high.

Fig. 2.05 - Schedule for interviewing student teachers in training

With minor differences, this set of questions was used for A-level students, teachers, student teachers and parents with children in 6th Forms. For administrative purposes, question 1 on the form dealt with the personal details necessary for sub-group identity. Pilot versions of the schedules were tested with members of staff at ULTRALAB and the Teacher Training College.

02.04 Experience with the first design of methodological model

The size and quality of the sample student database was always dependent on a number of factors. These included:

- design of the questionnaire,
- number of secondary schools offering Technology at A-level,
- number of students taking Technology,
- my personal resources to handle the associated administration.

These factors remained whichever method of data gathering was finally chosen.

Since in the pilot trials of the questionnaire there were only 4 schools available out of 10, the implication was that to establish a database of 100 schools it would be necessary to contact a minimum of 250 schools. However, whereas the heads of technology departments in the 'pilot trial' schools had shown goodwill, there was no reason to expect such generosity unless the teachers perceived some advantage in participating in the research. Hence the number of schools that would have to be contacted by telephone was an unknown quantity, but it was probably going to be in excess of 300. Contact by telephone was considered to be a more effective method of recruitment, but was extremely time consuming. Contact by letter, using 'mail merge' software, was perceived to have a lower success rate, but was easier to manage.

While reflecting on the logistical issues outlined above, my Second Supervisor (Dr John Williams, then of The Engineering Council) expressed concerns about the reliability of regional trends derived from a database of 1000 cases, particularly when crossing national boundaries. It was a valid question. Some discussion took place about this issue together with the logistical concerns. The problem was to increase the size of the database so that it contained more cases, but to achieve this in a way that was administratively feasible and manageable.

Concurrently, my Director of Studies became concerned about the size of the database. In particular whether the type of school would be discernible in a database of 1000 cases, if the trends were present. Would the type of school namely Grammar, Secondary, or Independent, yield trends that were statistically reliable? Also, would gender trends be observable? These were important questions, and once again pointed to the requirement for a different methodological solution to establish the case database.

In the meanwhile, it became evident that Scotland, Northern Ireland and Wales required dedicated questionnaires designed around the same data gathering structure. There were either small terminology differences, or as in the case of Wales, the questionnaire was required to be in the Welsh language.

02.05 Methodological design solutions for final model

The solution proposed was to concentrate my limited resources on the study of secondary schools in England, so maximising the quality potential of the study. Pursuit of the studies in Scotland, Northern Ireland and Wales were brought to a close.

At the time of this study, there were about 3000 secondary schools in England, and some 1965 provided a 6th Form. The revised plan for the author was to write to the Heads of Technology Departments in all 6th Form secondary schools, and invite their participation in this research project. In a typical piece of consumer market research, the response rate to a postal inquiry would be less than 3%, or 59 schools in the case of this research programme. However, it became evident that National Curriculum Technology was a source of considerable concern, and a better response rate was anticipated.

Changes to the plans for recorded interviews were also proposed as follows:

Original model	No.	Revised model	No.
6th Form Students	20	6th Form Students	16
Student Teachers	20	Student Teachers	16
Teachers	24	Teachers	16
Parents	24	Parents	16
Total	88	Total	64

Fig. 2.06 - Revised plan for number of recorded interviews

In order to try and achieve a balanced response, each of these sub-groups was further divided. The division was along the lines of those 'who should know about the subject of technology through study', and those 'who had not studied technology'.

These methodological changes were accepted by the supervisors.

02.06 Revised methodological model

Fig. 2.07 below shows the revised methodological research model in diagrammatic format.

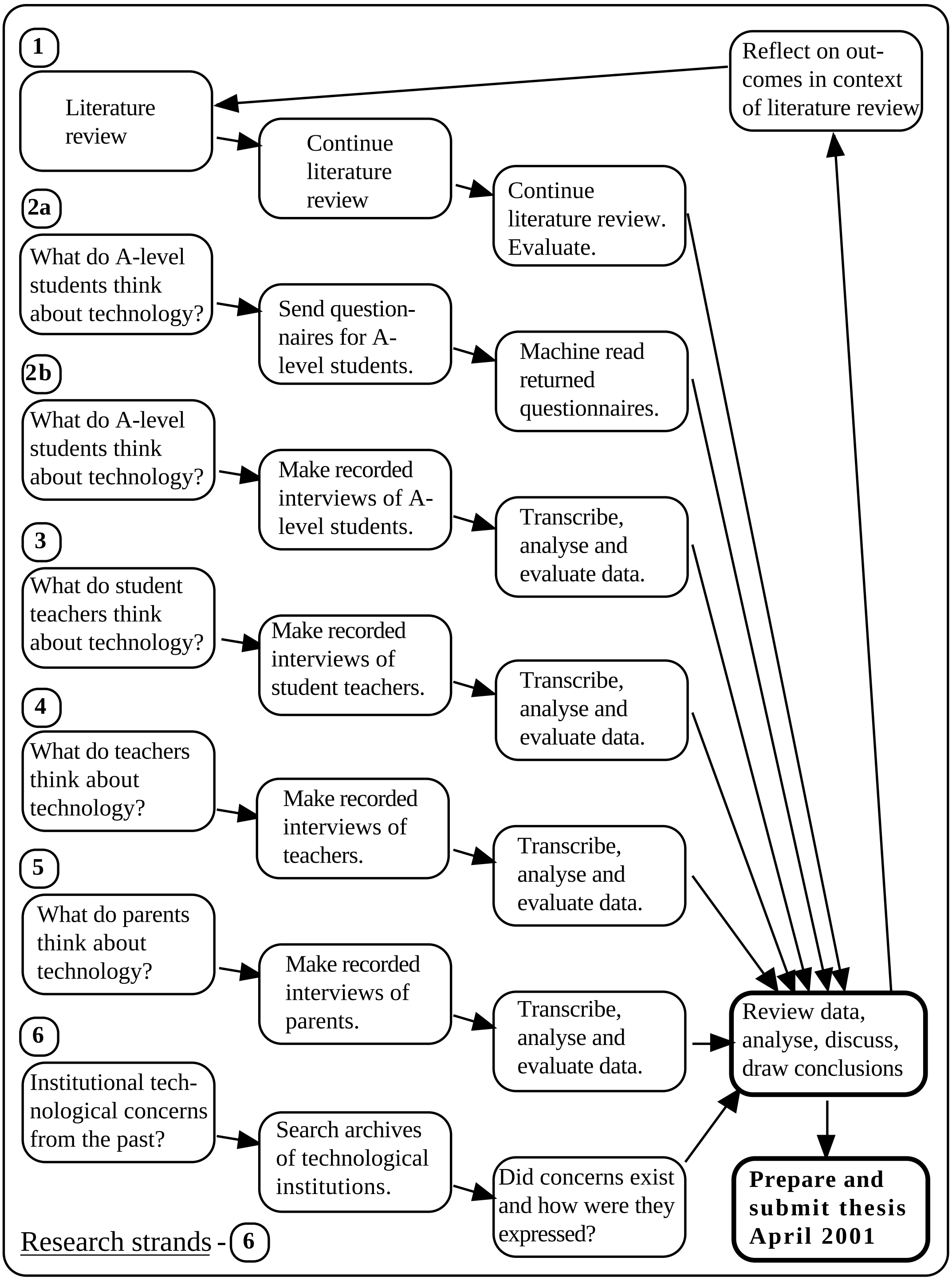


Fig. 2.07 - Diagrammatic representation of final methodological model of research

02.07 Final methodological model data gathering experience

<u>02.07.01 Questionnaires sent for completion by A-level students</u>

The data base for secondary schools in England was established using two sources. The first was the Ofsted list on the Internet from which to copy addresses. The second was 'The

Education Authorities Directory and Annual 1995' from which to verify 6th Form availability in the various secondary schools, and to add addresses for independent schools.

The address data base for England contains some 1965 secondary schools that take young people up 18/19 years of age. Using a 'mail merge' facility, letters of inquiry were sent to all these schools on 21st March 1996. The letters were sent to the heads of technology departments, and inquired whether:

- the school offered Technology at A-level,
- if so, would they be willing to participate in the research,
- and how many copies of the questionnaire would they require?

Hence, the sample database design was through a selective process, known in statistical terms as 'stratified random sampling'; stratified because of selection of a particular group in society, and random selection within that group.

The postal timing of 21st March was chosen on advice so that the letters would land on the desks of teachers at the beginning of the week before Easter. The assumption was that the teachers would take home their mail to deal with. The letter contained an overview of the research, a copy of the first page of the questionnaire, a response slip for those willing to participate, and a response paid envelope. A summary of the research findings was promised, as well as institutional and personal anonymity.

Positive replies were received from 315 schools representing an initial response rate of 16%. More than 6700 copies of the questionnaire were requested; the smallest number was 4 and the largest was 120. This level of response was perceived as symptomatic of the concerns held by teachers, and indeed many of them commented on the need for this research. A further 60 heads of technology advised there was no A-level course available at their schools; many considered this a regrettable situation and some were apologetic.

A total of 167 packages of questionnaires were returned to ULTRALAB. Some questionnaires were spoiled in transit, and simply because they were not returned in the document wallets. Damaged questionnaires could not be scanned, but where they were legible they were rewritten. Fewer questionnaires were returned by many schools than they were sent. Some 148 schools did not return any questionnaires. However, a database of 3105 cases from 167 schools was established. Such a database addressed the concerns of the supervisory team, and was within the limits of practicality as determined by the Optical Mark Reader and other technological support.

<u>02.07.02 Recorded interviews</u>

The programme of recorded interviews started mid-January 1997, and was concluded mid-May 1997. A total of 63 out of 64 interviews took place. The shortfall occurred because one technology teacher could not find a 'humanities' colleague willing to participate in the research project. However, 63 out of 64 recorded interviews was a good outcome.

02.08 Information technology resources

The work in this project was enhanced significantly by the use of computers (Apple Macintosh) as a primary desk-top-publishing and analytical tool. The software resources used for the research and the thesis were as shown in Fig. 2.08.

Application name	Purpose of usage
ClarisWorks 4/5 AppleWorks 5, 6	Text, spreadsheets, graphs, charts, drawings, schools lists databases, literature review database
Telnet	Electronic interrogation of library indexes
Data Desk 5	Statistical analysis of returned A-level questionnaires
Formpro 1990	Design of questionnaires for optical mark reading
HyperCard	Literature review reference data base
Conc 1.76/1.80	Content analysis - specifically ‘key-word-in-context’
Netscape Navigator	Provide access to Internet
FirstClass	Internal message and conference system
Eudora Light	E-mail system
Photoshop Enhancer	Software for downloading digital camera images

Fig. 2.08 - Information Technology applications used in research

Conc 1.76 was provided free by the Evan Antworth, Computing Department, Dallas, Texas. It runs on a Macintosh computer, and was down-loaded from the Internet July 1997. An update was down-loaded as Conc 1.80 in 1999.

2.09 The structure of this thesis

The subject of this research is 'the place and perception of technology in the National Curriculum'. Hence, in the first instance, the *nature* of technology should be considered if the *place* of technology is going to be understood. Chapter 3 comments on 'The origins of technology', and Chapter 4 considers 'The evolution of technology up to the Industrial Revolution'.

Mankind exists in a multi-dimensional world—Tufte (1991:9). The tools and technology of mankind have always extended the productivity and/or capability of humankind in a world that is multi-dimensional. Mankind's technology is evident in his three-dimensional artefacts by which he is surrounded, and non-verbal thought is inherent in technology—Ferguson (1977:827). Manipulating images that become artefacts involves spatial activity—Hindle (1981:133-138), and non-verbal thought.

So it follows that the path to understanding technology can be achieved only through illustrations together with a written account—Hindle (1981:x). A combination of illustrations with text is used in many parts of this thesis. All the illustrations have a figure reference number that is in two parts. The first part is the chapter prefix; the second part corresponds to the figure number in the chapter. (So the chart on the previous page is Fig. 2.08.) However, it is evident that illustrators, as chroniclers of history, did not always understand in detail the function of what they were reporting. So some illustrative errors should be expected, and these will be highlighted where they occur.

Lastly, the literary references used for points of argument in this thesis typically use the noun 'mankind' for the human species. From now on 'mankind' is replaced by the noun 'humankind'.

Chapter 3 - The origins of technology

03.01 The first steps

How did technology evolve into what we take for granted today? To understand the historical and cultural origins of technology, it is necessary to comprehend the development of the human species as a process distinct from that of all other animals. As social animals, the human species was notable for its 'culture', its toolmaking ability, and its ability to communicate ideas—Oakley (1972:1). Tools of a kind have been found on archeological sites, in the ancient traces of Stone Age human activity—Schick and Toth (1995:48), Bronowski (1979:29). In addition to communicating ideas, the human species differed from other animals by its 'imaginative gifts'—Bronowski (1979:20).

The tools of the Stone Age now appear primitive, but humankind evolved through learning about the properties of the materials by which it was surrounded. Those first tentative steps required imagination coupled with learning, perseverance allied to the study of cause and effect as part of the learning that produced the tools of the time. The thought led to the tool-making deed, and so a different way of 'doing' became established, thereby providing more easily the necessities for survival. The thought processes were an essential prerequisite to the action of producing the tools—humankind used its imagination in combination with its learning. Thus the beginnings of the tool-culture of humankind were established.

Stone Age tools were used to satisfy very basic needs—namely those of survival. In this context, they were used to obtain food, and as missiles to safeguard against predators or competitors—Schick and Toth (1995:48). From a viewpoint based in the 21st Century, and surrounded by the benefits of modern technology, it is exceptionally difficult to imagine how stone tools could have been used. In modern technology, we use the many natural substances that surround us. We have taken those substances to develop and manufacture an even greater selection of new material products with a range of properties for every purpose. This merely adds to the difficulty of comprehending both the existence of Stone Age tools and how they were used. However, the investigation and progressive understanding of human technology has been aided by research into the manufacture of early Stone Age tools as an experiment. The experiments included activities such as wood-working, animal butchery, and working on animal hides—Schick and Toth (1995:24).

03.02 Early Stone Age tool-making techniques

The primary requirement for the Stone Age tool-maker was to use stone as a material on which to create durable 'cutting edges'. Some of the Stone Age people were able to visualise the stone pebble as the material upon which a durable cutting edge could be worked. They also visualised the use they had in mind for that tool. How else would the Stone Age people use their imaginative gifts?

The following three diagrams, taken from Schick and Toth (1995:119), provide a pictorial summary of the major techniques determined by experiment. These were recent experiments, so the outcomes have been described by Schick and Toth (*ibid*) in modern language. Fig. 3.01 represents the most common technique that produced tools similar to those found at the earliest archeological sites.

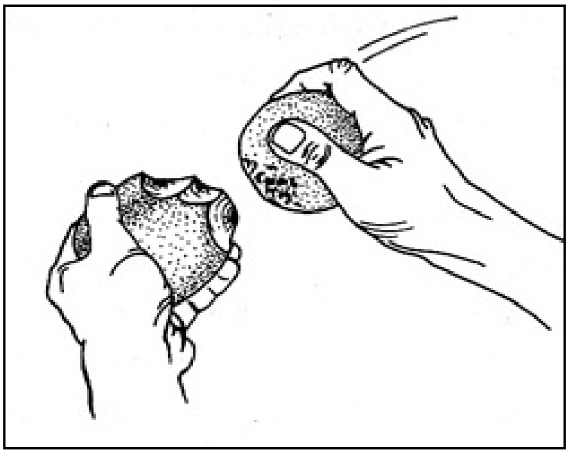


Fig. 3.01 - Hard-hammer percussion

In this technique, one pebble or rock was used to strike another. Some thought was required in the process of selecting the hammer stone. The stone, described as a cobble, had to be fairly smooth over most of its surface to minimise digging into the hand. The stone from which flakes were struck was known as the core.

The bipolar technique is illustrated in Fig. 3.02, in which the core was held on a third rock used as an anvil. A hammer stone was held in the preferred hand to strike the core, while the core was held on the anvil in the non-preferred hand. Typically, the hammer stone would strike flakes off the core top. Sometimes, the act of delivering force onto the core against the anvil produced flakes from the bottom of the core. The production of flakes from both ends of the core provided the name 'bipolar technique'.

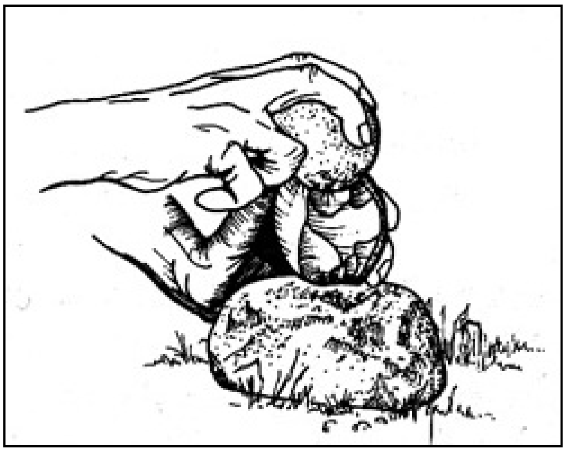


Fig. 3.02 - Bipolar techniique

Fig. 3.03 shows the anvil technique. In this method, the core was the active part of the process; it was struck against a larger stationary stone or anvil in order to generate the forces of fracture. This method was used when the core was very large, but it required two hands.

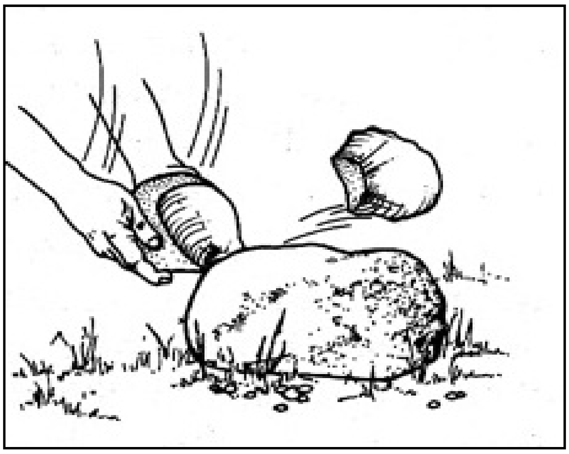


Fig. 3.03 - The anvil technique

There was an inherent danger in the method shown in Fig. 3.03, since sharp stone pieces and flakes could hit the head or body. Similar disadvantages arose in a further technique of throwing the core against an anvil stone, but that method is not illustrated here.

Fig. 3.04, illustrates an example of a pointed stone hand-axe, and shows the method thought to be used to hold the tool—Mitchell and Middleton (1981:6).

Fig. 3.04 - Pointed stone hand-axe

As a method of holding, the palm grip makes sense because the tool has a rough surface finish, and the gripping forces generated by the hand would be spread over a greater area. Hence the level of discomfort in the hand would have been less. However, while the palm grip makes sense, the position of the arm would not have been suitable for all applications of the tool. As illustrated in relation to the arm, the hand-axe would have been in use on a task that was at about head height, say for the removal of a tree branch. For uses at a lower level, say on the ground, it would have been more comfortable to hold the axe tool with an angle between the back of the hand and the arm.

A 'tool' is an object that has been used for some purpose—Schick and Toth (1995:48); it maybe used as found in its natural state, or modified to suit a special purpose. Tool use is not confined to the human species; non-human species such as chimpanzees use stones or fallen small branches to break open nut shells. In this process, branches or stones serve as either the hammer tool or the anvil tool. Chimpanzees also modify their tools; twigs are stripped to make them suitable for fishing termites or ants from nests—Schick and Toth (1995:49).

According to Schick and Toth (1995:26), the first stone tools occurred some 2,400,000 years ago. Bronowski (1979:40) considers that it was only 2,000,000 years ago, and this coincides with Oakley (1972:5) who refers to the early part of the Pleistocene period.

Mammals other than humankind changed over time and developed specialised equipment to help them live and survive in their habitat. For example, the teeth and hooves of horses living on grassy plains, the incisor teeth of beavers for stripping and felling trees, and the strong-gripping claws and sharp canine teeth of predatory cats—Oakley (*ibid*). The human species retained the five-fingered hand, that was particularly useful when it acquired the ability to walk upright as a matter of routine; the hands were free to use tools—Oakley (*ibid*).

Animals of all species, including human, leave indications of what they were; but the only animal that left indications of what it *created* was the human animal—Bronowski (1979:42); it used tools as extensions of itself. Tools enhanced its capability, productivity and creativity, and when it had finished with them it was able to put them down. The specialised physiques of all other animals feature appendages that cannot be put down. This alone restricts animals other than the human species to the habitat for which their physique evolved. The human species on the other hand was free to wander, and use the materials it found wherever it went. Wherever the human species wandered, it continued to make and use tools from the materials it found.

03.03 Other significant inventions

With the first acts of stone tool-making, the human species made not one but two inventions that were crucial to its evolution and its technology. The first, a simple blow by a hammer stone put an edge on another pebble to form the working tool. This basic working tool changed little over the next two million years. The second was the deliberate act of preparing and storing pebbles for later use—Bronowski (1979:40). The first Stone Age tools became standard implements, and this implies a long tradition of skill gradually learned—Oakley (1972:5). Making tools for both immediate and future use, indicates an ability for 'conceptual thought'—Oakley (1972:3). The suitability of stone as a material for the tools of early humankind was indicated by the duration of the Stone Age. This included the choice of material, how to fashion the tool, and how to use it—entirely imaginative activity.

The process of evolution of humankind included the development of a larger brain, and according to Schick and Toth (1995:26) this occurred about 2,000,000 years ago. The human ancestors with the larger brain, *Australopithecus*, also made two significant inventions - stone tools and 'social organisation'. The latter was perceived as a great step towards cultural evolution, and 'culture is a learned form of behaviour—a communally preferred form, which (like other inventions) has been adopted by a whole society'—Bronowski (1979:40/48). This is just one definition of 'culture', a crucial concept that has a bearing on the whole of this thesis. Technology and culture will be discussed in Chapter 6.

The biological evolution of the human species, which separated us from our ape ancestors, was a process that took millions of years as follows:

200,000,000 years ago	- the first mammals
65,000,000 years ago	- the first primates
35,000,000 years ago	- the first apelike forms
4,000,000 years ago	- the first (known) bipedal hominids
2,400,000 years ago	- the first stone tools
2,000,000 years ago	- the first evidence of brain expansion [in humankind]
400,000 years ago	- early archaic *Homo sapiens*—Schick and Toth (1995:26).

However, the cultural evolution that now distinguishes us from our foraging and hunting/ gathering predecessors, started the domestication of certain animals and the cultivation of plants—Asimov (1990:10), Bronowski (1979:59). And so started the agricultural way of life, 'the change from which civilisation took off'—Bronowski (1979:60).

Land used for herding and agriculture could support a larger population—Asimov (1990:11). The nomadic way of life was such that only the simplest of technologies could be carried from place to place on a daily basis—for example a goatskin bag on a simple wooden frame, for making yoghourt [*sic*]—Bronowski (1979:61-74). Settled agriculture on the other hand, was a deviation from the hunter/gatherer way of life; it was the deviation that laid the foundation for technological evolution, and eventually physics and science—Bronowski (*ibid*).

Then came the evolution of concepts with a particular significance for civilisation. Settled agriculture and domestication of the first animals achieved a level of productivity beyond the immediate need of the farmers. Goats and sheep were sources of food and material. Also, the ox and the ass as draught animals pulled the plough 'the most powerful invention in all agriculture'—Bronowski (1979:74/78). As a lever, the plough was an effective tool for turning over and lifting soil, so raising the capability and productivity of the human species.

It took imagination to harness the power of draught animals to the plough; this tool became part of a technological system, with skilled members of the human species in control—in other words a machine—Bronowski (1979:79). Farmers produced more food than their immediate needs—Asimov (1990:12). In farming communities or villages, people were free to develop craft skills and to 'trade' their products for some of the farmers' 'extra produce'. The 'extra produce' went into circulation in the local community, and was used to 'barter'; this was the start of trade. Coins were not invented until 640 BC—Asimov (1990:36).

The tool-makers of the human species continued to develop uses for natural materials. About 7000 BC, artisans produced pottery for storage and cooking—Asimov (time line), Schick and Toth (1995:305). The first flax cords were produced as early as 6000 BC; these cords made nets for fishing. Finer nets became the first cloth, which revolutionised clothing—Asimov (1990:14). Catching more fish than a family could eat also yielded 'extra produce'. By using its technology on the land and on the seas, the human species had learned to generate extra produce which could be bartered. The extra produce was the basic currency of all trade and all economies until the invention of coinage.

Settled agriculture led to a progressive understanding of mechanics, and eventually science, and continued the state of permanent change for the human species. This evolution, as technology, was for a long time sufficiently slow to minimise the fear of change. As we progress however, the pace of technological change is increasing. We have lost sight of the roots of technology, and this lingering ignorance will remain until National Curriculum documents contain definitions of 'Technology' and 'Design'. Since technology has roots in the Stone Age, it is appropriate to quote the perception of two archaeologists. Schick and Toth (1995:49) state:

> Technology is something much larger than the tool itself. It refers to the system of rules and procedures prescribing how tools are made and used … To have a technology *per se*, there should be some agreed-upon ways of doing things in a social group—that is, there should be some learned, *cultural* aspect to the tool use or artifact manufacture.

With the growth in the imaginative ideas of the human species, technology has become a vast subject within our tool-culture. Technology is in a constant state of change. This perpetual state of change occurs through the revision and/or updating of existing technologies, with the addition of new technologies as they are developed and introduced. The combination of updating old technologies and introducing new technologies happens as humankind continues to expand and extend its capability and productivity within the world of its existence, within the world of its experience.

The human species has learnt on a continuous basis how to use the available materials, evolved uses that would provide for its further needs, and to cope with the natural world. By so doing, it has constantly demonstrated remarkable ingenuity, perseverance and inventiveness. Although there are 'downsides' to some aspects of technology that present causes for concern, all the positive benefits are taken for granted.

Definitions of technology are necessary as a vital step to understanding the place of technology in our society. It can be argued that as a society we neither see nor understand our dependency on technology, and this argument will be developed.

03.04 'Technology' as a word

In terms of history, 'technology' is a relatively recent word, yet its origins are contentious. For example, Rose (1971:16) writes '… the word "technology" was a German invention of the 1770s …'. In the Oxford English Dictionary (1961:137), however, there is a reference to 'Technology' as early as 1658. In any event, this relatively recent word enables description of earlier ages and practices of humankind.

03.05 In summary

As we have seen, technology evolved as the means by which the human species developed a degree of freedom not shared by any other animals. Other animals evolved specialised physiques to survive in their surroundings. So they were restricted to their habitats. The human species on the other hand invented tools, used its imagination, and learning from experience. Humankind also used its hand/eye coordinated skills on the available stone materials, and learnt about the properties of the materials by which it was surrounded.

Because Stone Age humankind learned to make and use tools as extensions of itself, the human species was not constrained by its habitats. Humankind could put down and pick up its primitive tools as it chose, and was freed to wander. The imaginative thought processes that guided the hands to produce the first tools in suitable materials, were crucial in the evolution of the human species. Humankind was served by its technology. The greatest tribute that can be paid to those first tools is that the human species survived and evolved because of them, but they also laid the foundation of our tool-culture.

Culture, as collected learned preferable forms of behaviour, was explicit in the evolutionary technological processes. Settled agriculture created the platform from which humankind could use its imaginative gifts to explore further the properties of available materials. Also, to discover how those properties could be utilised for its benefit, to increase its capability and productivity. The members of the human species extended their capability and productivity by inventing settled agriculture and herding. Thus farming communities were able to produce beyond their immediate needs. What they did not need, the 'extra produce', was used to barter for artefacts produced by artisans. By 7000 BC, artisans were producing pottery for storage and cooking—Asimov (time line), Schick and Toth (1995:305).

So economic infrastructure was first established on farming communities; artisans made artefacts to trade for some of the 'extra produce'. Trading became part of the culture. An interdependency was established between those with the skills and resources to produce more than was required for their immediate needs, and those with useful artefacts to meet perceived needs. The artisans were also producing beyond their immediate needs, and survived because of their imaginative ideas in combination with their hand/eye coordinated skills. Barter as the system of trade was eventually replaced by a system of coinage, but not before 640 BC. Coins were yet another product of the early tool-cultures.

Within their socioeconomic communities, the inhabitants learned to develop the skills for which they had the greatest aptitude, and the knowledge of access to the necessary resources. Through bartering their produce, the farmers and the artisans were competing with their skills and their knowledge. This then was the place and perception of technology in earlier times. Those who understood, lived and survived by their technological skills and knowledge. Some pushed forward the frontiers of their skills and knowledge, and handed down what they had learnt, but it was a slow process.

Before closing this chapter, some comment should be made on perceived overlapping areas of study. As an example, for Sauer[1] (1889-1975), 'geography was inseparable from human history inasmuch as the Earth, its resources, and its environment are profoundly affected by humanity'. The geographer also studies 'the elements of culture, such as artifacts and tools, techniques, attitudes, [and] customs'[2].

This thesis reflects on how humankind has used the resources of the earth to sustain itself, but in particular through the creative activity of the mind. The creative imagination of humankind gave rise to the continuous expansion of the products of our tool culture, and the tool inventory that now underpins the way we live as individuals and as a society. As stated earlier, from a view point based in the 21st Century, the origins of our tool culture are not easy to comprehend. However, reflect on the following:

> When Captain Cook [1728-1729] first sailed into the South Seas, they were surprised by the native demand 'for iron'. Indeed, 'iron was their beloved article'. 'A nail' could be exchanged for 'a good-sized pig', or 'four hundred pounds of fish' for 'improvised knives' —Smiles (1863:1).
>
> 'The principal tools of the Otaheitan' natives were of 'wood, stone and flint'; Cook thought them clumsy. The 'adzes and axes' were made of 'stone'. The 'bone of the human forearm' was commonly used as a 'gouge'. For a knife they used a 'shell, or a bit of flint or a jasper'. 'A shark's tooth, fixed to a piece of wood, served for an auger; a piece of coral for a file; and the skin of a sting-ray for a polisher. Their saw was made of jagged fishes' teeth fixed on the convex edge of a piece of hard wood'—Smiles (1863:2).
>
> The native stone tools were made 'by rubbing one stone on another' to achieve the 'required shape'; they were 'inefficient', 'soon became blunted and useless', and the 'laborious process of making new tools had to be begun all over again'. 'The delight of the islanders at being put in possession of a material which was capable of taking a comparatively sharp edge and keeping it, may therefore readily be imagined'. Iron was identified by the natives with 'power, efficiency, and wealth; and they were ready almost to fall down and worship their new tools, esteeming the axe as a deity, offering sacrifices to the saw, and holding the knife in special veneration'—Smiles (1863:3).

Lastly, fire was 'tamed' some 500,000 years ago—Asimov (1990: time line), and used as a tool; see also Oakley (1955:36), Bronowski (1979:41), Basalla (1988:13), Schick and Toth (1995:68). With the eventual refinement of precision as a technology applied to the design

[1] http://search.britannica.com/eb/article?eu=67581&tocid=0&query=carl%20o.%20sauer

[2] http://search.britannica.com/eb/article?eu=118093&tocid=32061&query=carl%20o.%20sauer

and manufacture of machined parts after the Industrial Revolution, fire could be applied as a tool with increasing sophistication, and the technology of welding provides one example.

The next chapter considers the evolution of technology up to the Industrial Revolution. The technologies were based essentially on learning practical skills achieved by imaginative application of hand/eye co-ordination, together with ingenious uses for available materials. This thesis reflects on the historical and cultural origins of technology through one key concept namely that of the cutting edge. The cutting edge remains an exceptionally important concept which eventually enabled humankind to progress to the technologies of precision as the key to replaceable parts and mass production. The way we now live is totally dependent on the technologies of precision. Up to the 17th Century, the range of materials available was limited. Before the second half of the 19th Century the influence of science on industry was not significant. The inner compulsion for humankind was to improve capability and productivity by reasoning processes.

Chapter 4

The evolution of technology up to the Industrial Revolution

04.01 Introduction

If the evolution of technology is to be understood, some consideration should be given to the key phenomenon embedded in the process, namely that of 'invention'. In Chapter 3, reference was made to the imaginative gifts of humankind—Bronowski (1979:20). Humans have a noticeable aptitude for formulating and structuring ideas—Oakley (1972:3). Understanding those gifts and aptitude is fundamental to comprehending the evolution of humankind. It is equally fundamental if the technological evolution sought by humankind in order to enhance its capability and productivity, is to be put in perspective.

Human beings enhanced their capability and productivity using the materials by which they were surrounded. But the pace of change also needs to be understood. During the Stone Age, ideas as visual images were slow to emerge. As the formulation of new ideas gathered pace, they were eventually shared with others. The learning spread, and as a consequence more ideas and new discoveries emerged that further enhanced the capability and productivity of humankind. Thought and action existed in 'preliterate societies'—Usher (1954:59).

Historical and cultural reflection discloses a repetitive process at the core of technological continuity and progression. Iteration of common principles becomes apparent as knowledge-builds-on-knowledge, creating successions of new convergent syntheses, providing the continuity and progression manifest in technology. Since the processes were always iterative, their description introduces repetitive use of the core terms in this chapter, and the rest of the thesis.

04.02 The nature of invention

When innovation occurs, it does so as a result of a number of factors coming together, or as a 'convergent synthesis'—Usher (in Woodbury 1972a:i). Those factors include seeing an advantage in doing something in a different way, but as a process of visualised non-verbal images. The creative innovative process is arguably dominated by visual non-verbal images —Basalla (1993:67), Ferguson (1977:827). But the thought processes, as they engage in visual non-verbal images, require acts of intuitive insight to achieve innovation—Usher (1954:64-66). The act of insight is symbolised in Fig. 4.01 below—see Usher (1954:66).

Fig. 4.01 symbolises a synthesis of familiar methods—Usher (1954:66). The incomplete circle at '1' represents the perception of a problem. At '2', the broken circle described as 'the setting of the stage', implies that a solution is feasible although not necessarily imminent. The act of insight is represented by the full circle at '3', whilst the bolder circle at '4' symbolises 'critical revision' and resolution of the problem—Usher (*ibid*).

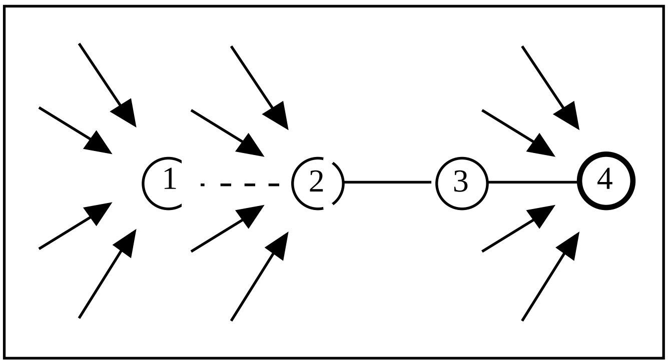


Fig. 4.01 - The emergence of novelty in the act of insight

Hence when a potential innovator first appreciates the shortcomings of doing things in ways that have become traditional, the first step of the inventive process has become active. The potential innovator perceives how the 'present' way could be improved as a sequence of visualised images and, following an act of insight, they go on to visualise and implement the solution.

A potential innovator first has to acquire a high level of knowledge in the skills, methods and materials that have become traditional. Without such a level of expertise, it is highly unlikely that 'ways of doing things better' would be visualised or implemented. When this innovative process has run its course, invention has taken place. But strategic invention can take generations.

The process, briefly summarised in Fig. 4.01, represents variable periods of time that allow of 'cumulation'—Usher (1954:67). Accumulation of experience and knowledge is possible in human societies because of their life span—Usher (*ibid*). Ever since the Stone Age, this cumulative acquisition has been a social cultural achievement; the enormity of this cultural process was long overlooked—Usher (1954:68). However, this process yields successions of significant inventions as products, bringing together many specific features of novelty, and many familiar methods—Usher (*ibid*). Thus invention is a social and hence cultural process —Basalla (1993:103). This cultural process is 'cumulative synthesis', represented by Usher (1954:69) as shown in Fig. 4.02.

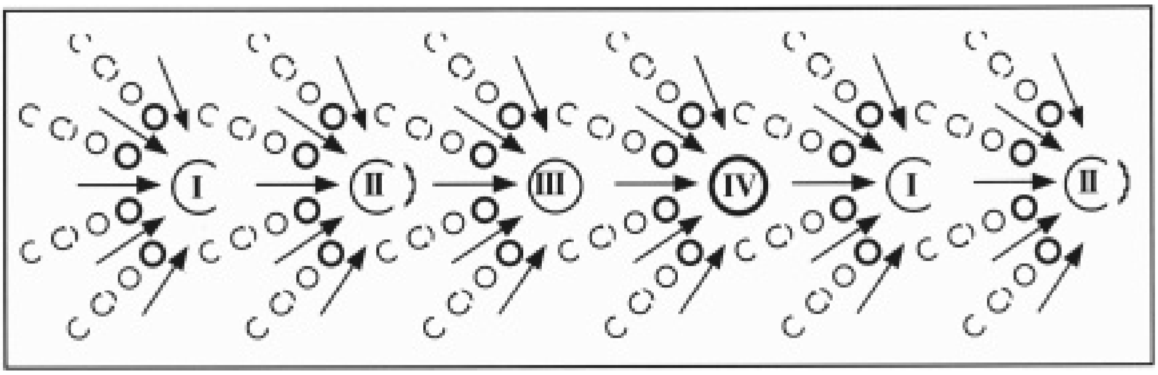


Fig. 4.02 - The process of cumulative synthesis

Fig. 4.02 represents one-and-a-half cycles of strategic invention—Usher (*ibid*), with constituent parts as follows:

- the strings of four small circles represent 'acts of insight' as shown in Fig. 4.01.
- arrows represent traditional methods that were once novel, and now in a new synthesis.
- the number of arrows and traditional methods at each step are variables.

The arrows and small circles represent separate 'multi-linear' processes—Usher (1954:69). Roman numerals 'I', 'II', and 'III' symbolise strategic inventions that have 'accumulated' and enabled further acts of insight, leading to a new strategic invention symbolised by 'IV'. The invention at 'IV' eventually becomes part of a new cumulation, a new convergent synthesis, and a new cycle of innovation begins at the second 'I' and 'II' as shown in Fig. 4.02. As stated earlier, this social process can take many generations.

As innovators attempt to find different ways of doing things, they share another factor common in the convergent synthesis, namely an 'inner compulsion'—Woodbury (1972a: Preface). Woodbury (*ibid*), goes on to argue that the 'inner compulsion … is quite independent of social and economic forces'. But surely primitive human societies learned to do things in ways that were different because of social forces, namely those to do with improving the chances of survival, and more recently the quality of life—Newton (1993:7). In an industrial society, the personal innovative compulsion is mostly not independent of social and economic forces.

For those with the gift of invention, the innovative compulsion has always been a powerful force within humankind. People derive great pleasure and satisfaction from the demonstration of their skills, and having obtained the proof of their imaginative ideas and their skills, they love to make further improvements—Bronowski (1979:116).

A latent capacity for invention exists among all peoples—Basalla (1993:65). In a modern industrial society, innovation is rarely an act of inspiration as is popularly held in the romantic concept of invention—Usher (in Woodbury 1972a:iv). Furthermore, innovation does not proceed from the implicit to the explicit in an inevitable linear relationship: rather it is a multilinear process—Usher (*ibid*). A multilinear process in a convergent synthesis whereby the west may like to think that the number of factors involved are possibly more complex in a modern industrial society than they were for primitive societies. Nevertheless, one factor that was common for primitive humankind, and should be present for ourselves today, is that of sustaining ourselves as a society. How many in our society today can perceive that need, or understand the central role of technology in that context?

Technology is as old as humankind, and has evolved alongside humankind. Since the Stone Age, technology has been in a state of continuous evolution. The continuity and progression of humankind through the generations, has been matched by continuity and progression in technology. Each generation has developed its own 'cumulation', derived its own 'acts of insight', and produced its own strategic inventions. Thus each generation has evolved its own technology; the technology of its culture, of its own imaginative capability and era.

Technology is many things, but at the core it is to do with extending human productivity and capability in every aspect of human experience, and this includes improving the convenience and the quality of the way we live. Additionally, as humans developed their technology, they discovered an ever-increasing variety of materials to enhance the way they live. The way we live now is entirely due to the evolution of technology, through the Stone Age, the Bronze Age and the Iron Age. One implication of this statement is that each 'basic material' age after the Stone Age provided the foundation for succeeding ages. The term 'basic material' rather than 'raw material' has been used since a variety of material types were represented. Stone appears in many different forms, and constituent mixes. Bronze at the simplest level is an amalgam of copper (an element) with a small amount of tin (another element). Iron is an element. An element is a substance that cannot be resolved by chemical means into simpler substances—OED.

From the previous paragraph, the Stone Age provided the basis for the Bronze Age, and the Bronze Age provided the foundation for the Iron Age. Certainly the tool shapes that had evolved in stone could be found in the first bronze tools—Basalla (1993:32). The shape of Stone Age tools evolved as people increased their knowledge of the properties of stone. Similarly, as humans became more familiar with the properties of metals, they made better more durable tools—Basalla (1993:31). But the forms of some modern tools such as the axe, hammer and saw have their precedents in the early stone equivalents—Basalla (1993:32). Continuity and progression in technology has brought us through the Industrial Revolution to the way we live now, as briefly summarised in Fig. 4.03 below. This continuity supports the theory of 'multi-linear convergent synthesis'.

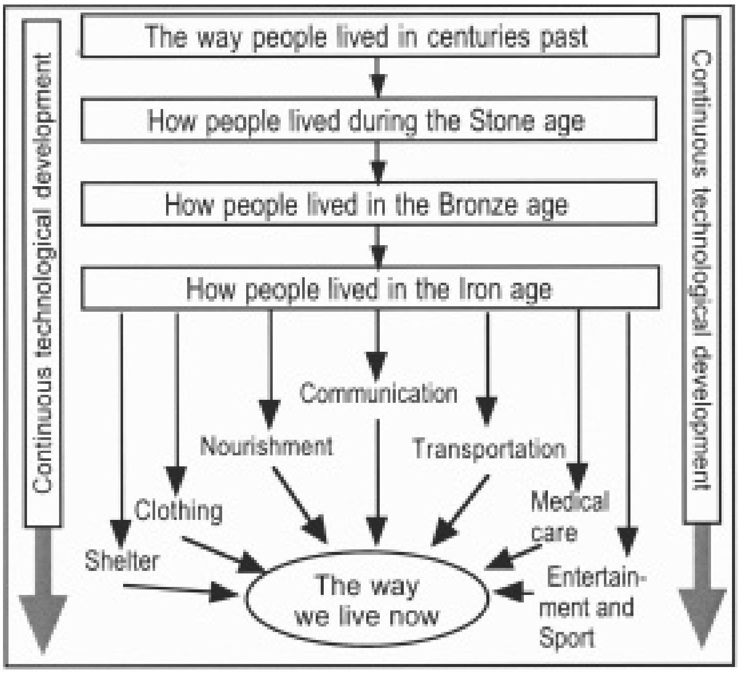


Fig. 4.03 - Technological evolution in every aspect of human existence has brought us to the way we live now

In Fig. 4.03, note how Bronze and Iron have named at least two of the past ages, and because of technology we now live in the Space Age. But these ages, together with the Dark Ages and the Middle Ages, were almost certainly not contemporaneous names, as are the Space Age and the Information Age. Computers made space travel possible, and because of the spread in computer use, we now find ourselves in the Information Age. Schick and Toth (1995:271) refer to the 'preservation of prehistoric wood at Clacton-on-Sea…, in particular the broken shaft and tip of a spear made out of yew. This is the earliest definitive evidence of wood technology in the prehistoric record.' However, wood has apparently not been used to name an Age. As humans learned about the new materials around them, they found ways to incorporate those materials into their tools. So the tools of humankind could be classified in the following 'ages':

- 'No tools
- Wooden tools
- Stone tools
- Copper (Bronze) tools
- Iron tools
- Multi material machine tools
- Silicon [chip] controlled machine tools'—Mellor (1997:1)

As humans increased their knowledge of materials and their mechanical skills, so their productivity and capability has increased. The knowledge of humankind has built on knowledge—Richmond (1993:17). However, Fig. 4.03 does not disclose the pace of technological change, the outcome of an expanding knowledge base. The period of the Stone Age lasted for two million years—Schick and Toth (1995:26). Through the imaginative application of humankind and visual ideas forcing the pace of change, no other technological age was destined to last so long. The pace of change is critically important when attempting to comprehend our dependency on technology, since there has been an imaginative explosion. This research will demonstrate that technology is perceived as a recent phenomenon, but it is clear that this is just one of many misunderstandings.

04.03 The pace of technological change

The bipedal species of humankind emerged about 4,000,000 years ago—Desmond (1987: Introduction). The first stone tools occurred some 2,000,000 years ago—Oakley (1972:5). *[Note: Recent archeological information points to the possibility of new timing on these events that has yet to be clarified—Mayr (1997:544)].* Arguably, the Industrial Revolution[3] started about 250 years ago—Rubinstein (1994:1). Even with the uncertainty about when humanity first started to use tools, it is possible to develop a useful model for the pace of change.

[3] Industrial Revolution is a term used by economists, historians, sociologists and scientists—for economists or historians in addition to Rubinstein, see for example Pollard and Crossley (1968:174), Robbins (1990:17), Landes (1972:71), West (1975:3), Fay (1950:3), Hutton (1996:1) and Miller (1992:134). Among scientists consider Pacey (1996:18), Basalla (1993:27), and Rose and Rose (1971:17).
Referring to a specific point in time for the start of the Industrial Revolution not only mis-represents the continuity and progression that has taken place in technology, but implies a mathematical model of progression as a step function which is just not feasible. However, for the author's purpose, it is a convenient vehicle to illustrate and present points of argument.

In a time frame from Bipedal humankind to the present day lies the difficulty of understanding the pace of change. How can the span of a thousand years in time, let alone a million years, be comprehended? It may be better understood if each year as a unit of time is represented by a smaller unit of time. Fig. 4.04 represents each year of actual time as one second in time—a ratio of some 31,557,600 to 1. Such a model borrows from an idea by Desmond (1987: Introduction). He represented the whole of the existence of the earth on the face of a 24 hour clock.

Event	Years ago		Equivalent as seconds expressed in days/hours
Appearance of Bipedal humans	4,000,000	=	46.3 days
First stone tools (1)	2,400,000	=	27.78 days
Oil lamp invented (2)	20,000	=	5.56 hours
Agriculture developed (2)	10,000	=	2.78 hours
Bronze discovered (2)	5,600	=	1.56 hours
Candles used (2)	4,800	=	1.33 hours
Glass used (2)	4,500	=	1.25 hours
Alphabet developed (2)	3,700	=	1.03 hours
Iron Age began (2)	3,000	=	0.83 hours
Abacus used (2)	2,500	=	0.69 hours
Parchment (2)	2,170	=	0.60 hours
Glass-blowing developed (2)	2,100	=	0.58 hours
Waterwheel invented (2)	2,080	=	0.58 hours
Steam power used (2)	2,050	=	0.57 hours
Industrial Revolution (3)	**240**	**=**	**4.00 minutes**
Faraday's experiments (4)	168	=	2.80 minutes
Candles for lighting removed from Retail Price Index (5)	43	=	0.72 minutes

References:

(1) Schick and Toth (1995:26)
(2) Asimov (1990: Time Line)
(3) Rubinstein (1994:1)
(4) Usher (1954:400); discovery of the principles of the dynamo to produce electrical power—see later in this Chapter.
(5) CSO (94) 84—see also Chapter 5.

Fig. 4.04 - Technological pace of change.
Model of elapsed time - each year of actual time represented as a second

From Fig. 4.04, the first stone tools appeared 28 days ago, agriculture started less than three hours ago, and the Industrial Revolution started about four minutes ago. Faraday's experiments in 1831, which led to the discovery of the dynamo and eventually to the technology of electrical power, occurred less than three minutes ago. However, lighting by electricity or gas was not sufficiently widespread until 1956 for the humble candle to be taken off the Retail Price Index.

What is most striking about such a comparison is the increasing imaginative activity which has enriched the capability and productivity of humankind, and this activity continues to accelerate. This has been made possible because of socially cumulated knowledge and skills, with acts of insight contributing through further imaginative activity to strategic invention. The pace of technological change has been truly remarkable.

Although Fig. 4.04 helps to comprehend the pace of technological change, it greatly distorts the time required for the innovative process to take place. The gestation period leading to change in the Stone Age was clearly of great duration. Since we have no way of knowing how it worked, it is reasonable to reflect on how that process may have come about.

Gradually, as the simple technologies spread and each new generation acquired the skills of the established ways of doing things, further opportunities were created by a new 'convergent synthesis'. Stone Age humans manipulated what they knew, including their practical skills, knowledge of available materials and where to find those materials, with what they were able to visualise. The younger generations would acquire the practical skills learnt by their elders, and some would eventually visualise newer ways of doing things. So the nature of the convergent synthesis providing the basis for change was probably along the following lines:

- A significant level of skill in the traditional technologies of the time.
- A significant level of understanding of the properties of the materials available.
- Skills in traditional methods provided the foundation for visualising a better way.
- Having visualised a better way, the inventor found ways to implement the solution.
- The solution was based on the best practice of imaginative skills in combination with practical knowledge for some aspect of technology that was already useful.
- The outcome would be a small improvement or step in the prevailing technology.
- This process goes on *ad infinitum*, but only through those with the aptitude and compulsion.

However, reflecting on today's situation, although we are all tool-users we are not all tool-designers or tool-makers. This situation has been the case throughout the history of humankind. So it is reasonable to suppose that Stone Age humankind had different levels of capability and productivity. Also, those different levels of capability would have had a fundamental influence on the pace of technological change. The different escalating levels of capability in tool-use (or technology) could have been as follows:

- Those younger people who, with training, could use tools.
- Those who could visualise the process and take easily to tool use.
- Those who could see where improvements were possible.
- Those with the highest level of skill in tool use who could imagine better ways, could design (visualise) improvements and carry them out, so creating a better or new tool, or technology.

The increasing sophistication, complexity and pace of change of technology has clearly brought about a transition in the last of these points. Typically, a designer no longer possesses all the skills, nor necessarily all the relevant knowledge. However, a good designer knows how or where to obtain the knowledge required. Every new idea is only as good as the quality of the imaginative analysis of the problem to be resolved. The quality of imagination in the solution dictates how well accepted the new technology becomes. Tools and technology are inseparable. All animals, other than humankind, developed within the confines of their habitats. Humankind differed from all other animals by their imagination, and their ability to make and use tools—Oakley (1972:1). These capabilities allowed humans to wander, to make new tools from the materials available wherever they went.

When the tools had served their immediate purpose, they could be put down until they were required again. Thus every implement we pick up to use for some purpose is a tool by generic definition. All categories of functional implements are 'tools' first and foremost. Implements such as musical instruments, cooking utensils, crockery and cutlery are tools. Tools provide the basis of technology. Names for artefact sub-groups were required to make communication easier. When we reflect upon this, it becomes clear that there is a great diversity of human artefacts and tools; we would now find it impossible to function without them. Without exception we are all tool-users, but few are tool-makers or tool-designers at the highest level. Similarly, while we are all technology-users, we are not all technology-designers or technology-makers.

04.04 Technology and continuity

Continuity in technology is complex. It encompasses diversity, perceived need as well as the multi-linear convergent synthesis that is required to achieve technological breakthrough. Not every culture identifies the same need, so technology is culture-specific.

An indicator of the imaginative activity of humankind may be gauged by the number and diversity of its artefacts. One method of gauging that diversity is to consider the patents issued in the USA; assuming an artefact for each one, technological diversity can be said to be three times greater than organic diversity—Basalla (1993:2). Although this methodology was acknowledged as crude, the variety of human artefacts remains just as surprising as the variety of 'living things'—Basalla (*ibid*).

'Need' or 'necessity' appears in all three issues of the Statutory Order for Design and Technology or Technology—see:

- Design and Technology for ages 5 to 16, 1989:1.
- Technology for ages 5 to 16, 1992:6.
- Design and Technology for ages 5 to 16, 1995:3.

However, 'need' may not always be the spur for technological invention—Basalla (1993:6). The automobile is one example—during its first ten years 1895-1905, it was a toy 'for those who could afford' it—(*ibid*). For many, it is now a necessity.

Whether 'necessity or need' were the spurs for technological evolution was further tested by

Basalla (1993:11) when researching the origins of the wheel. What started as a quest to discover the 'universal human need' for the wheel, concluded with the wheel perceived as an invention that was culture-specific to the West—(*ibid*). As an outcome of his research, Basalla (*ibid*) deduced:

- 'Wheeled vehicles were not necessarily invented to facilitate the movement of goods.'
- 'Western civilisation is a wheel-centered civilisation that has carried rotary motion in transportation to a high state of development.'
- 'The wheel is not a unique mechanical contrivance necessary, or useful, to all people at all times.'

So it follows that the structure of the convergent synthesis will not be the same for each culture. In other words, there would be no point in developing the wheel in a society that did not have even the most rudimentary roads. Thus technology was and is culture-specific.

Animals other than humankind have always existed without fire or stone tools—Basalla (1993:13). One assumption is that people could have similarly survived—Basalla (*ibid*). However, basic to primitive humankind's existence was the need to obtain food and drink, and to ward-off competitors and predators. Those were fundamental needs for which the human species sought the aid of technology. Humans sought to elevate their way of doing the things that occupied their day—the things they saw as necessary for their survival. Some were also responding to an inner compulsion to do those things with greater capability and productivity. The only way they could was by using the materials they found around them. So began the evolution of technology with a continuity spurred by the imagination of humankind. But each society or culture responded to its own convergent synthesis.

04.05 Technology and precedent

The regions of the earth that primitive human societies chose to inhabit, provided the resources upon which they became dependent. The regions they chose were determined by their skills in using the available resources. So the regions were associated with their technology—Usher (1954:2). Primitive human societies were limited also by the quality of their knowledge and techniques in using the materials they found in their environment—Usher (1954:9). So humankind was influenced by its environment, but equally, its environment was influenced by humankind; the process of evolution was 'doubly dynamic' —Usher (1954:2). Technology was the pivotal factor in the evolution of humankind, and represented the outcome of imaginative activity. In other words, the acquisition, retention and handing-down of knowledge and skills developed by humankind—Usher (1954:2). As humankind evolved, the technology of humankind also played an important part in the development of its mind—Usher (*ibid*). Technology therefore, especially in the area of mechanical change, offers a convenient vehicle through which to study the innovative processes of the mind in all fields—Usher (*ibid*). Technology remains a pivotal constituent in the existence of humankind, but few understand the 'how' or the 'why' in this argument.

In the discussion on convergent synthesis, reference was made to the wide range of abilities and/or skills possessed by the human species. A newly acquired enhancement in skill may be sufficient for mechanical innovation at a basic level. At the highest level however, innovative processes exhibit 'abstract concepts'—Usher (1954:56), particularly as the imaginative activity increased in scope. The growth in mechanical knowledge was such that by the 15th Century, the difference between 'pure' and 'applied science' could be discerned —Usher (*ibid*). Science became increasingly influential in the area of mechanical invention, which exhibited 'all the characteristics of innovation in any of the conceptual fields'—Usher (*ibid*). Historical records allowed more thorough examination of the mechanical inventive processes than was possible in 'many portions of the history of philosophy and the arts'—Usher (*ibid*). Thus the emergence of novelty in thought and action, could be studied in general through innovative mechanical processes—Usher (1954:57).

The implication of the multilinear convergent synthesis is that since the Stone Age there has always been a precedent for a new tool or piece of technological advancement. Thus it becomes difficult to support the popular belief of the hero inventor. The hero inventor operates in a single linear mode, and moves from the implicit to the explicit—Usher (in Woodbury 1972a:iv). However, such an argument, the multilinear convergent synthesis, poses questions about the precedents for the primitive tools of Stone Age humankind. Were these toolos wooden sticks fashioned for different functions? In any event, with such early precedents, the gestation period in the first technological steps of humankind were bound to be of great duration. The multilinear convergent synthesis available to Stone Age humankind would have been extremely limited.

The history of technology reveals that human beings have persistently sought to elevate the conditions of their existence, and doing this by using the materials they found around them —Daumas (1969:Preface). The artefacts of humankind are too numerous to study in this thesis. As a study, the history of technology is made more difficult because it is 'culture-specific'. However, the subject of this research—the place and perception of technology in the curriculum—will be adequately served by an examination of one of the machine tool technologies, namely the lathe.

The evolution of the lathe will serve also to understand the evolution of technology through to the Industrial Revolution, and to the way we live now. By the time of the Industrial Revolution an increasingly wide range of materials was available, and some could be worked with increasing levels of precision. Precision manufacture was the key to inter-changeable parts, and a primary requirement for mass-production—Williamson (1968:3). The way we live now is made possible because of mass-production.

A study of the evolution of the lathe will show how humankind sought continuously to improve the methodology of its technology. The analysis will consider continuity and progression, hence precedent, and explore the concept of the multilinear convergent synthesis. The analysis will start from an early precedent. Acts of insight responsible for innovation, and possible improvement in technological methodology, will be highlighted.

The term 'possible' is used since the scholarly history of the technology of machine tools has not been extensive—Woodbury (1972d:10).

The level of electrical lighting we enjoy today became possible because of machine tools, and particularly the lathe. The generator sets that produce the necessary electrical power, are typically driven by steam turbines. Without machine tools, neither generator sets nor steam turbines could be produced. Machine tools and electricity generating sets now have a mutual dependency, so how were any of them achieved where none existed?

The purpose here is not to provide an exhaustive dissertation on the evolution of the lathe, even if records allowed, but to demonstrate the continuity and progression that prevailed in the technology through acts of insight. Those acts included learning about new materials, how to work those materials, and eventually to identify the materials in which the technology of precision could be achieved and retained. Imaginative solutions were also required to perceived functional problems. In combination with new materials, a new convergent synthesis emerged that provided the 'strategic invention' of the industrial lathe.

04.06 Technology and the evolution of machine tools

In western industrial societies, every product bears witness of technological achievement. Products such as cars, trains, ships and aircraft are obvious examples, as well as all the equipment used in the home. However, none of these or any other modern products would be feasible without machine tools. Pioneers such as James Watt (steam engine), George Stephenson (locomotive), Gottlieb Daimler (car), Rudolph Diesel (compression ignition engine), and the Wright Brothers (aeroplane) became household names because of their achievements. However, none of the achievements of these famous pioneers would have been possible without machine tools—Rolt (1965:11). Machine tools have a special place in the evolution of technology—Rolt (*ibid*). Although historians and sociologists acknowledge the 'powerful influence of technology', they have not considered the role of machine tools; to do so, it becomes necessary to examine the 'hardware'—Woodbury (1972a:Preface).

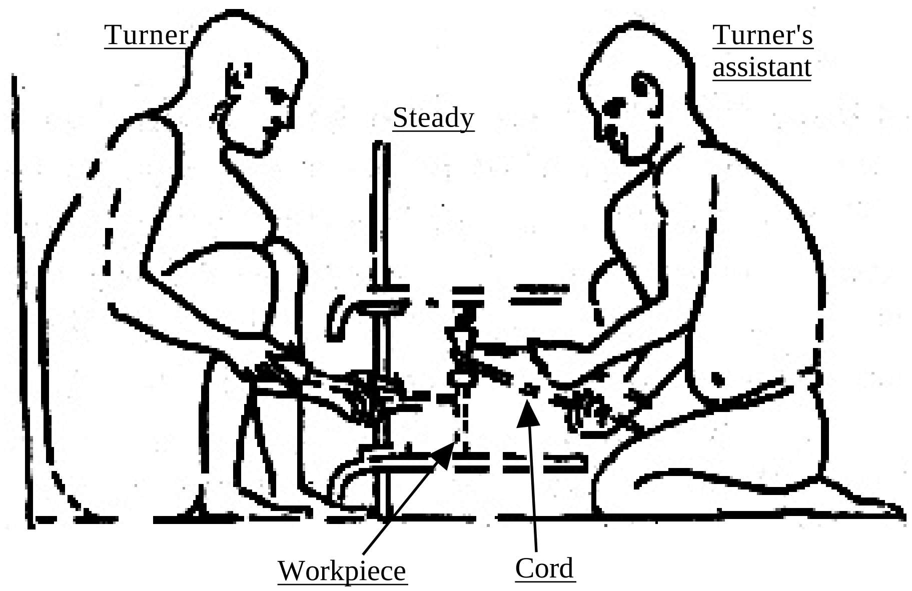
There were many pioneers in the field of machine-tool development. As tool-makers, their place in history is less well known since their achievements appear within the workshop, to be admired only by engineers—Rolt (1965:11). Modern machine tools are designed to cut and shape materials, particularly metal—Gilbert (1975:1). They also allow objects to be produced with greater consistency and accuracy, a prerequisite for interchangeable parts as the key to mass production—Evans (1989:12).

There are a number of basic machine-tool configurations including the lathe, the grinding machine, the milling machine, and the gear-cutting machine. The most important of these was the lathe. Its origins in time are uncertain, and have to be inferred from artifacts that have come down to us—Woodbury (1972d:18). The available scholarly history of the lathe is mostly German in origin, 'and their books are out of print'—Woodbury (1972d:11). Two relatively recent scholarly works include Rolt (1965), and Woodbury (1972).

04.06.01 The earliest lathes

Lathes are used to make things. As tools, they extend the productivity and capability of humankind. The lathe allows a workpiece to be rotated about a fixed axis for the removal of unwanted material in order to create a smooth circular finish. This technique is still known as 'turning'. Typically, a tool is held against the revolving workpiece to remove excess material. The remains of turned wooden bowls or vessels were discovered in Italy dating from c.700 BC, in Asia Minor from the 7th Century BC, and in Upper Bavaria from the 6th Century BC—Woodbury (1972d:20/21).

Although the remains of turned artifacts have been found from such early times, there are no surviving examples of lathes from the same periods—Woodbury (1972d:30). However, there are illustrations of lathes for reference. One of the earliest illustrations appeared in an Egyptian grave of the 3rd Century BC—Woodbury (1972d:32). Fig. 4.05 shows this early lathe with two workers: (1) the turner, doing the more skilled task, and (2) a person providing the motive rotary force through a cord. A wooden furniture leg was being made—Gilbert (1975:2).



Note: The illustration shows two people working on a very early lathe. The person on the right was providing rotary to and fro motion of a workpiece by means of a cord. The person on the left (called the turner) used this rotary to and fro motion to cut and shape the work piece. The turner used the steady as a fulcrum to control the cutting edge on the workpiece.

Fig. 4.05 - Early representation of a lathe

The earliest lathes were driven by cord—Rolt (1965:20).

04.07 Early improvements in lathe technology

The spread of lathe technology in the 'ancient world' was attributed largely to the Romans—Woodbury (1972d:38). By the Middle Ages there were a number of important advances in the development of the lathe—Woodbury (*ibid*). The progressive steps included:

- a spring-pole-and-treadle-drive system to rotate the workpiece, again to and fro,
- a more rigid structure in the bed and stocks,
- the first mechanical means of holding the cutting tool,
- continuous drive of the workpiece.

Each of these improvements required an act of insight. To recapitulate, there are two groups of variables in technological progress, and they are often entwined. The first has to do with the materials available, and whether imaginative methods and tools exist or can be found for working those materials. The second has to do with the imaginative perception of a better way of doing something, an improvement on a method that has become traditional.

<u>04.07.01 The pole lathe</u>

Fig. 4.06 below reveals a number of acts of insight in the 'pole lathe' of the 14th Century, as illustrated in the *Mendelesches Brüderbuch*—Rolt (1965:21).

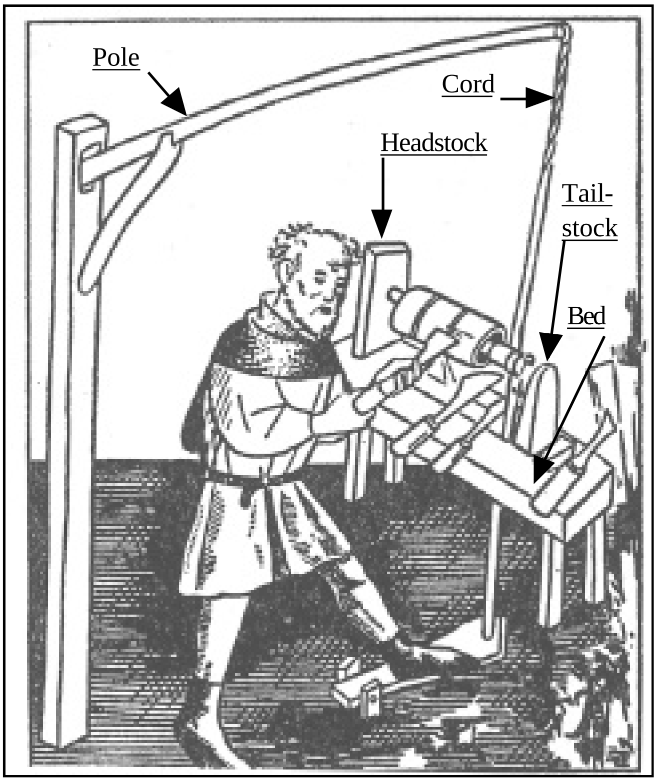


Fig. 4.06 - A German pole lathe of 1395

The cord-driven system was operated by treadle, and the spring-like properties of a wooden pole in bending returned the cord. The 'bed' of the lathe was now made from two substantial wooden members in parallel, and joined at either end. The 'tailstock' was secured between the parallel timbers. Wedges were used to adjust the tailstock position relative to the headstock, to accommodate different lengths of workpiece—Woodbury (1972d:44). The pole lathe exhibited many elements of purpose design in the components, and here was the basic form of the modern lathe.

Although the cord-driven lathe could provide cutting action in only one direction, it survived a long time. It came into use before the 3rd Century BC, and was seen in England as late as 1945—Bronowski (1979:78). Until the 18th Century, the lathe was used mostly for shaping timber—Woodbury (1972d:13).

For turning metals, however, the cord-driven lathe was at a serious disadvantage. The torque reaction to the cutting forces was far greater, and more accurate control and guidance of the cutting tool was required. Coordinating new skill requirements with oscillating rotation of the workpiece, as well as providing additional human muscle driving power, pointed to the need for a new drive system—Woodbury (1972d:44).

Reference was made to a 'water-driven' lathe in Germany in 1590—Woodbury (1972d:46). Although the method was not discussed, it was an early form of continuous drive system by means other than 'human muscles'—Woodbury (*ibid*). Continuous drive of the workpiece also exercised the mind of Leonardo Da Vinci c. 1500—Rolt (1965:28), who revealed insights into some of the problems for the lathe designer.

04.07.02 Holding the cutting tool by mechanical means

Hitherto, the cutting tool was hand-held and applied to the workpiece by hand. A mechanical means of holding and applying the cutting tool to the workpiece was attributed to the technology of the clockmaker—Woodbury (1972d:47). Towards the end of the 14th Century, a market developed for smaller clocks—Rolt (1965:23). Clockmaking was already an established skilled technology, and growth in demand for smaller clocks generated new methods that included greater accuracy of parts production—Rolt (*ibid*). Screw threads were an essential part of the technology of the clockmaker; a lathe for making screws appears in Fig. 4.07 overleaf, and comes from the *Mitteralterlichen Hausbuch*—Rolt (1965:24).

Referring to Fig. 4.07, the cross-slide tool-holder appears to be an enlarged image by comparison with the lathe where it was used. When in use, the cross-slide toolholder was fitted in the slot in the bed of the lathe beneath the workpiece, and was secured in place by a wedge—Rolt (1965:24). A separate screw secured the tool in the rest, while a further screw fed the cutting tool at a tangent to the axis of the workpiece. The coarseness of cut was controlled by the feed screw.

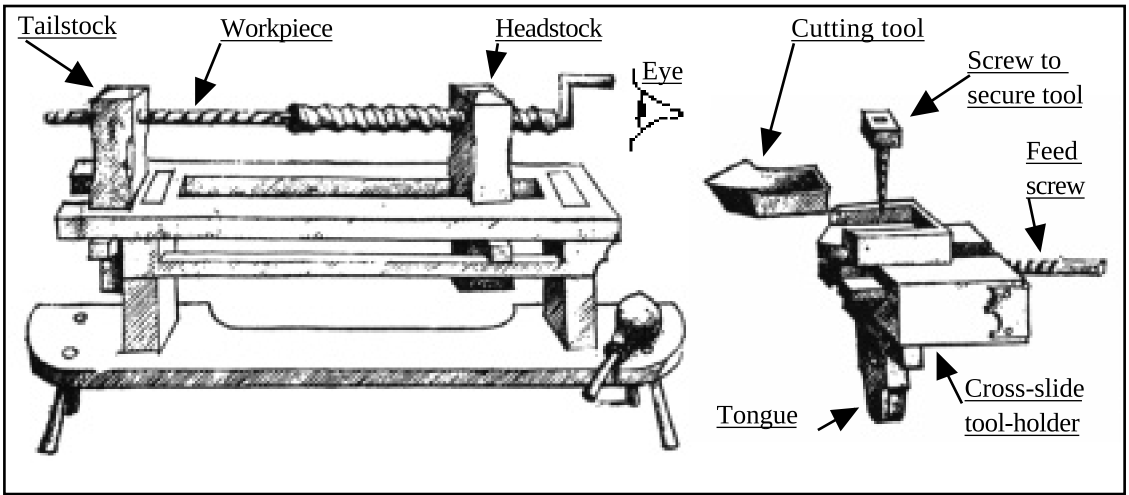


Fig. 4.07 - Clockmaker's lathe with cross-slide toolholder

The principle of the screw thread was part of the multi-linear convergent synthesis within the strategic invention of the lathe in Fig. 4.07. The origin of the screw thread was attributed to Archimedes to raise water—Rolt (1965:24). However, Deshayes (1962:191) argues that the screw was possibly invented by Archytas (c. 400 BC), but it was Archimedes (c 287-212) who spread the application, particularly in the field of hydraulics.

04.08 The technological influence of the clockmaker and instrument maker

By the 18th Century there had been two centuries of fine quality craftsmanship in clock and instrument making, but it was highly dependent 'upon hand skill'—Woodbury (1972d:64). The skills and techniques of precision evolved first with these craftsmen, because so many of the parts they made were small—Woodbury (*ibid*), mostly in brass, and could be made on the Clockmaker's 'turn', see Fig. 4.08—Woodbury (1972d:65).

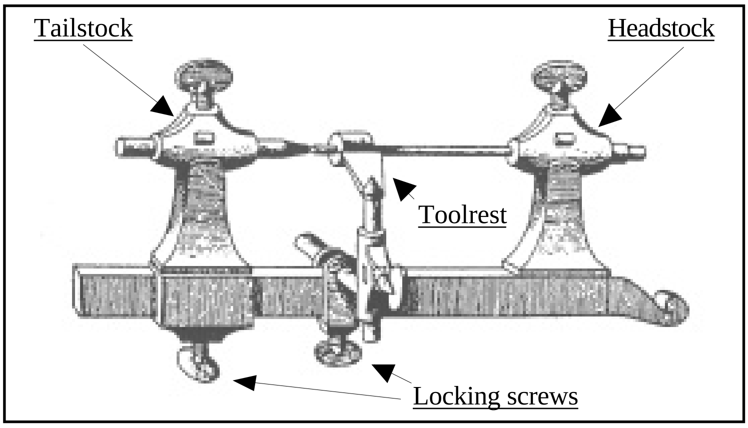


Fig. 4.08 - Clockmaker's 'turn', 1741

The 'turn' was usually made of brass with a fixed headstock, and an adjustable tailstock—Woodbury (1972d:65). Drive was by cord attached to a hand bow; the tool-rest was easily adjustable, but considerable thought and hand skill were necessary for making the small shafts and spindles with precision—Woodbury (*ibid*).

The precision instrument makers had a profound effect on the course of technological history—Rolt (1965:38). Their knowledge and skills provided scientists with instruments capable of accurate measurements to an extent previously unknown—Rolt (*ibid*). Scientists were able to 'formulate theories' that engineers could use in place of empirical methods, with significant results 'towards the end of the 18th Century'—Rolt (*ibid*).

In the middle of the 18th Century, the move 'from pure to applied science' was arguably in its infancy, so the impact of 'scientific discovery on practical technology' was insignificant—Rolt (1965:38). With contemporary technology, machine-tool precision was feasible only on a miniature scale; it could not be scaled up for heavier industrial use—Rolt (*ibid*). The incentive to scale-up was the promise of '… the tireless power of the steam engine' that pointed to the need for 'heavy machine tools'—Rolt (1965:39). But the first steam engines had to be produced without heavy machine tools—Rolt (*ibid*).

For the United Kingdom, the period 1770-1840 encompassed the beginning of the Industrial Revolution—Roderick and Stephens (1978:151). As this period of change gathered pace, new ideas flourished; the traditional methods of millwright, carpenter and blacksmith in the industrial workshops were no longer adequate—Rolt (1965:39). Previously, the dictum had been 'never use iron where wood will do'—Rolt (*ibid*). Now however, progression into a new age required new approaches to cutting and shaping 'that intractable metal with speed and precision'—Rolt (*ibid*).

04.09 Workshops of the 18th Century

Before the 18th Century, the lathe evolved as a tool to make artefacts in wood, horn, ivory and the softer metals—Woodbury (1972d:78). In 1701, a treatise by Plumier considered the problems of turning iron, including the design of the lathe—Woodbury (*ibid*). Plumier's design appears in Fig. 4.09 overleaf, and comes from Woodbury (1972d:79). The treatise covered many important subjects—Woodbury (1972d:78). Briefly, they included:

- lathe construction, rigidity and strength required for turning iron with some precision,
- workpiece material - select to avoid 'slag' inclusions which makes 'turning impossible',
- workpiece mounting - with care and 'proper lubrication' of the centres,
- cutting tool - 'how to choose, shape, sharpen', how to hold and use, how to keep cool 'so as not to draw its temper' [soften],
- driving spindle - how to mount in split cast bearings of soft metal,
- driving system - 'two men to turn the wheel'—Woodbury (1972d:80).

From the inset diagram in Fig. 4.09 overleaf, it may be seen that Plumier's cutting tool was not applied by mechanical means. The hand tool was held in a cut-out on a block of iron against the workpiece. The dimensions of the cut-out would have been calculated to place the cutting edge on the workpiece. Considerable force would be required to make the cutting edge effective on iron.

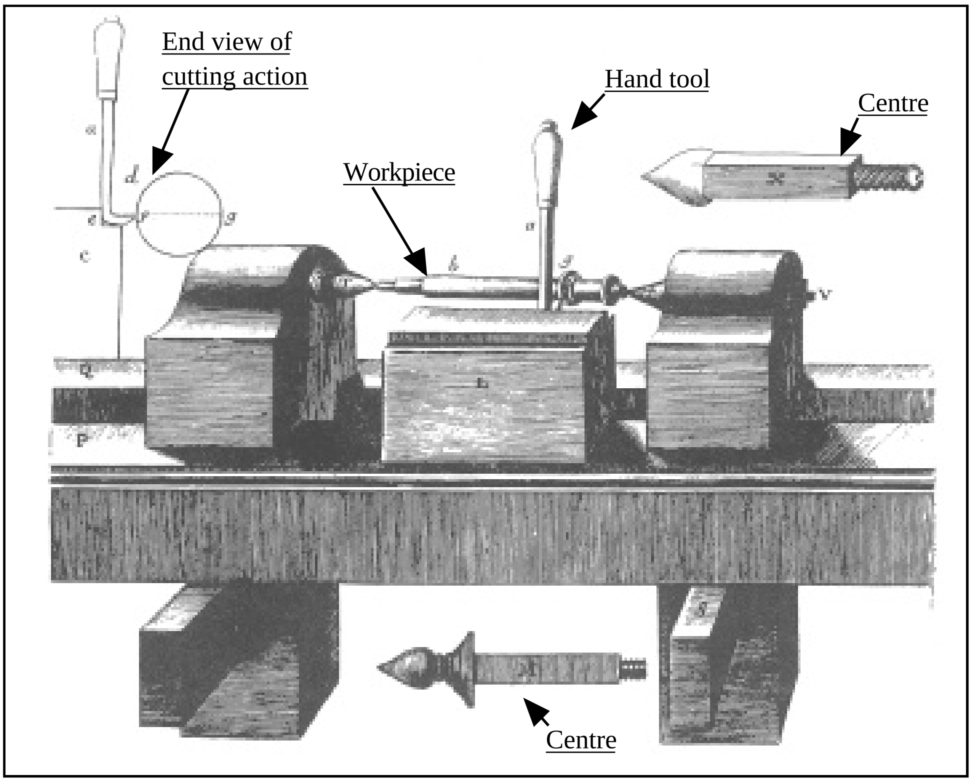


Fig. 4.09 - Plumier's iron-cutting Lathe, 1701

Plumier had clearly arrived at a number of significant insights. They were all in a quest with modern similarities—the production of precision parts using tools that have limitations—Woodbury (*ibid*). However, it was the limitations of their tools that pushed the imagination of the best minds and advanced the causes of technological evolution. Lathes similar to Plumier's for cutting metal were in common use 'by the last quarter of the 18th Century'—Woodbury (1972d:80). One example appears in Diderot's Encyclopaedia of 1771—Rolt (1965:64), as reproduced in Fig. 4.10.

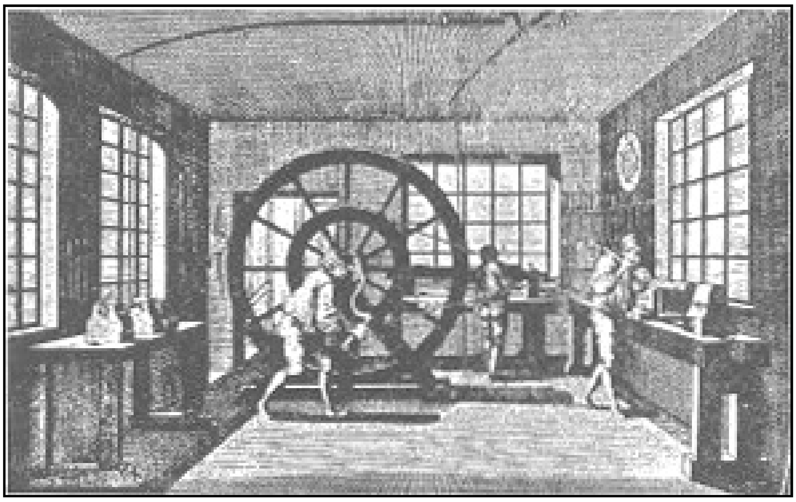


Fig. 4.10 - A turner's workshop of 1771 (Diderot)

In Fig. 4.10, the heavier structure and drive system of the metal-cutting lathe distinguishes it from the two traditional pole lathes of the time—Rolt (1965:64). The metal-cutting lathe on the right was driven by a large pulley mounted on the same shaft as a larger flywheel; these were rotated by a handcrank—Rolt (*ibid*). Turning iron on this machine required significant skill and muscular effort—Rolt (*ibid*).

04.10 Workshops of the 19th Century

By the middle of the 19th Century, the industrial lathe had come of age—Woodbury (1972d:96). Certain primary design criteria were established. Machine tools were expensive, and their capability for greater productivity had to be realised—Rolt (1965:40). Few workshops could afford purpose-designed machines for gear-cutting, screw-cutting or boring, so the industrial lathe had to be adaptable—Woodbury (1972d:97). The design criteria for the industrial lathe had evolved as follows:

- A capability to machine substantial workpieces in iron or steel. Therefore the lathe had to be in iron or steel to withstand the stresses of cutting those materials.
- A source of power to drive the workpiece and cutting tool at economical rates.
- Rigidity of construction to achieve precision in workpieces. Such rigidity was dependent on both design and choice of materials; wood was unsuitable.
- The lathe must be capable of a variety of work including screw-cutting and boring.
- A gear-driven lead-screw built into the lathe for precision screw-cutting; also for 'longitudinal feed' of the cutting tool along the workpiece.
- Alternative gear sets for the lead-screw to produce screws with different thread pitches.
- 'A sliding tailstock to take work of different lengths'.
- A chuck and faceplate for turning and/or boring workpieces without using the tailstock—Woodbury (1972d:96/97).

These briefly defined design criteria for the lathe represented the cumulative acquisition of knowledge and skill as social cultural achievement. A few gifted people understood this synthesis, and used it to make their own contribution in machine tool design—none more so than Maudslay—Woodbury (1972d:99).

<u>04.10.01 Maudslay's influence and precision engineering</u>

Maudslay lived from 1771 to 1831—Rolt (1965:83). Up to the 18th Century, the technology for producing parts with precision was limited to the clock and instrument makers, as discussed earlier. However, Maudslay designed and constructed lathes precise enough to produce industrial workpieces with precision—Woodbury (1972d:100). More recently, precision engineering was described as:

> '…work at the forefront of design and manufacturing technology…'—McKeown (1986:148), and
> '…manufacturing to tolerances better than one part in 10^4 (or one part in 10^5)'—Evans (1989:ix).

The technology of precision engineering has evolved over the past 200 years—McKeown

(1986:148). It has developed to:

- Overcome the need for fitting and promote automatic assembly,
- 'Improve interchangeability of components,
- Improve quality control,
- Reduce scrap, rework, and conventional inspection,
- Achieve longer wear/fatigue life of components,
- Achieve greater miniaturisation and packing densities,
- Achieve further advances in technology and science'—McKeown (*ibid*).

In the 20th Century, precision engineering has become part of the science and technology of 'metrology'. To obtain and retain precision in turned parts, lathes had to be designed and built with precision—Woodbury (1972d:100). In the machine-tool design process therefore, there were three further criteria:

- 'precision flat surfaces … to mount head and tailstocks,
- precision lead screws,
- spindle bearings and tailstock centers to ensure precision rotation of the work'—Woodbury (*ibid*).

These criteria were well understood by Maudslay—Woodbury (1972d:100).

<u>04.10.02 Maudslay's influence and precision engineering - flat surfaces</u>

For true flat surfaces in machine tool design—Woodbury (1972d:101), states:

> The usual method of checking then and now was by use of a standard plane surface, or surface plate. A small amount of red lead or other material is smeared lightly over the surface to be tested. It is then rubbed lightly with the surface plate, and any high points will be clearly indicated by the removal of the red lead.

Master surface plates must be neither convex nor concave in any direction—Rolt (1965:88). The original standard plane surfaces were achieved as a source of reference by a similar method; in this case however, '… three, or possibly four …' plates were worked together—Rolt (1965:87). After filing to obtain a flat surface, Maudslay introduced 'scraping' with a hand-tool as a further refinement, and for easier control of the finishing process to achieve precision—Rolt (*ibid*). Maudslay established exacting requirements, ensuring his workmen had standard flat surfaces besides their places of work that were used regularly—Woodbury (1972d:101).   Maudslay's method of hand finishing was still in use for precision surfaces, '… despite the advent of precision grinding machines'—Rolt (1965:87).

A screw-cutting lathe designed and built by Maudslay, dating from 1797, and now in the Science Museum, illustrates the quality of his innovative thinking in the field of screw threads, and many aspects of lathe design—see Woodbury (1972d:101-103).

04.11 Stature and esteem of the machine tool-makers

The synthesis of the cumulative elements of precision, became standard practice in Maudslay's workshops—Woodbury (1972d:108). Maudslay's micrometer of 1805, now housed in the Science Museum, was an example of his concern for precision—Rolt (1965:89). The screw in this instrument 'has a pitch of 100 threads to the inch and carries an index wheel marked with 100 divisions on its periphery'—Rolt (*ibid*). Hence each division was the equivalent of 0.0001 inches—Rolt (*ibid*). Maudslay's micrometer was tested by the National Physical Laboratory in 1918, and found to have extraordinary accuracy 'considering its age'—Rolt (*ibid*). Maudslay referred to his micrometer as the 'Lord Chancellor', since it was used to settle disputes about 'accuracy of workmanship'—Rolt (1965:89).

But Maudslay's influence went beyond his own insights in machine tool design and the prerequisites for precision—Woodbury (*ibid*). Richard Roberts (1789–1864) and Joseph Whitworth (1803–1887) received their technical training with Maudslay; both went on to make their own imaginative contributions as machine tool builders—Woodbury (*ibid*). In addition to Roberts and Whitworth, the associates of Maudslay included Joseph Clement, and James Nasmyth (1808-1890); their collective influence on machine tool design was 'extensive and important'—Williamson (1968:2). Rolt (1965:90) similarly refers to Clement, Nasmyth, Roberts and Whitworth working for a time with Maudslay.

Hundreds of engineers contributed to the history of machine-tool development—Rolt (1965:90). Among these, Clement, Fox, Nasmyth, Roberts, and Whitworth were '… the most celebrated … great engineers and tool-makers …'—Rolt (*ibid*). They achieved national or international recognition in their own right through innovative machine tool design—Rolt (1965:90–121). Among his contemporaries, Maudslay stood 'supreme'—Rolt (*ibid*). His introduction of precision methods in the workshop, transformed the techniques of mechanical engineering in the space of one life-time—Rolt (*ibid*). These methodological changes created the platform for the development of steam power '… and the complete transformation of many industries by the substitution of ingenious machines for hand methods'—Rolt (1965:91). At the time, these were sensational developments that came about because of the '"behind-the-scenes revolution" … wrought by Henry Maudslay and his school'—Rolt (*ibid*).

Addressing the British Association at Manchester in 1861, the President William Fairbairn summarised the machine-tool revolution that he had witnessed as follows:

> When I first entered this city the whole of the machinery was executed by hand. There were neither planing, slotting nor shaping machines; and, with the exception of very imperfect lathes and a few drills, the preparatory operations of [engineering] construction were effected entirely by the hands of workmen. Now everything is done by machine tools with a degree of accuracy which the unaided hand could never accomplish. …—Rolt (1965:91).

Maudslay began the revolution that was realised by 'contemporaries and successors'—Rolt (*ibid*). It was Whitworth, however, who eventually emerged as the foremost figure in machine tool design and development. He succeeded Maudslay and '… became the most celebrated manufacturer of machine tools in the world'—Rolt (1965:113). By 1850, Whitworth's stature was such that his machine tools 'dominated the workshops of the world'—Rolt (1965:121), a view shared by Woodbury (1972d:113).

Whitworth also influenced screw-thread design. At first there were no standards in industry, but by 1840, and because of Maudslay and Clement, the larger British engineering firms had each adopted its own standard ranges of screw-threads—Rolt (1965:118), but the standards differed between firms. Whitworth realised the process of change was incomplete, and that only 'a national standard would do'—Rolt (*ibid*). So he obtained examples of screw threads from the foremost engineering firms for the purposes of measurement, and found that the 'mean of the angles' between the thread sides was 55^0—Rolt (*ibid*). Whitworth adopted this angle as the standard regardless of thread diameter, so defining the proportions between pitch (threads per unit distance), and thread depth—Rolt (*ibid*).

Whitworth made known 'his findings and proposals to the Institution of Civil Engineers in 1841 and by 1860 the Whitworth thread had been generally adopted throughout Britain'—Rolt (*ibid*). The Whitworth thread form became a British National Standard, and continues to have an angle of 55^0 between the sides—Horton *et al* (1971:1338). Fig. 4.11 shows a lathe by Whitworth from 1843, now housed in the Science Museum—Rolt (1965:116).

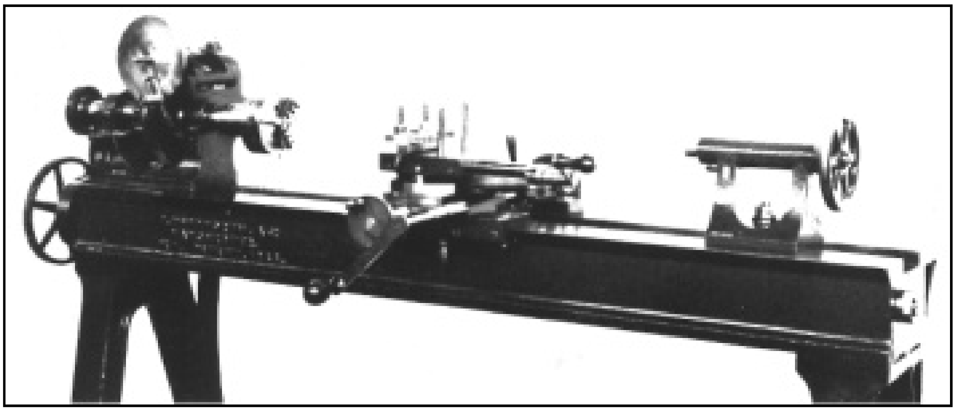


Fig. 4.11 Whitworth's lathe with automatic cross-feed, 1843
Crown Copyright, Science Museum, London

Whitworth's interest in machine tools went beyond the lathe. He produced a range of precision industrial tools including gear cutting-machines, drilling machines, planing machines, screw-cutting machines, travelling-head shaping machines, and slotting machines—Steeds (1969:46-152).

In the period from 1700 to 1910, the metal-cutting machine-tool industry grew rapidly—Steeds (1969:vii). The basic types of machine tools which had emerged included 'lathes, drilling machines and boring machines, planers, slotters and shapers, milling machines, gear-cutting machines, and grinding machines'—Steeds (*ibid*).

The machine-tool makers 'were the true "back-room boys" of the Industrial Revolution'—Rolt (1970:128). Their machines made finished parts for steam engines from rough forgings or castings at speeds and levels of precision that were 'ever increasing'—Rolt (*ibid*). Processes in the machine tool workshops would not have been understood by the lay public—Rolt (*ibid*), and this would be the case today.

The Great Exhibition of 1851 celebrated the inventive and productive capability that had given the UK industrial world leadership; 'British manufacturers … won most of the awards in all classes of exhibits'—Hazeldean (1986). But it was the 'high noon' for British industry—Rolt (1970:148). Britain's industrial prowess would never be the same—Rolt (1970:177).

04.12 In summary

Technology has evolved through the imaginative gifts of humans—Bronowski (1979:20). They have an aptitude for formulating and structuring ideas—Oakley (1972:3). From the earliest times, humans have learnt about the materials surrounding them. Their acquired knowledge has been used to enhance their ability to survive. During the Stone Age, ideas as visual images were slow to emerge. As the formulation of new ideas gathered pace, they were eventually shared with others. The learning spread, and so more ideas and new discoveries emerged that further enhanced the capability and productivity of humankind. Thought and action were inherent in preliterate societies—Usher (1954:59).

The inventive process as social cumulation has only recently been understood—Usher (1954:68). When innovation occurs, it does so as a convergent synthesis—Usher (*ibid*). The creative inventive process is arguably dominated by visual non-verbal images that require acts of intuitive insight to achieve innovation—Ferguson (1977:827). A potential innovator first has to acquire a high level of knowledge in the skills, methods and materials that have become traditional. Without expertise, it is unlikely that 'ways of doing things better' would be visualised or implemented.

The innovative compulsion has always been a powerful force with humankind—Woodbury (1972a: Preface). Humans derive great pleasure and satisfaction from the demonstration of their skills, and they love to make further improvement—Bronowski (1979:116).

Technology has evolved alongside humankind. Since the Stone Age, each generation has found its own technology; the technology of its culture, of its own imaginative capability and era. Primitive human societies sought to inhabit regions of the earth that would provide the resources they needed to survive. So their choice of region was linked with their technology—Usher (1954:2). Humans were limited by the quality of their knowledge and techniques in using the materials found in their chosen environment—Usher (1954:9).

Technology and tools are inseparable. Animals developed within the confines of their habitats. Humans differed from all other animals by their imagination, and their ability to make and use tools. These capabilities allowed humans to wander, to make new tools wherever they went. When the tools had served their immediate purpose, they could be put down until they were once more required. Thus every implement we pick up to use for some purpose is a tool by generic definition. Tools provide the basis of technology. Without exception we are all users of tools and technology, but we are not all technology-designers or technology-makers.

Technology was the pivotal factor in the evolution of humankind; it represented the product of imaginative activity. As humankind evolved, their technology also played an important part in the development of their minds—Usher (1954:2). Technology in the area of mechanical change offers a method through which to study the innovative processes of the mind in all fields—Usher (*ibid*). Technology remains the pivotal creative system in the existence of humankind.

The implication of the multilinear convergent synthesis is that since the Stone Age there has been a precedent for a new tool or piece of technological advancement. Thus it becomes difficult to support the popular belief of the hero inventor. The hero inventor operates in a single linear mode, and moves from the implicit to the explicit—Usher (in Woodbury 1972a:iv).

The progress of mechanical invention down the ages exhibits the structure of innovation in any of the conceptual fields. Historical records allow more thorough examination of the mechanical inventive processes than was possible in many conceptual fields—Usher (1954:56). So it is possible to study the emergence of novelty in thought and action through innovative mechanical processes—Usher (1954:57).

Primitive societies are totally dependent on their technologies. Equally, the evolution of technology in western industrialised societies has produced a state of total dependency, but how widely is this understood? Historians and sociologists acknowledge the powerful influence of technology, but they have not considered the role of machine tools—Woodbury (1972a:Preface). There were many pioneers in the field of machine tool development. As tool-makers, their achievements appeared in the workshop, to be admired only by engineers —Rolt (1965:11). The machine-tool makers were the 'backroom boys' of the Industrial Revolution—Rolt (1970:128).

The earliest machine tool appears to have been the lathe. Turned artifacts date from as early as 700 BC—Woodbury (1972d:20/21). The evolution of the lathe supports the theory of multi-linear convergent synthesis. Early lathes were cord-driven, and examples were found as recently as 1945—Bronowski (1979:78). A more rigid lathe construction did not appear before the 14th Century—Woodbury (1972d:44). Rigidity of construction was a prerequisite for precision turning and precision engineering.

At first, the cutting tool was applied to the workpiece by hand. A mechanical means of applying the cutting tool was attributed to the technology of the clock-maker towards the end of the 14th Century—Woodbury (1972d:47).

Many of the parts made by clock and instrument makers were small, so the skills and techniques of precision evolved first with these craftsmen—Rolt (1965:23). Most of the small turned parts were in brass, and could be made on the clockmaker's lathe or 'turn'. The precision instrument makers had a profound effect on technology—Rolt (1965:38). They provided scientists with instruments capable of accurate measurements to an extent previously unknown—Rolt (*ibid*). Scientists were able to 'formulate theories' that engineers could use in place of empirical methods—Rolt (*ibid*).

In the middle of the 18th Century, the move from theoretical to applied science was in its infancy, so the impact of 'scientific discovery on practical technology' was insignificant—Rolt (1965:38). During this period, machine-tool precision was feasible only on a miniature scale; it could not be scaled up for heavier industrial uses—Rolt (*ibid*). By the end of the 18th Century, lathes constructed in iron to turn iron were in common use, but the cutting tools were not held by mechanical means.

The industrial lathe came of age by the middle of the 19th Century with a significant list of design criteria as social cumulation—Woodbury (1972d:96/97). The design criteria defined a strategic invention that was the outcome of a new multi-linear convergent synthesis. These criteria were joined through acts of insight by the leading machine-tool designers, who recognised the importance of precision flat surfaces, of precision lead-screws and of precision rotation of the workpiece. Also, how precision in these substantially different fields could be achieved and retained to produce a lathe as a flexible durable machine tool, capable of producing precision parts for machines.

By the time the lathe had come of age, a range of special-purpose machine tools had evolved. The lathe and these machine tools evolved because of imaginative activity continually at the forefront of mechanical methodological knowledge, together with new materials technology. The materials of the Stone Age were simple, but they are still used. Eventually, more than 100 elemental substances were found, and the pace of that discovery is captured in Fig. 4.12 overleaf.

The growth in discovery of new elements and materials coincided with the Industrial Revolution. Chemistry is 'the science of the elements & compounds & their laws of combination & behaviour …'—OED. The elements, in many different chemical mixes and/or combinations provide all the materials now available—Brady *et al* (1986:vii). The '… most important and most widely used … materials run into some 14,000'—Brady *et al* (*ibid*). A branch of chemistry known as metallurgy is 'the scientific study of the nature and properties of metals …'—Chambers English Dictionary. There are no fewer than '2,000 varieties of steel'—van Vlack (1969:1).

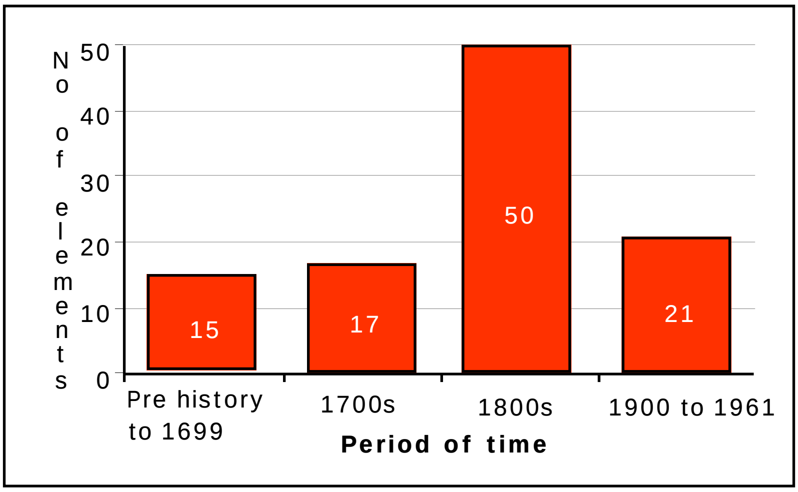


Fig. 4.12 - No of elements discovered at different periods in time-After Emsley (1989:227)

The availability of more and more materials enabled the human species to extend their capability and productivity. The growth in material availability was one of the key components in the accelerating technological process that has brought us to the way we live now as symbolised in Fig. 4.03.

At the simplest level, a characteristic format of technology has prevailed that spanned the evolution of humankind from the Stone Age to the Space Age—the format that has brought us to the way we live now. The introduction to this chapter made reference to the imaginative gifts of humans, and their aptitude for formulating and structuring ideas. Humans enhanced their capability and productivity by making tools from the materials they found around them. But the knowledge of humankind built on knowledge as cumulative acquisition, and was manifested as social cultural achievement in their tools, and their tool-culture. So the tools of humans became progressively more sophisticated. Eventually humans learnt to work with precision. Precision was the key to interchangeable parts and mass-production. And imagination in combination with mass-production has brought us to the way we live now. For humankind, the key components of this process may be defined as follows:

- an inner compulsion to make change in order to improve capability and/or productivity.
- innovation—imaginative thought processes that engage in non-verbal images.
- cumulative acquisition—knowledge building on knowledge of methods and materials, in other words the development of skills and expertise.
- convergent synthesis—manifested as a new solution to a perceived problem; thought turned into action, in other words, invention.

In addition to being the basic components of technology, these are the components of survival for a primitive or a modern western industrial society. One of the variables in this process would be the material resources available. Another factor has to do with the role of social grouping, and in this context two definitions of technology make interesting comparison. As archaeologists, Schick and Toth (1995:49) state:

> To have a technology per se, there should be some agreed upon ways of doing things in a social group—that is, should be some learned, cultural aspect to the tool use or artifact manufacture.

For a definition in a more modern setting, Cross *et al* (1989:27), states:

> Technology is the application of scientific and other organised knowledge to practical tasks by hierarchically ordered systems that involve people and machines.

However, the technology of machine tools was hardly touched by science before the middle of 18th Century—Rolt (1965:38). Indeed the process of invention was discovered before science. All the modern technologies upon which we now depend have a matrix of multi-linear components that were the products of imagination at some time in the past. In new strategic inventions, multi-linear components have a mutual dependency, and precision makes possible all the technologies required by any modern industrial society. Each of the seven groups shown below, have an evolved technological structure that covers the way we live now. Within each group, there are strategic inventions that are too numerous to count. They were each derived from a convergent synthesis, as the products of imagination. These groups provide us with:

1 shelter
2 clothing
3 nourishment
4 communication
5 transportation
6 medical care
7 entertainment and sport

These societal functions are dependent on industry to produce the supporting products, and industry is dependent on technology. The products and services of industry are the life-blood of any industrialised society; such societies could not otherwise function—Owers (1993b:11). Furthermore, it is no overstatement to say:

> If at a stroke the benefits of technology could be removed, not only would this paper disappear, but we would be sitting without shelter, without heating, without either an organised system of food provision or medical care, unclothed on the mud, looking for cover to hide our embarrassment—Owers (1993b:7).

The origin of technology was discussed in the previous chapter. It was argued that technology was based essentially on learning practical skills achieved by imaginative application of hand/eye co-ordination, together with ingenious ways of using available materials. This chapter has carried forward and enlarged on that argument from the Stone Age through to the Industrial Revolution.

Before the second half of the 19th Century, the influence of science in industry was not significant. The knowledge of humankind has built continuously on knowledge, thus providing the impetus for the technological continuity that has brought us to the way we live now. The process of invention as social cultural achievement evolved in mechanical knowledge, and before humankind had learnt to organise and acquire new knowledge on a scientific basis.

Science became increasingly influential, but as an additional source of organised knowledge. As a further source of knowledge, science offered new understanding and explanations for methods that had become traditional or empirical, based on practical technology. The contribution made by science would not have been possible without practical technology, nor without the resolution of precision.

Historically, technology is the generic creative system by which we live, by which we survive, and by which we advance our capability and productivity on every front of human experience; technology is inherent in our tool-culture. The driving force for technological change, now aided by the components of science and mathematics, has always been a human inner compulsion to improve capability and productivity. Here in summary is the essential place of technology in a western industrialised society. But in an industrial society, the consumer has a vital role in the process, and one that is too often overlooked. It will be considered along with how technology functions in industry in Chapter 5.

Chapter 5

Technology, Industry and Wealth Creation

05.01 Introduction

As Stone Age humankind was dependent on tools, so is humankind today. Every society, whether 'native' or 'western industrialised', is dependent on tools to enhance productivity and/or capability to sustain itself. In western industrialised societies, tool use has evolved to dependence on sophisticated technologies. The nature of that dependency is complex, encompassing tools, technology, materials, methods, organisations, industry and above all the application of imagination; but consumers have a role too. So there is an important circular relationship in this dependency that is not easy to perceive. However, the government is keen to promote understanding since a manufacturing industry that is competitive is a wealth creator for the state, and wealth creation is required to sustain ourselves as a society. These are the issues that will be discussed in this chapter, while continuing to show the historical and cultural iterative process at the core of technological continuity and progression by repetitive use of the core terms.

For the lay person, what happens in industry is one of the hardest activities to place in a societal perspective. Perhaps the role of technology in industry or society is even more difficult to grasp. And yet both are vital in the culture of a western industrialised society.

The nature of the vital relationship between industry and society maybe indicated by reference to the records of the government's Central Statistical Office (CSO). In April 1994, the CSO celebrated '… 80 years of official price watching.' The change in prices for certain goods and services over this period of time were published. The changes were measured by an index known in 1914 as 'the Cost of Living Index'. By 1994, it was known as 'the Retail Prices Index.' The RPI tracks inflation as a proportion of the family budget, and should be of interest to everyone because '… it is used in wage negotiations and to increase state benefits'—CSO (94) 84. Some of the changes are reproduced in Fig. 5.01 overleaf.

From these data, it maybe calculated that life expectancy for both sexes improved by 42% between 1914 and 1994. An obvious factor in such an improvement would be the quality of education and training of medical staff, including knowledge that has built on knowledge, on an increasingly scientific basis. But less obvious would be the contribution made by the products and services of industry through new and improving technology—a general problem for our society. In this context the CSO (94) 84 states:

> As people become generally more prosperous and sophisticated, their needs change and so do their spending habits. In 1914 very few homes had electricity or gas, so candles were widely used for lighting and therefore featured in the cost of living index. Candles finally went out in 1956.

		THEN - 1914	NOW - 1994
Population		43.0 million (GB & NI)	58.0 million (UK)
Life expectancy	- Males	51.5 years	73.2 years
	- Females	55.4 years	78.7 years
Food as a proportion of 'Index'		60%	15%
Motor vehicles licensed		300 000	24 851 000
Price of a car		£730 (20HP 4cyl.)	£6 995 (1.4L)

Fig. 5.01 - A few statistics from the period 1914-1994, Published by CSO 26.04.1994

Changes in the products shown on the index list, reflected the growing affluence of society. In 1914, food as a proportion of the index represented 60%; by 1994 it was only 15%. Such changes were only possible because of technology, including increased mechanisation in agriculture, and a wider choice of affordable products. The CSO goes on to state:

> The RPI is also a measure of purchasing power. For instance, since 1914 the pound has shrunk in value … to purchase what a pound could buy in 1914, you would now need to spend around £50.

So at the same level of technology, a car that cost £730 in 1914 would have cost £36 500 in 1994. How many could afford such prices today? With improvements in product development technology, in manufacturing technology and in materials technology, there was a car in 1994 available for £6995. The modern car had superior performance and economy, superior ride and handling, much lower cost of ownership, and was safer.

These CSO data should similarly be a cause for celebration of the achievements of industry and technology, but there were no such references. Is this because, as stated in the second paragraph, the functions of industry and technology are difficult to place in a societal perspective?

To survive, industry has to produce good quality products that people want to buy. These can range from a simple cotton reel for example to an industrial measuring instrument, to a car. Consumers include members of the public as well as commercial enterprises. But modern industry is up against growing competition in both domestic and overseas markets. This may bring cheaper products for the consumer, but it raises questions about society's ability to create the wealth required to sustain itself against a background of ever-increasing expectations. Society has to recognise this situation before it can respond.

By far the greatest part of human existence has been supported by technology based on mechanical principles 'without much … theoretical understanding'—Cotterell (1990:11). The mechanical understanding passed down the generations and became empirical knowledge. With almost no mechanical theory '… the ancient Egyptians built pyramids and transported monoliths weighing several hundreds of tonnes'—Cotterell (*ibid*). The crucial place of science in the creation of new technology '… is a recent phenomenon'—Cotterell (*ibid*). The knowledge of mechanical understanding continues to grow because the development of theory is aided by science. But the adoption of technology with a scientific basis will always rely on a marriage with practical mechanical technology, and frequently through the mastery of precision to achieve utility. This transition in the structure of technology is supported by the definitions quoted in the previous chapter and reproduced here. As archaeologists, Schick and Toth (1995:49), stated:

> To have a technology per se, there should be some agreed upon ways of doing things in a social group—that is, should be some learned, cultural aspect to the tool use or artifact manufacture.

And more recently, Cross *et al* (1989:27) stated:

> Technology is the application of scientific and other organised knowledge to practical tasks by hierarchically ordered systems that involve people and machines.

In the first of these definitions, the structure is entirely empirical, combining social organisation and cultural elements to achieve a practical outcome. For the second definition, scientific and other organised knowledge is combined with a more sophisticated organisation of people, together with machines to accomplish practical tasks.

05.01.01. Selection of case studies

The two definitions above show that a transition has taken place in the structure of technology. This transition continues since technology is the generic creative system by which the capability and/or productivity of humankind is enhanced, and on a continuous basis. In this chapter, examples will be discussed from industry to show the ever-changing nature of technology as knowledge continues to build on knowledge, and as the additional knowledge base of science became more influential. The early manufacture of bobbins including cotton reels, and the manufacture of an instrument to measure electrical resistance, will be discussed. The third example will consider the 'team' aspects of technology, and manufacturing industry as wealth creator to the state will be discussed in the final section.

The wooden bobbin was perhaps not the earliest example of mass-production. Indeed, the 'ships' blocks' that were made of wood at the 'Royal Dockyard' in 'Portsmouth' are regarded as the 'first' example of mass-production by 'machine-tools'—Gilbert (1965:1). In 1796, the Government were persuaded to 'undertake the manufacture of blocks … by power-driven machinery'—Gilbert (1965:2). The machines were designed and built by Henry Maudslay (see also page 47) in collaboration with Isambard Kingdom Brunel, another famous engineer—Gilbert (1965:5). Their machines were the 'earliest machine-tools' of a 'substantial size', and since they were made entirely of metal their 'rigidity and accuracy' were greatly improved—Gilbert (1965:1). 'By 1808' the annual output of these machines was '130,000 blocks'—Gilbert (1965:1). However, the case study of bobbins has been chosen as a better example to illustrate the technological dependency of a local community. Such an argument was not possible with the block-making technology.

Societal dependency on technology typically keeps pace with new products and services. But as technology changes, so the nature of societal dependency also changes and human expectations are lifted. This dependency has a two-way relationship—producing products and services that people want to buy supports the local economic infrastructure. The manufacture of bobbins was achieved using a level of practical technology that was nevertheless the outcome of imaginative visual images, as well as entrepreneurial drive.

Although some accuracy was necessary in the production of bobbins, a far greater level of precision was required to produce an instrument to measure electrical resistance. The design of the instrument was achieved because of scientific understanding, but it could only be produced through a marriage with the technology of practical precision. So the practical precision technology of the instrument maker which had provided scientists with more accurate measuring instruments as discussed on page 45, was now required to make feasible the design born of scientific understanding. And here, the technology of practical precision for one small but vital component will be examined.

These two examples represent levels of technology that are roughly 100 years apart, a period when great strides were made in the technology of power and light generation. By today's standards, a simple organisational structure was required to produce bobbins. The system of organisation to produce an electrical instrument was more complicated, since more and greater skills were required. However, the type of management structure can result in an organisational culture that is counter-productive for the quality of the product, and this will be discussed in relation to the production of a car. This modern and third example will show the dependency on scientifically based technology, and show how organisational integration of the parts is essential to create an effective team to produce a product that people want to buy. In each example there would have been a conscious effort to use affordable technology. Although it is always moving on, the format that has characterised technology since the Stone Age continues to prevail in all these examples—that is the application of imagination on the available materials in order to create better tools for the purpose of enhancing productivity and/or capability to ensure survival as a society.

Lastly, these case studies will offer opportunities to expose rarely heard counter arguments to popular and damaging beliefs about manufacturing and the production line. In particular beliefs that threaten our ability to sustain ourselves as a society; that is to create the wealth to pay for all the services we expect and demand from the state.

05.02 The manufacture of bobbins

During the 1830s, the bobbin industry expanded rapidly to service the demands of the textile trade—White (1977:335). Cotton-reels were just one of the products of the bobbin industry. For suppliers to compete through economic manufacture, they were dependent on a number of technological strands coming together. These included a mill suitable for the manufacturing processes, suitable machines and tools, a supply of raw material, and power to drive the machines. Social cumulation was represented in each of these technological strands, and handed down as cultural achievement. The workforce comprised a team.

The textile industries concentrated in a number of areas of the British Isles, and they all required a supply of bobbins—White (*ibid*). In the West Riding, demands were serviced by workshops nearby, or 'bobbin departments' within the mills—White (*ibid*). Northern Ireland and Scotland had similar arrangements, but the industry in Lakeland was unique, since it was separated by many miles from its customers—White (*ibid*). Lakeland was a natural location for the wood turning industry: the many streams were sources of power to drive waterwheels, and 'coppice woodlands' provided the raw material—Ayris *et al* (1995:8).

The industry was established before electrical power was available, so waterwheels were used first to drive the manufacturing machinery. A heritage museum known as Stott Park Bobbin Mill near Hawkshead in the Lake District was one example—Ayris *et al* (1995). Stott Park was purpose-designed for bobbin turning and it was erected during 1835—White (1977:336). The history of Stott Park provides an insight into the technology of the time.

<u>05.02.01. Light and the layout of the mill</u>

From the layout of the mill shown in Fig. 5.02 below, it maybe seen that some thought was given to the light required for the manufacturing processes. Orientation of the building afforded good use of daylight; the lathes were situated against the window cills, allowing the operatives to face outwards—White (1977:336), to avoid working in their own shadow.

Natural daylight was an important consideration, since the technologies of cheap artificial lighting were not available. Gas lighting began as a series of 'False starts' between 1783 and 1804—Barty-King (1984:13). The many difficulties with gas were epitomised in a trial of the '"incandescent lamp" [electric light bulb] invented by Mr J W Swan' that took place on 11 October 1881—Barty-King (1984:136). The occasion was the opening of the new Savoy Theatre in the Strand, and commenting on the reaction, Barty-King (*ibid)* goes on:

> So far as the audience of 11 October were concerned, it was a resounding success; when the electric lights were turned on they 'cheered to the very echo.'

The acclamation for the new technology was a public demonstration of a need identified, as well as accumulated frustration with the difficulties of achieving artificial lighting through the medium of gas—see Barty-King (1984). Hence the detailed attention to the use of natural daylight at Stott Park in the 1830s, and in particular for a product requiring dimensional consistency, although not precision.

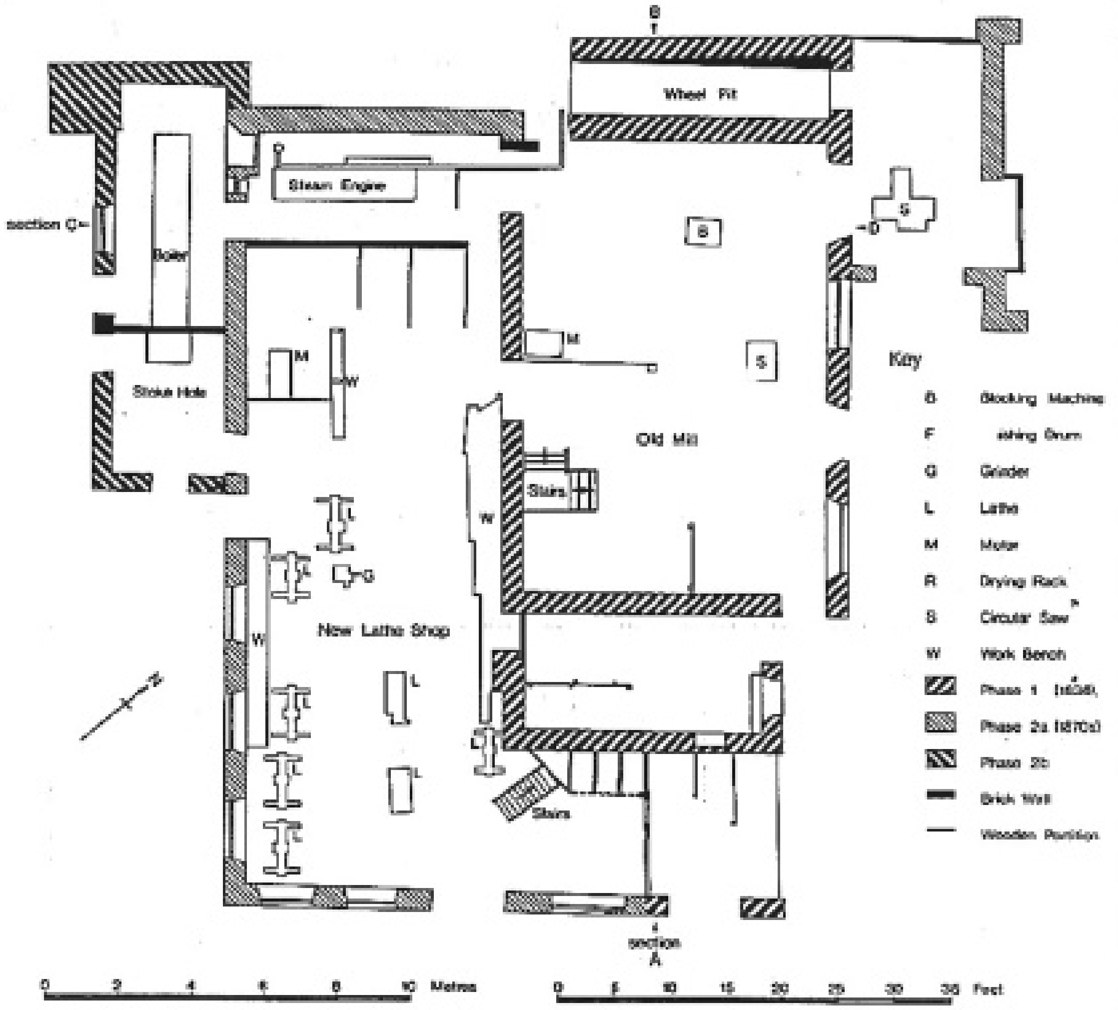


Fig. 5.02 - Plan of Stott Park bobbin mill. From White (1977:339)

<u>05.02.02. Power generation and the layout of the mill</u>

An economic source of power was crucial in order to produce bobbins. The location of the building was also influenced by the stream as the source of power, and the plan of the mill in Fig. 5.02 shows a waterwheel pit alongside the building—White (1977:339).

The early forms of power generation derived by humankind now appear puny. Those early forms however, demonstrated how the ingenuity of humankind met the challenge to advance its capability and productivity in yet another technological field. Early mechanisms included the 'noria', the 'horizontal water wheel', and 'the water wheel with toothed wheels or gears'—Usher (1954:161). As separate social cultural achievements of 'cumulative synthesis', these designs represented three inventions.

The noria was in use during the last century BC, but it was only effective where there was a large volume of rapidly flowing water—Usher (1954:164). The horizontal water wheel was traced to before the 3rd Century AD, and used to drive millstones—Usher (1954:166). Mills with similar water wheels were used in many parts of Europe as late as the 19th Century—Usher (*ibid*). A description by Vitruvius (*c.* 27 BC) details 'water wheel with toothed wheels or gears' during Roman times—Usher (1954:168).

There were three basic types of water wheel 'undershot', 'breast' and 'overshot'—Usher (1954:161). These names were derived from describing the flow of water to the wheel. Fig. 5.03 shows an early waterwheel at Stott Park—Ayris *et al* (1995:8). It was described as 'probably high breast shot'—White (1977:336); the end of a chute maybe seen in Fig. 5.03. Water was supplied from a 'substantial pond'—White (*ibid*).

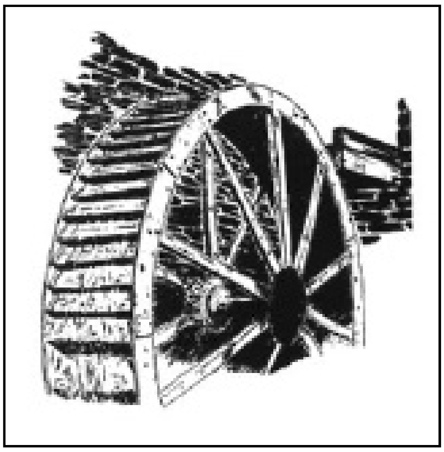


Fig. 5.03 - The waterwheel at Stott Park Bobbin Mill
From Ayris et al (1995:8), Crown copyright

The waterwheel was 9.8m (32ft) in diameter, and was advertised as 'equal to sixteen horses' power'—Ayris *et al* (1995:8), a sign of scientific understanding. The main prime mover until well into the 20th Century was water-derived power at Stott Park—White (1977:345). From Fig. 5.03 it maybe seen that visual images were a crucial part of the detailed design process for the waterwheel. Neither the book by Ayris *et al* (1995), nor the paper by White (1977) provides more detail of the waterwheel. The power generated by the waterwheel was dependent on the volume of water available. At times there were water shortages when the long dayshift could be extended 'into the night'—White (1977:342).

A steam engine was installed at Stott Park '… probably in 1880'; with enough steam pressure it could develop 20 horse power—Ayris *et al* (1995:8). The steam engine was installed in the 'New Lathe Shop' see Fig. 5.02, but there is no reference to when the shop was built. The third turbine was used to power the saw shop, and it worked in tandem with the steam engine as the prime mover for the new lathe shop—Ayris *et al* (*ibid*).

Lastly, reference to the Hoover Dam in the USA will help to place in perspective the pace of change in the technology of power generation from water. Construction of the Hoover Dam started in 1933, and was completed by October 1936, when the first of 17 hydroelectric generator sets went 'into full operation'—Hoover Dam web site. The last generator set went into service in 1961, when the output for the dam was rated in excess of 2000 megawatts—

Hoover Dam (*ibid*). That is equivalent to 157 700 horse power for each generator set.

In 1835, a water wheel at Stott Park generated 16 horsepower. A century later, a single generator set at the Hoover Dam could produce nearly 10 000 times more power. Within a century, the technology of humankind yielded 'the world's largest hydroelectric installation' —Hoover Dam (*ibid*). It was a new strategic invention made possible because of numerous separate 'multi-linear' processes that once had the status of strategic inventions in their own right. The ongoing pattern of knowledge building on knowledge and social cumulation which characterises technology, enabled the further act of imaginative insight that gave rise to the strategic development of the Hoover Dam. Some of the separate strands as multi-linear processes would have included materials technology, applying the science of hydrostatics, and last but not least the technology of precision in the turbines and generator sets.

05.02.03. The raw material for Stott Park

Wood for bobbin manufacture came from the local slopes; they had been coppiced to make charcoal fuel for the iron trade, and 'now provided the mills with their raw material'—White (1977:336). The demand for bobbins by the Lancashire cotton mills became so great that a local supply of wood was economically vital—Ayris *et al* (1995:8). The wood was mostly ash, birch or sycamore—Ayris *et al* (1995:3).

05.02.04. The manufacturing processes

Fig. 5.04 overleaf shows the main lathe shop as it was at Stott Park in the 1890s—Ayris *et al* (1995:11-12). All the machines used in the production processes were driven from an overhead shaft that ran the length of the main lathe shop, and was coupled directly to the source of power. Pulley-wheels were mounted on this shaft according to the number of machines to be operated. The complete shaft is not visible, but some ten wheels maybe seen in Fig. 5.04 as well as the belts that transferred power to the machines.

There were six stages in the manufacture of bobbins, including cutting, boring, roughing, drying, finishing and polishing—Ayris *et al* (1995:13-17). The first three stages were usually completed when the wood contained some sap—Ayris *et al* (*ibid*). The thinner and thicker poles were sorted before 'cutting' respectively into 65 and 100mm (2½ and 4 inch) lengths, to provide blanks from which the bobbins were made—Ayris *et al* (*ibid*). The blanks were subsequently bored to provide an axis for the turning operations.

After boring the blanks entered the 'roughing' stage, a process that removed excess material. Up to this stage the wood contained some moisture, but the 'finishing' process was easier on dry pieces; various drying rooms were situated around the mill—Ayris *et al* (1995:15).

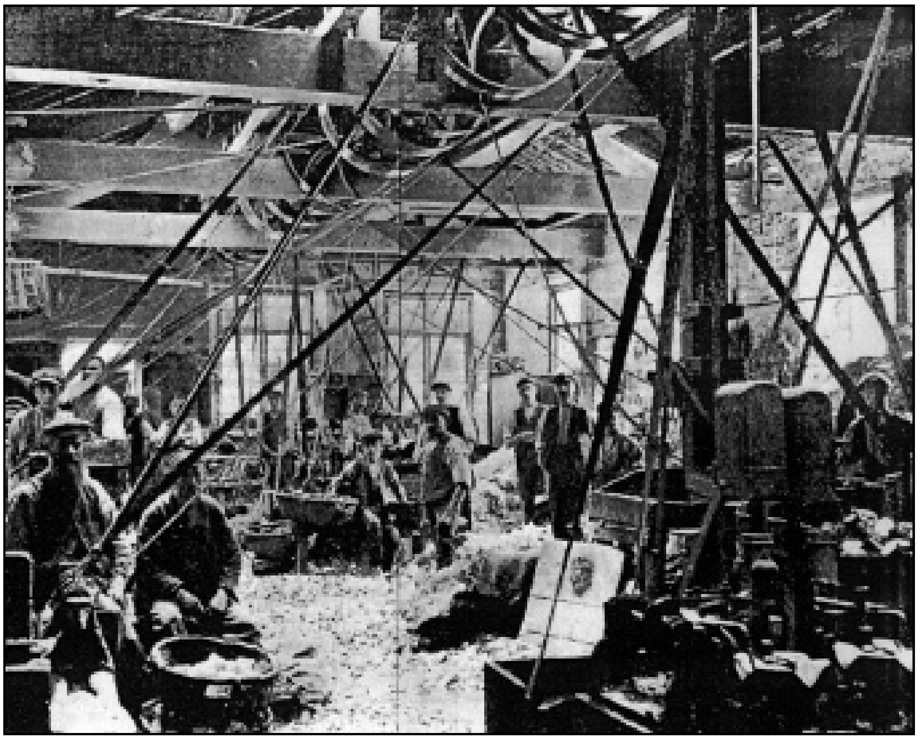


Fig. 5.04 - Main lathe shop in the 1890s
From Ayris et al (1995:11-12) Crown copyright

'Finishing' required the greater level of skill, and better final products were produced when the roughed out blanks were dry. The isometric drawing of a finishing lathe shown in Fig. 5.05 below, illustrates the most complex of the machines used in the production process.

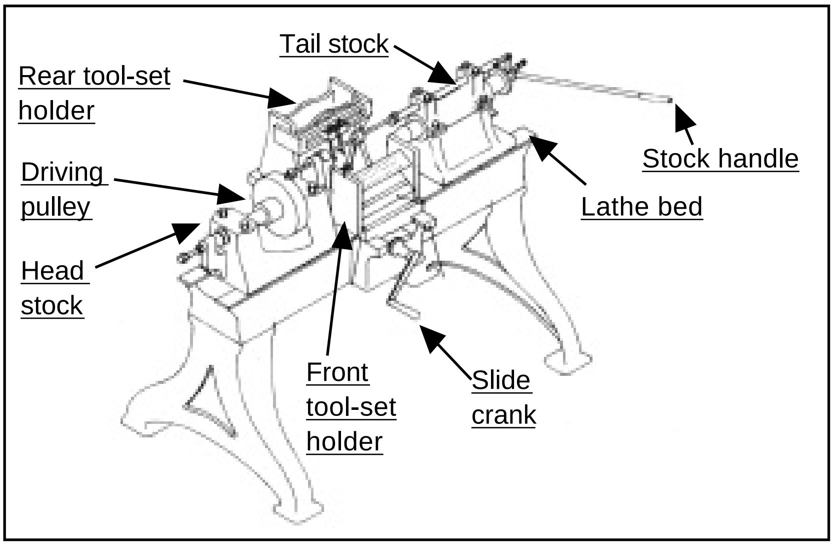


Fig. 5.05 - Isometric view of a finishing lathe in the late 1960s
From Ayris et al (1995:15), Crown copyright

The finishing lathe as shown in Fig. 5.05 represented numerous design criteria as social cumulation of methodological knowledge designed to reduce bobbin handling time in the machining process, and this will be discussed further.

The requirements of the customer determined the final shape of the bobbin including length and diameter as a specification for finishing—Ayris *et al* (*ibid*). The bobbin shape fixed how the cutting tools would be set-up, and the operators were responsible for their own tools—Ayris *et al* (1995:17). This included tool design, tool making, tool setting-up and the maintenance of the cutting edges of the tool.

Setting-up was time-consuming, but the aim of the complex tool arrangement within the design of the finishing lathe was to reduce bobbin handling time in the machining process, and hence reduce piece costs. The tools were arranged between front and rear sets so that the 'gougers' and 'toppers' were applied to the rough bobbin before the 'end tools' and the 'rounder tools'. This arrangement probably helped to prolong the life of the tool cutting edges. Certainly the earlier roughing process, to remove the coarse uneven outside material from the bobbin blank, would have prolonged the life of the cutting edges of the finishing tools. By adopting methods to prolong the life of the tool cutting edges, the intervals between tool resharpening were extended. So the machine 'down-time' was reduced, and more parts were produced at competitive prices.

Polishing was the last operation required to prepare the bobbins ready for delivery, and this was completed in a polishing barrel. The machined bobbins were placed in the barrel through a trap door together with a piece of paraffin wax—Ayris *et al* (1995:17). The barrel or drum was rotated from one of the sources of power used to drive other machinery; after some 20 to 30 minutes, a 'varnish-like finish' appeared on the bobbins, and they were then ready for transportation to customers.

To recapitulate, at Stott Park in the Lake district, a group of people with entrepreneurial drive, pooled their knowledge and skills including tools, a source of power, and a source of raw material to produce bobbins. Producing bobbins as a product that people wanted to buy, followed the same formula for products that were bartered before coins were invented in 640BC. But whether the products were sold or exchanged, in effect what was being bartered were the skills and knowledge of the local community, the basis upon which any society sustains itself. And any society sustains itself by imaginative technological application.

05.02.05. Stott Park - the local economic impact

By modern standards, the bobbin products at Stott Park were produced with a level of technology that may now appear elementary. However, when the business started in 1835, the process was close to the leading edge of affordable technology that was capable of producing pieces at low unit cost. Stott Park was to occupy an important place in the economic infrastructure of the Lake District—White (1977:335).

The industrial revolution was first experienced by Britain—Rubinstein (1994:1). It began about the middle of the eighteenth century, and by 1850 Britain was the workshop of the world—Rubinstein (*ibid*). The industrial revolution happened first in Britain because of entrepreneurial drive and a conjunction between evolving technologies. These included significant changes in the technologies of 'power, transportation, mining, metallurgy, and in the manufacture of textiles'—Woodbury (1972d:118). There was an on-going mutual dependency between new and changing technologies established on the basis of knowledge building on knowledge. The expanding textile trade and the demand for new designs of spinning and weaving machines, also pushed machine-tool development—Rolt (1965:139). By the 1830s, the cotton industry was 'wholly mechanised'—Pollard *et al* (1968:197). Thus technological capability and productivity advanced hand-in-hand.

Bobbin manufacture at Stott Park began in 1835 at a time of economic expansion. With an increasing demand for its products, the cotton industry contributed to the UK's economic growth. The expansion of the Lancashire cotton trade stimulated demand for bobbins, and an order for 'ten million' was 'not uncommon'—White (1977:335). Evidence suggests that trade during the 1830s was prosperous—White (1977:340). The local press ran many advertisements for premises, for coppice or bobbin wood, as well as for bobbin turners—White (*ibid*). One advert was addressed to 'men doing over 15 gross of 13⁄4 in. spinning bobbins per week'; 'those who qualified would be paid 2d per gross over Union price'—White (*ibid*). In 1869, wages in 'Cumbria' and 'Lancashire' were compared with those in 'Devon, 'where workers were paid at only half the rate'—White (1977:344).

Stott Park was the last mill of its type, and after trading for some 135 years it finally closed in 1971, because bobbins in synthetic materials were preferred—White (1977:335). So it was the new technology associated with materials that finally caused the decline of the industry. The Coward family's entrepreneurial efforts and technological improvements were eventually overtaken by the pace of technological change, and in a field in which they probably had no experience. Gaining that experience would have required massive new capital investment, recruitment of expertise with knowledge and skills of the plastics industry and materials, the design and manufacture of plastics moulding tools and the machines on which to use those tools.

Being overtaken by the pace of change of technology should be a cause for systematic reflection in any manufacturing company, and in any local community. As consumers we are constantly looking for better quality at lower prices, and this impinges directly on the manufacturers production processes. A small proportion of humankind has an inner compulsion to make change happen through better productivity and/or capability—as a technological process it cannot be stopped. And indeed it is a process that consumers have come to depend on for cheaper, better quality products.

05.02.06. Stott Park - social considerations

The mill at Stott Park manifested technology in action that was the means of economic sustainment for a local community, and as part of a wider economic infrastructure. The workers at Stott Park comprised a team with a variety of skills. When the mill lease was put up for early occupation in 1836, a capability to run thirty lathes was advertised—White (1977:336). However, between the wars only some fifteen to twenty people were employed

—White (1977:345).

Bobbin manufacture was symptomatic of a stage in the evolution of manufacturing industry in general. Originally, as the first stage, artefacts were made by individual craftsmen working on their own—Forty (1992:43). In the second stage, the various tasks of hand fabrication were separated among craftsmen under the supervision 'of a master'—Forty (*ibid*). The introduction of machines within a factory system was the third stage—Forty (*ibid*), and represented the way of working at Stott Park. The progression through these three stages was intended to achieve lower unit cost with better unit quality and consistency. This will be discussed in greater depth later in this chapter.

However, there were concerns with the factory system of bobbin manufacture, particularly the dust and machinery—White (1977:342). The hazards of working in the bobbin industry were included in the *'Report of Commissioners on Employment of Children and Young Persons in Trades and Manufactures not already regulated by Law'* (1863-67). The Commissioners did not visit Stott Park, but they took evidence from people as young as 10 who had been injured working at other mills in the area—White (*ibid*). Complaints concerning injuries were justified, since right up to the demise of the industry machines were in use without guards for 'pieces being worked' or for 'moving parts'—White (*ibid*).

Dust appears to have been the greater cause for concern—White (1977:342). Turning so many bobbins in a day from dry timber would have generated considerable amounts of dust. It was recommended that 'work places should be airy and well ventilated', but it was recognised that this was not easy to do, given 'the nature of the work'—White (*ibid*).

The employment of children should be put in perspective. In this context the *'Report of the Commissioners appointed to inquire into the State of Popular Education in England'* [*The Newcastle Report*] makes interesting reading. The Commission was set-up in 1858, and the report was published in 1861. The role of the State was considered, and the suggestion that education should be free was rejected. Furthermore, the evidence of the Reverend James Fraser, one of ten Assistant Commissioners, read as follows:

> … Even if it were possible, I doubt whether it would be desirable, with a view to the real interests of the peasant boy, to keep him at school till he was 14 or 15 years of age. But it is not possible. We must make up our minds to see the last of him, as far as the day school is concerned, at 10 or 11. We must frame our system of education upon this hypothesis; and I venture to maintain that it is quite possible to teach a child soundly and thoroughly, in a way that he shall not forget it, all that is necessary for him to possess in the shape of intellectual attainment, by the time that he was ten years old.

The fact that the Commissioners agreed with this 'observation' was recorded in the report—Newcastle (1861:243).

Education for young people surfaced again in the *Elementary Education Act* of 1870—

Maclure (1986:98); it was clearly a national debate. When W E Forster, Vice-President Education Department, introduced his bill in the House of Commons on February 17 1870, he stated:

> … Compulsory attendance from 5 to 13 (with exceptions) was a matter for local option and enforcement by bye-laws—Maclure (*ibid*).

So up to 1870 there was no compulsory education for children over ten years of age. In the absence of an educational system for young people in the late 19th Century, industry offered gainful occupation and a useful learning opportunity with a wage to take home to parents. But that is not how it is remembered in the national psyche; the common recollection approved by the opinion-leaders of society would be represented by:

> We are not in the business of producing fodder for factories' - frequently heard from primary and secondary school teachers and headteachers in the late 20th Century.

Value judgments will be discussed in the next chapter; meanwhile here in summary is yet another insight into the place of technology for Stott Park as a local economic community in the wider national infrastructure. At the national level there were social concerns about working conditions in factories and education for the poor. As knowledge continued to build on knowledge, these concerns would be confronted, but the 'factory fodder' image of industry was destined to remain; disparagement has always been easier than understanding.

The discovery of electricity was destined to continue enhancing the productivity, capability, and the conditions of humankind, influencing both the factory and the home.

05.03 The discovery and use of electricity

Electricity on demand at the throw of a switch is today taken for granted, but it is a relatively recent technology, and one that depends on electromagnetic principles. Greek philosophers knew that when amber was rubbed, bits of straw would be attracted to it—Halliday *et al* (1997:538). Amber is a yellow translucent fossil resin—see OED.

During the Middle Ages, the electromagnetic properties of lodestone (a magnetic iron ore) were used by sailors to magnetise their compass needles for navigation, since the treated needle would always point to the north—Byers (1988:8). In 1600, Dr William Gilbert was observing the magnetic properties of lodestone and described what he saw as *electricity*; this he derived from *elektron*, the Greek word meaning amber—Byers (*ibid*).

Scientific interest in 'electricity' grew, and in 1746 Professor Pieter van Musschenbroek at Leyden University found by chance that electricity could be stored in a jar—Byers (1988:8). The glass jar was water filled, and encircled with a metal band, and became known as the Leyden Jar; the electricity was 'stored in the glass between the water and the metal'—Byers (*ibid*). By accident, Musschenbroek received an electric-shock that frightened and 'prostrated him for two days'—Byers (*ibid*). A year later in 1747, Benjamin Franklin flew a kite into a thunderstorm to prove that lightning was 'electrical in nature'; a key tied to the end of the kite string emitted a spark 'to charge a Leyden Jar'—Byers (1988:9). Franklin could have been electrocuted—Byers (*ibid*).

In 1821, Michael Faraday (1791-1867) showed that 'a wire connected to a battery would rotate around a fixed magnet'—Byers (1988:10). By 1831, Faraday had 'established … the relationship between electrical and magnetic effects'—Bowers (1990:4). Other inventors worked on the dynamo so that by 1870, the basic 'winding' variations were defined—Usher (1954:400). By 1880, the actions necessary to achieve 'lighting, power production, and traction' were feasible—Usher (1954:401).

However, the growth of the electricity supply industry was a tortuous one spanning more than five decades—Poulter (1986:178). Many of the difficulties would have been associated with discovering new methods in the engineering workshops to produce parts with precision that would reliably support the new electricity generating and supply technologies. But there were also difficulties with electricity system supply standards. In 1928, 'there were thirty-three different AC [alternating current] systems, and twenty-four different DC [direct current] systems—Poulter (*ibid*). One of the earliest installations was in the small market town of Godalming in Surrey; the lights were switched on in September 1881—Byers (1988:6). By 1931, fewer than half the homes in Britain were connected to an electricity supply—Bowers (1990:1).

As previously discussed, the process of invention stems from social cumulation when knowledge builds on knowledge. Invention as a process was discovered before science. Up to the discovery of electricity, technology as the creative system of humankind had had foundations almost entirely within mechanical principles, and nearly all of it was empirically determined. However, the outcomes of Faraday's experiments were to bring about further change and spawn new industry because of the addition of scientific knowledge.

Change and new industry go hand-in-hand, and is one of the hall-marks of technology. Also, as discussed earlier, the technology of precision was resolved as the outcome of social cumulation of knowledge building on knowledge in the design and manufacture of machine tools, and in particular the lathe. Without the lathe, the benefits of Faraday's experimental results could never have been realised. With the additional knowledge of science, the strategic inventions of electricity generation and supply were realised as the outcomes of yet further social cumulation. On page 59 in this chapter the following was stated:

> But the adoption of technology with a scientific basis will always rely on a marriage with practical mechanical technology, and frequently through the mastery of precision to achieve utility.

This is a fundamental tenet and applies equally to the electricity generation and supply industry. The growth of the supply industry triggered a demand 'for the wiring of houses', and the measurement of electrical resistance became a vital factor—*The Evershed Golden Jubilee* (1936:4)—for reasons of safety. So the new technology had spawned a new requirement, including the need for a means of measuring '… extremely high resistance, such as insulation resistance'—patent specification 400,728 by Rolfe *et al* (1933:1). An instrument was designed and produced to this patent by Evershed & Vignoles of Chiswick, and introduced as the 'Wee Megger' tester, employing Faraday's principles. Visual imagination was required in the design of the instrument, while manufacture was dependent both on designers and the precision skills of many craftsmen, not least the quality of visual imagination of the tool-maker. Imagination is required at the highest levels in all the areas of practical skill. Hand/eye coordination as directed by the visual imagination is a fundamental requirement for good tool-makers and instrument-makers. Surely, similar capabilities exist in good surgeons, dentists, and the stonemasons who build cathedrals.

Before discussing the Megger tester and the tool-maker however, it is worthwhile reflecting on the imaginative skills of one particular instrument-maker, namely John Harrison, an English clockmaker. Before his clocks were invented, navigation on the high seas was based on a crude system of 'dead reckoning' to determine position 'east or west of home port'—Sobel (1996:13). This system was a source of alarm for Samuel Pepys—Sobel (1996:16) as Secretary of the Board of Admiralty. He wrote about a voyage to Tangier in 1683, and referred to their 'confusion … nonsensical arguments … and disorder' when attempting good reckonings—Sobel (1996:16). After four warships foundered in 1707 on the Scilly Isles with the loss of two thousand hands, Parliament passed the Longitude Act of 1714—Sobel (1996:16). A prize of £20,000 was offered 'for a "Practicable and Useful" means of determining longitude'—Sobel (1996:8).

Sailors had long known how to determine their latitude on the high seas from the sun or certain stars—Sobel (1996:4). But to fix the ship's position on the seas, the meridian of longitude was required. The Earth revolves once every 24 hours, or fifteen degrees in every hour. If a precise knowledge of the time at the home port was known at the same instant the time on board ship was calculated from the height of the sun, the longitudinal meridian could be determined, and hence the ship's position on the seas—Sobel (1996:4).

Without a formal education or apprenticeship, Harrison did what Sir Isaac Newton thought impossible; he invented a clock to show 'true time from the home port' in 'any part of the world'—Sobel (1996:8). His clocks were virtually free from friction [jewelled bearings], they had no pendulum, and were made with parts that compensated for changes in temperature to keep 'the clock's rate constant'—Sobel (1996:9).

Harrison's 'magic box' was distrusted by 'the scientific elite', and his attempts to claim the prize were thwarted by the commissioners who 'changed the contest rules whenever they saw fit' to accommodate the 'astronomers over … Harrison and his fellow "mechanics"'—Sobel (1996:9). Exhausted by forty years of 'political intrigue' and 'academic backbiting', Harrison prevailed when he appealed to King George III and received his monetary reward in 1773—Sobel (*ibid*). The Royal Navy had fewer than 200 ships in 1860, but they owned some 800 chronometers to Harrison's design—Sobel (1996:164). Harrison died on 24th March 1776, precisely eighty three years after his birth in 1693, holding 'martyr status among clock-makers'—Sobel (1996:152).

Harrison had demonstrated the formula by which the leading edge of technology has been pushed forward since the Stone Age. Through his chronometer, Harrion enhanced the safety, productivity and capability of captains at sea. But it is doubtful that the innovative and inventive capabilities that he demonstrated were then understood by the public at large—a problem for our society today. Harrison's imaginative and creative skills also spread, and with many other industries those skills helped to sustain a local economic community.

05.03.01 The Wee Megger tester

What distinguishes humankind from all other animals is the ability to visualise, to think in concepts, and to make and use tools—chapter 3. Manufacturers of products with an engineering or technological foundation, typically have a tool-room wherein the craft of tool-making is pursued in order to underpin the factory mainstream production processes with many tools, fixtures and purpose made precision gauges. In this way, tool-rooms enhance factory production capability and productivity, raising quality and consistency of mainstream production, as well as lowering unit costs.

Here, the production of just one of many vital parts for the Megger tester instrument will be considered through the process of design and making devised by a tool-maker. Patent No. 400,728 by Rolfe *et al* (1933:1) covered the Megger tester, designed to measure electrical resistance. Although bench models designed on the same principles were available before the Wee Megger, they were heavy and bulky—patent (*ibid*). The Wee Megger was 'compact' with 'parts as small as possible', employing 'the properties of modern materials as much as possible'—patent (*ibid*). When any machine is dismantled, many innovations will emerge; typically they will be the outcome of social cumulation—in other words knowledge handed down and enhanced through further imaginative contribution and experience.

Fig. 5.06 overleaf shows the Wee Megger tester and its small size. Probes or clips attached to the insulated wire leads (shown in red and blue), put the insulation material under test to 500 or 250 volts and determine its 'electrical resistance'. The Wee Megger had many innovations for the 1930s, including:

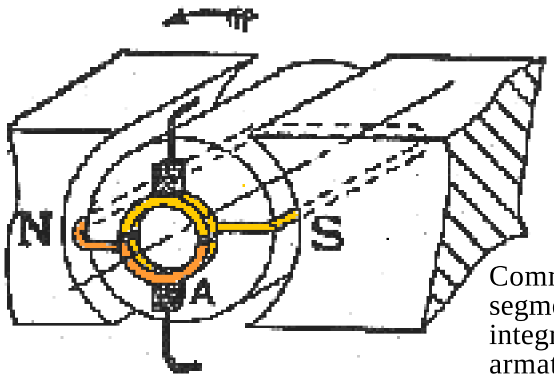
- small size, measuring 10.79 x 13.34 cm (4.25 x 5.25 inches);
- a compressed moulded casing in the 'Trade Mark [insulating] material "Bakelite"';
- a hand-driven generator with 'cobalt steel permanent magnets';
- a fold-away handle for turning the generator (the knob recess maybe seen in Fig. 5.06);
- the generator was driven through 'a one-way clutch' so that when the handle was released, it would not continue to turn;
- a moving coil system designed to measure resistance, and assembled as 'a single unit … with its pivots and bearings … including the scale … and pointer'. The lower pivot comprised an adjustable jewelled bearing [to minimise friction]—patent (*ibid*).

Fig. 5.06 - The Wee Megger Tester

Clever design placed the hand-driven generator system at one end of the case, and the sub-system for measuring resistance at the other end. Resistance was measured by moving-coils designed as a single unit sub-assembly—patent (*ibid*). The coil system and the needle were very light to minimise mechanical inertia for fast reaction to electrical inputs. There were two coils in opposition—a pressure or voltage coil and a current or amperage coil. Interaction between these coils determined the electrical resistance of the materials under test. The level of resistance was read from a scale calibrated in 'Ohms' from 'Zero' to 'Infinity. Each instrument was individually calibrated with its scale, in order to ensure accuracy.

Typically, early designs of meter had only one coil, and the needle was restrained at the zero reading by a light spring. Great care had to be taken to align the zero reading in such designs, but even light springs have manufacturing tolerances that would introduce inaccuracies of measurement further up the scale. Inaccuracies could also be introduced because of voltage variations. With two coils in electrical opposition, the Megger tester had no such limitations; the needle was free to settle at the precise measurement of resistance.

The Wee Megger was the outcome of significant design thought and imagination, aided by scientific understanding of the principles of electricity, and new materials. Knowledge of electricity together with entrepreneurial drive also perceived a market opportunity, the chance for business, for employment during the 1930s recession, and to make profits to support further investment in new research and design. It is critically important for each company to acquire its own store of knowledge and expertise, to establish and develop its own skills base. And here, as stated earlier, the imaginative contribution made by one tool-maker will be demonstrated in the case of the Megger tester. The Stone Age concept of the 'cutting-edge' was once more employed, and now additionally supported by the more recent creative productive concept of 'forming', as will be shown for the production of a switching commutator segment (see Fig. 5.08 below). A diagrammatic arrangement for a commutator appears on the next page in Fig. 5.07—Clayton and Shelley (1951:45) showing the segments; the design criteria stem directly from Faraday's principles.



Note: The two-part commutator is a reversing switch with two equal segments as shown in the diagram. These segments are mounted on but insulated from the spindle, and are separated by a small air space or other insulating material—Clayton and Shelley (1951:45). For the Wee Megger tester, the segments were moulded in 'Bakelite', and mounted on the spindle.

Fig. 5.07 - Diagrammatic arrangement of a commutator

Jack Bartle was an outstanding craftsman who designed the sequential series of tools to produce a commutator segment. Except for the first 'blank' stage, the parts produced by his sequence of tools appears in Fig. 5.08 below.

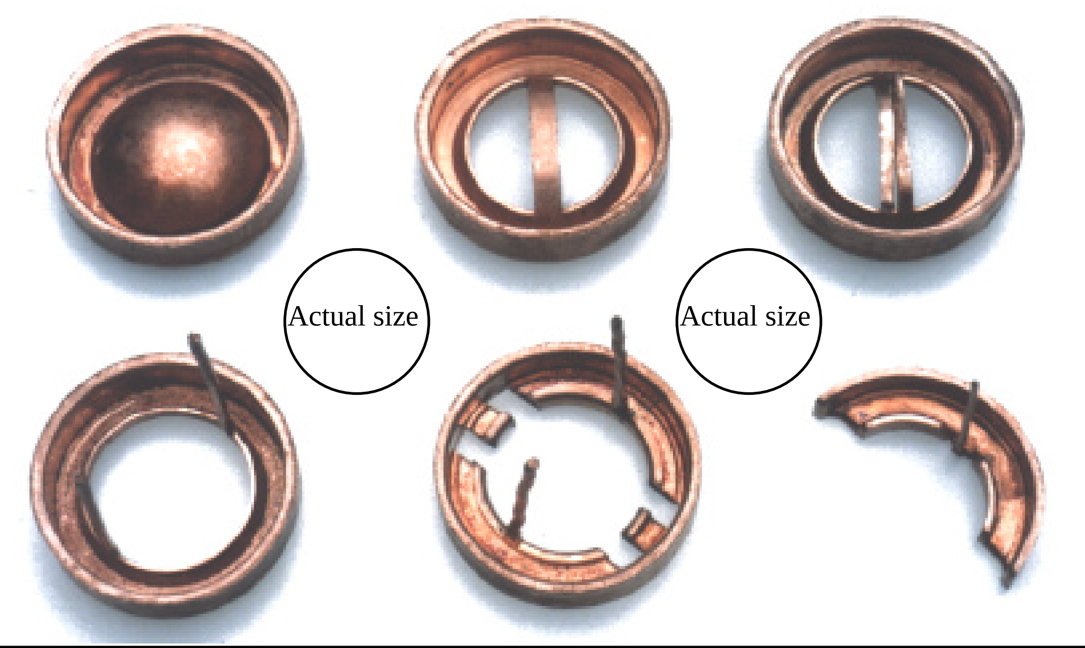


Fig. 5.08 - Process sequence to produce a commutator segment

The whole purpose of making the commutator segment and wire as one integral part was to avoid the alternative solution of soldering the wire and segment together. As an integral unit, quality and reliability were designed into the part, with a similar 'quality and reliability' knock-on effect for the instrument as a whole. Considering the alternative design solution of a soldered joint, a failure on an assembled instrument would have been an expensive repair. Once the tools were established and proven, producing the segments for commutators as described here would also be cheaper. Although press-tools produce cheap parts, they are themselves costly to make because of the knowledge, skills and materials required.

During World War 2, a Japanese copy of the Wee Megger tester was captured and sent to Evershed and Vignoles for examination. They found that the commutator segment was produced with a wire soldered in place on the segment. Things have progressed since then; although Japanese companies were once noted for copying, they are now leaders in design, design management and 'investment policies' for products in mass markets—Evans (1990:404).

The Wee Megger Tester produced first in the 1930s would not have been possible without an understanding of electricity, and a marriage with precision technology to achieve utility. The sequence of tools necessary to produce the commutator segment were designed by an imgainative creative toolmaker. Lastly, the Wee Megger Tester was the product of a new convergent synthesis of skills, practical and scientific knowledge, with new and existing materials—always the bedrock of new technology.

05.04 Technology and design

As the generic creative system of humankind, technology encompasses the design process. Since technology is as old as humankind so is the design process, but that is not the usual perception. In the context of business and industry, design is perceived as a phenomenon of 'the eighties'—Gorb (1990:15), and considered *now* to be 'an inescapable concern of every company'—Oakley (1990:3). Furthermore, good design is perceived to be essential for manufacturing industry, and important for competitiveness—Roy (1990:49). The place of design in our lives would be better served if technology were perceived as the creative system that has brought us from the Stone Age to the way we live now.

For industry, design is a complex process of making choices and/or decisions about:

- product appearance
- product functionality
- product manufacturing methods, and
- organisational structure.

As each generation learned from the past and built knowledge onto what was handed down, the design process has became more complicated. It becomes more diverse as new generations appear with new inner compulsions to make change happen. In this climate, with an ever-increasing pace of change, successions of new technological tools have appeared down through the ages. As a recent example, CAD/CAM[4] increases capability and productivity in the design process, offering the opportunity to ask difficult questions more

[4] Computer-aided design, in combination with computer-aided manufacture; the use of computers to design parts, and subsequently to control the manufacturing process—Chambers English Dictionary (1994:191/196)

easily, so elevating the design decision making process. This has become increasingly necessary, particularly in manufacturing industry, where design is now driven by:

- rising consumer expectations,
- greater world-wide competition,
- growth in legal requirements governing product functionality,
- growth in legal requirements for Health and Safety at Work,
- exhortation by government for more competitive firms—see section 05.05.

Cost-competitive achievements in the first four of these are vital for any manufacturing company, and there are diverse vested interests in the outcome, including:

- dealership companies who need products that people want to buy, so as to stay in business, for profitability, and continuity of employment,
- component supply companies for continuity of business, and continuity of employment,
- parent manufacturing industries with successful product programmes to create profits for reinvestment in new research and design, and continuity of employment,
- society needs wealth creation—see section 5.05.

More will be said about these issues in Chapter 8.

05.04.01. Product appearance, function and manufacturing methods

Appearance has long been perceived as the essential outcome of the design process—Forty (1992:6). For Stone Age humankind, appearance would have dictated when a cobble had been suitably worked to provide a tool with a durable cutting edge. Some functional analysis of the appearance as an outcome of the design and manufacturing process was implied, and this is often the case with many products, since the design has to recognise what is feasible in the method of making. The link between form, function and the method of making is evident for example in the clothes we wear, the many different shapes of bottle that exist, and the many different designs of china crockery—Miller (1992:116). But in the case of the Hoover Dam hydroelectric generation plant, the appearance was dictated by terrain and function.

By expressing choice of appearance in products, consumers also make a considerable impact on the manufacturing processes—an impact that will surprise and possibly disappoint many. As tea-drinking became popular during the 18th Century, there was a steady increase in the demand for ceramic cups since pewter pots were unsuitable for drinking hot liquids—Forty (1992:18). As a potter, Josiah Wedgwood was particularly successful; his business ethic was 'to make more pots, sell more pots, and …, if possible, to increase unit profit on them' —Forty (1992:29). To sell their products, potters usually sent completed batches '… either direct to markets, or to merchants'—Forty (*ibid*). Wedgwood sold some pottery this way when he started in 1759, but he also used the 'novel technique' of selling from samples or catalogues in showrooms—Forty (*ibid*).

When customers placed their orders against samples or illustrations, they expected to receive replicas, but consistency of manufacture was a 'major problem'—Forty (1992:30). The fault lay with the potter-craftsmen since they could not help introducing their own variations —Forty (1992:34).

Pottery started as an industry in which a single person was responsible for every stage of manufacture—Forty (1992:32). By 1730, forms of craft specialisation were already established such as 'throwing', 'handling', or 'making glaze or slip'—Forty (*ibid*). Mid-18th Century potteries typically comprised a number of workshops in which employees performed a single task on the pots; in one pottery there were seven different occupational stages—Forty (*ibid*). In order to address the problems of manufacturing consistency, Wedgwood decided that a further stage was necessary, namely the preparation of a set of instructions for every workman, or a 'design' stage—Forty (1992:34). In the potteries, 'designing' was the preserve of a craftsman or master potter, and they became known as 'modellers'—Forty (*ibid*).

The preparation of instructions by modellers for every stage of manufacture became crucial because without 'precise' instructions the men would introduce their own 'variations'—Forty (1992:34). Preparing instructions for every stage of manufacture was so important for 'absolute consistency', that 'modellers became the most highly paid'—Forty (*ibid*). For some stages of manufacture, Wedgwood found that 'less skilled labour' could be used—Forty (1992:33). In most industries, it became increasingly important that designs should eliminate 'chance and variation' using the available means of production, since lack of consistency would be 'judged a failure'—Forty (1992:37).

Although the consumer was provided with cheaper products of uniformly high standard, such methods of manufacture were bound to require different workforce skills. Separating the stages of manufacture paved the way not only for greater consistency—as demanded by consumers—but further opportunities to use machines and to reduce production costs. However, this was not the perception in the mid-19th Century. Then, it was considered that machine manufacture 'had … poisoned the surviving craftsmen', and there was a widely accepted view that 'machines led to inferior design'—Forty (1992:42).

What had started before the Victorian era, but was not perceived, was the transition from an agrarian to an industrial economy, and the growth in population made possible because of new machines—Rolt (1988:136-138). The great early mechanical engineers such as Nasmyth and Whitworth, themselves practical craftsmen, learnt that in 'their new and rapidly expanding industry', the high standards of work required could only be done by machines—Rolt (*ibid*). The 'dispossessed countrymen and hand-weavers', who gravitated to 'the new textile towns' from necessity, had insufficient ability or aptitude—Rolt (*ibid*). In the engineering industry, machines were designed not to usurp the skill of hand/eye coordination, 'but to make good its deficiency'—Rolt (*ibid*).

The census of 1801 revealed that there were 'nine million people' in England and Wales, and 'only $2\frac{1}{2}$ million lived in towns'—Rolt (1988:138). By 1851, the comparisons were eighteen and ten million respectively, due entirely to the change from an agrarian to an industrial [technologically driven] economy—Rolt (*ibid*). This research will show that outside of industry the production-line process is widely disparaged. But consumers demand cheaper products of uniformly high standard, and will take imported goods to satisfy their expectations.

Technological functional advance could not be achieved without imagination and innovation in the design of the product and manufacturing processes. Functionality has always been the driving force of these processes in the many tools of humankind, but even product function is perceived to be benefiting from a 'much renewed interest' because of 'many new technical possibilities'—Oakley (1990:5). In this context, reference is made to 'cheap, reliable electronics, including microprocessors and computing devices … breathing new life into many products'—Oakley (*ibid*). This is a fact; however, micro-electronics created a new convergent synthesis, enabling cameras to be designed and manufactured with greater functional capability with silicon chips. Micro-electronics and precision technology made computers possible, accelerating inevitable change in both manufacturing and product design methods.

<u>05.04.02. Organisational structure</u>

The two definitions of technology discussed on page 59, refer respectively to 'ways of doing things in a social group', and 'involve people and machines'. Among the higher animals, humankind has developed the greatest material culture, and produced a wide range of objects and artefacts—Cotterell (1990:1). And for technology, as the generic creative system of humankind responsible for all these objects, the social structures can be equally sophisticated and complex. Imagine for example the social organisation used by the Greeks to make triremes, the Egyptians to construct pyramids or the Romans to build aqueducts. The range of skills, the types of knowledge, and the numbers of people required were determined by the nature and size of the object to be made. To make triremes, pyramids, and aqueducts required significant numbers of people. They would have been organised in ways that recognised the separate crafts and technological skills; the methods of organisation would have reflected the imaginative gifts of humankind as discussed in chapter 4.

However, as new technologies cause continuous change, and nowadays at a faster rate, organisational change has also occurred. The production of bobbins at Stott Park exhibited a process that was essentially practical technology, but with some scientific understanding of water-derived power generation. Significantly greater scientific understanding and precision technology were necessary for the design and manufacture of the Wee Megger Tester in the 1930s. Within the time frame of a century, the automobile progressed from an expensive toy to an affordable essential product for many because of ongoing changes in technology, and in organisation. Changes in organisational structure reflected the greater range of skills acquired by humankind as knowledge continued to build on knowledge. The technology of precision became increasingly influential, as for example the outside of the car changed from covered wooden frames to sheet metal panels produced by press-tools. Wooden structures and fabric or panel covering were labour-intensive, and costly as manufacturing methods.

In industry, organisational change was driven not only by an increasing technological capability influenced by science, but also new managerial methods such as product planning. For manufacturers to remain competitive, 'design competence' was essential in three fields—Hawk (1990:68) as follows:

- 'management design', known traditionally as 'organisational design' or 'OD',
- 'product design', includes 'design professions in engineering, architecture, the arts',
- manufacturing 'process design', 'usually … the discipline of industrial engineering'.

A problem in any one of these areas could influence one or both of the other functions—Hawk (1990:69). The relationship between the functions of product design and manufacturing have not always been clearly understood—Oakley (1984:87). Achieving a convincing product design was clear, but transfer 'to the production system' was perceived as 'a critical aspect' for management—Oakley (1984:8). The product design function could be divorced from the manufacturing process design function, and in the worst cases a prototype would be handed over to manufacturing for them to mass produce. A modern resolution for this type of problem is known as 'simultaneous engineering', and embraces research, design, development, manufacturing, supply, purchasing, and marketing—Oakland (1995:57). An example of a car product-development organisation before simultaneous engineering appears in Fig. 5.09 below.

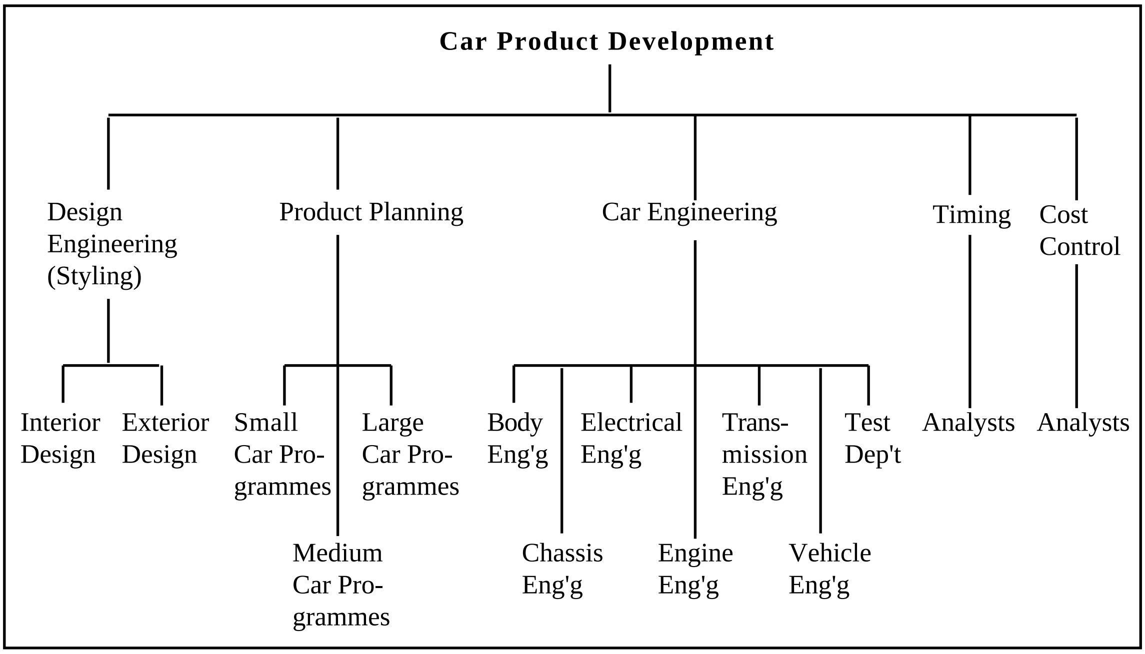


Fig. 5.09 - A car product development organisation

The example of car product-development shown in Fig. 5.09, comprises the functional organisations perceived as important before simultaneous engineering. The responsibilities were further divided in each of these functions. For Car Engineering, technological skills are required as a blend of practical knowledge combined with theoretical understanding in dedicated engineering disciplines with a scientific foundation that also continues to advance. Communication occurred at every level of the organisation shown in Fig. 5.09, so as to make effective the car product-development process that appears in Fig. 5.10 below.

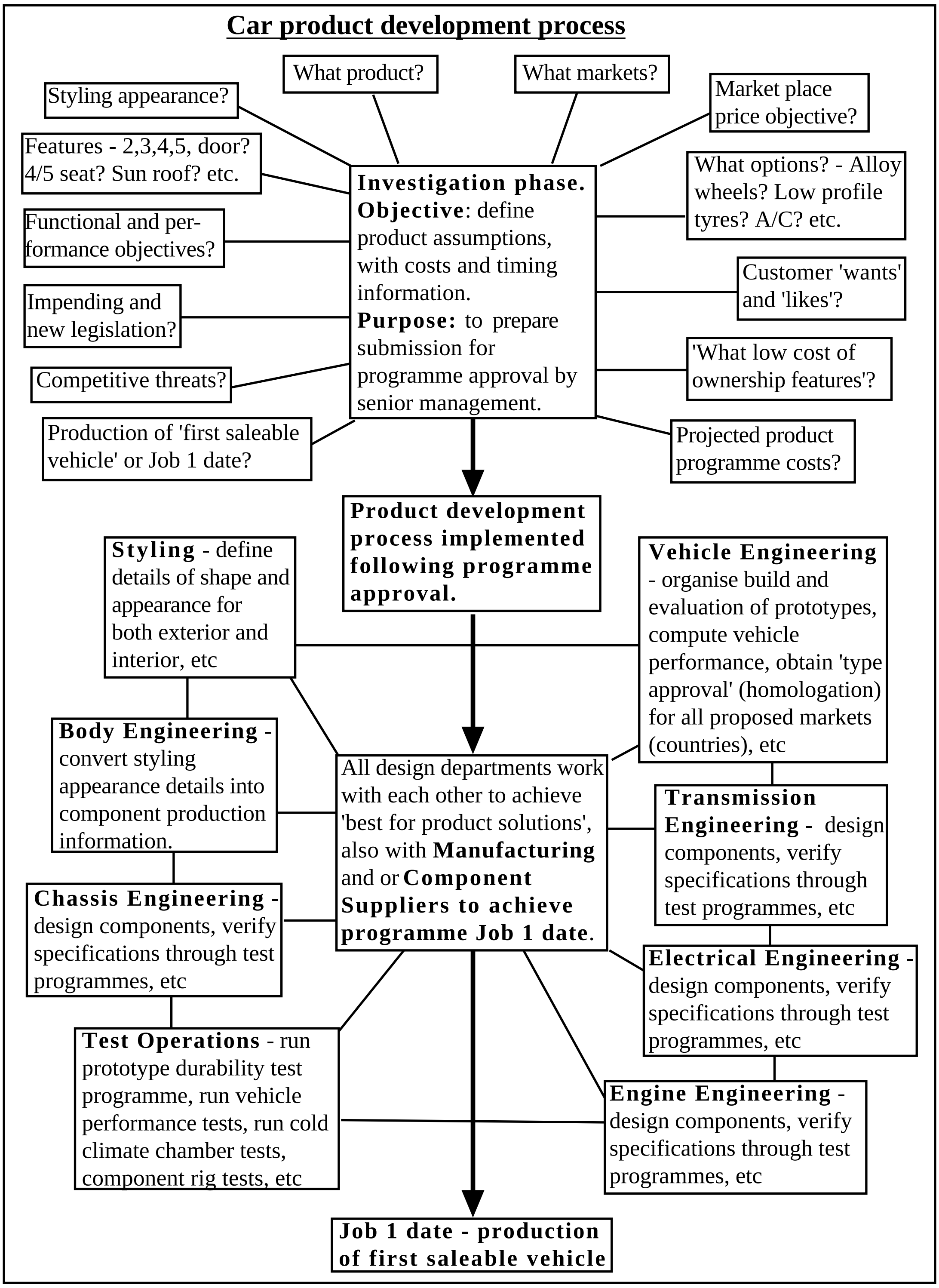


Fig. 5.10 - Car product development process

Referring to Fig. 5.10, the process starts with an 'investigation' to define product assumptions with costs and timing. This information includes the component department design objectives for 'piece costs', 'investment costs', 'weight objectives', 'lower cost of owner-ship', and 'timing'. These form a crucial part of the product objectives which also include programme profitability—the basis upon which management programme approval will be sought. The aim of the collective output of the process is to produce a specification for continuous production of cars from Job 1—the modern equivalent of Wedgwood's 'design' stage for 'absolute consistency' as discussed earlier.

The car product development process represented in Fig. 5.10, is easy to portray, but it masks a significant degree of complexity which maybe illustrated in part by a case study. The scenario is as follows: 'A manufacturer decides to fit an additional high-mounted stop lamp to a passenger car for sale in Europe'—Stanway (1997:18). The proposed fitment has the following potential legislative knock-on effect that has to be resolved before car sale:

> **Masses and Dimensions**: EC Directive 92/21EEC, plus national rules.
> The additional mass of the lamp and its wiring must be included in the calculations determining the laden and unladen masses of the vehicle. If the additional mass takes the full-specification vehicle outside the already-approved weight bands, a new type approval maybe necessary. This may have a knock-on effect of requiring a new Gross Vehicle Mass or Gross Axle Mass, which may mean different tyres, which may mean new noise, emissions, braking, steering, crash tests, etc. The implications of poor weight control at the design stage could be financially disastrous and tie up engineering resources for many months—Stanway (1997:19).

This case study indicates the design complexity for just one additional lamp perceived as a product requirement late in the programme. Whether necessary because of competitive market place requirements, or recently introduced legislative requirements, the knock-on effect in the product design and development process was significant. However, 'the motor car is one of the most heavily regulated products worldwide'—Stanway (1997:3), with a corresponding complexity in the product as a whole. There is a gradual process of trying to harmonise the many legal requirements governing car design and use, but it is a slow process—Stanway (*ibid*). The legal requirements maybe national or international in origin.

The legislative complexity that impinged on the car product development process for cars to be type approved by 1st June 1998, maybe gauged from the following:

- there were 89 separate EEC legal requirements to achieve type approval for car sales in countries belonging to the European Economic Community,
- there were also 104 separate ECE legal requirements to achieve type approval for car sales in countries belonging to the Economic Commission for Europe—Stanway (1997:22-29).

A similar level of complexity also obtains in the design of the vehicle for product marketing requirements that address customer expectations outside legislative requirements. Inadequate management of any part of this process creates a substantial business risk for the mass-car producer and the associated dependent dealership network.

However, organisational modes of behaviour or 'cultures' arise that are inappropriate for the task—Evans (1990:404). For example, in the organisation shown in Fig. 5.09, a culture of 'protecting the department' in the context of meeting the objectives would threaten what was best for the product in the market place. To overcome such problems, 'matrix' organisational designs have sometimes been adopted, as shown in Fig. 5.11 below.

Car Product Development Matrix Organisation

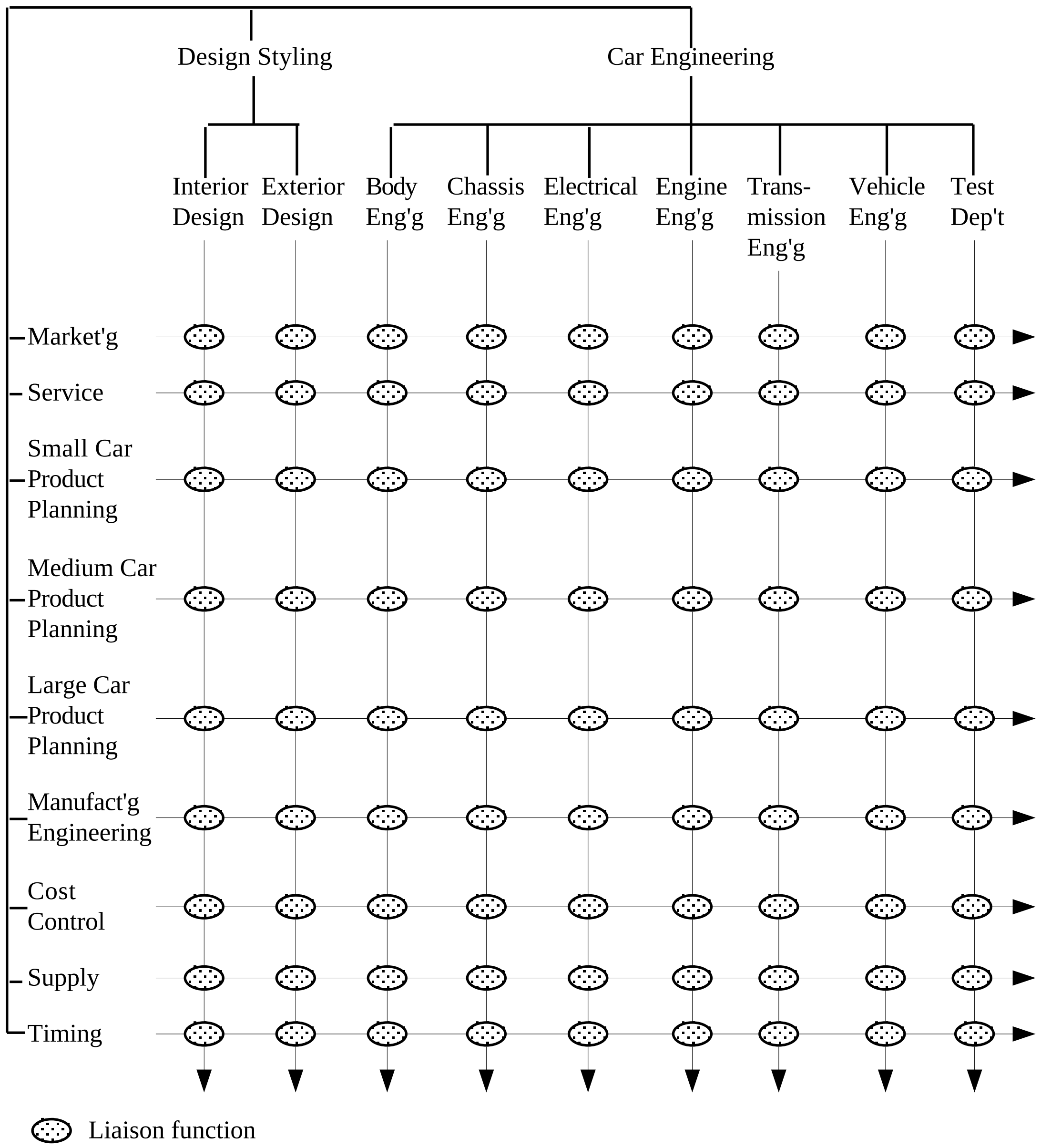


Fig. 5.11 - Matrix Car Product-Development Organisation

Matrix structures are suggested for organisations with technical responsibilities, requiring many 'functional inputs'—Farish (1995:33). With an organisation such as in Fig. 5.09, even in the framework of 'simultaneous engineering', if the resolution of a problem risked departmental objectives, the issue would be pushed up the hierarchy for resolution—see also Wilson (1990:130). Thus the hierarchy becomes overloaded—Wilson (*ibid*), and the requirement to focus on what is best for the product becomes diluted. In this respect, the matrix structure shown in Fig. 5.11, offers a number of advantages:

- problem resolution is handled by those directly involved,
- responsibility for meeting objectives is shared,
- responsibility for problem resolution is shared,
- programme 'risks' and 'opportunities' can be highlighted earlier,
- allows a flatter more efficient organisational structure.

The matrix structure also retains strong departmental functional identity, but with 'cross-linking'—Wilson (1990:131). Currently, it is perceived to offer 'better' management of the 'turbulent environments' of the complex [technological] innovative processes—Wilson (1990:130).

From the foregoing, it maybe appreciated that the technological processes involved in manufacturing industry can indeed be complex. As an example, producing a range of cars that people want to buy and on a regular basis that spans decades is an immense managerial task. What rides on the effectiveness of the management task is more than the success of companies; it is the well-being of local socio-economic communities. These are the aspects that will be considered in the next section.

05.05 Technology and wealth creation

In the context of long-term survival, firms need to incorporate the product-development process into their organisational structures—Farish (1995:5). However, many company managers feel uneasy about the design function, and although they would choose to be involved with financial matters, they leave design issues to others—Oakley (1984:6). In such a situation, the competitive edge for firms suffers from incomplete leadership.

The key to long-term survival for any firm is competitiveness—a performance characteristic encouraged by the Department for Trade and Industry, as encapsulated by Beckett (1997:3), President of the Board of Trade:

> The UK needs competitive firms to deliver the wealth that we need for our public services, to provide good jobs for all our people and to maximise quality of life.

The rationale for exhortation was made explicit by reference to various comparative measures including:

- the UK Gross Domestic Product (GDP) per head 'trails other advanced economies'—Beckett (1997:5),
- 'for decades we grew more slowly than other members[5] of the G7'—Beckett (1997:5),
- 'the UK invests too little … in equipment, infrastructure, technology and skills'—Beckett (1997:6),
- businesses are short of skilled people, although 'within the EU, the UK has the highest proportion of graduates in the population'—Beckett (1997:7),

[5] G7 comprises Canada, France, Germany, Italy, Japan, US, UK.

- investment in R&D as a percentage of GDP—the UK came fifth among the G7—Beckett (1997:8)
- interaction between elements such as investment, workforce skill levels, management and innovation were perceived as significant for improving 'the national economy'—Beckett (1997:9).

These unsatisfactory comparisons come from a report with the sub-title *Our Partnership with Business UK*, and concludes by asking how the partnership might best work with business—see Beckett (1997:51)—in order to:

- Increase the quantity and quality of business investment in the UK.
- Encourage more firms to be truly innovative in all aspects of their performance.
- Maximise the potential of all firms through the adoption of best practice.
- Ensure that the new opportunities of the Information Age are fully exploited by businesses, particularly small firms, and their employees.
- Develop and motivate a highly skilled workforce.
- Assess the impact of the EU on competitiveness.

In short, improvements in these areas are crucial to continue funding the running of our society. The expenditures planned for 1998-99, were highlighted in the 1996/97 Budget Statement as summarised in Fig. 5.12.

Departments	£ millions	Percent	
Defence	£22 240	8.13	
Foreign Office	£1 080	0.39	
Overseas Development	£2 320	0.85	
Agriculture, Fisheries and Food			
— except BSE	£2 830	1.03	
— expenditure for BSE	£580	0.21	
Trade and Industry programmes	£3 050	1.11	
Trade and Industry - Nat Inds	-£180	-0.07	
Transport	£4 600	1.68	
DOE - Local government	£31 740	11.60	◄
DOE - other	£7 640	2.79	◄
Home Office	6 810	2.49	
Legal Departments	£2 750	1.00	
Education and Employment	£14 010	5.12	
National Heritage	£960	0.35	
Health (of which NHS £35150)	£35 380	12.93	◄
Social Security	£82 950	30.31	◄
Scotland	£14 420	5.27	
Wales	£6 880	2.51	
Northern Ireland	£8 260	3.02	
Chancellor's Department	£3 200	1.17	
Cabinet Office	£1 080	0.39	
Eurpopean Communities	£2 390	0.87	
Local authority self-financed expenditure	£13 700	5.01	
Reserve	£5 000	1.83	
Sum	£273 690	100.00	
Control Total	£273 700		

Fig. 5.12 - Details of planned expenditure by government departments for 1998-99

The arrows in Fig. 5.12 show the largest public spending departments in government; they include Social Security, Health, and Environment—Budget Statement (1996-97:107). These three departments were projected to take some 58% of the budget or £158bn. This money has to be earned by the country through trade in manufactured goods and/or services, hence the exhortation for wealth creation.

By publishing the paper *'Competitiveness'*, the government seeks to raise the methodology of 'benchmarking' for the business world to compete with the best—Beckett (1997:3). The CBI estimate that by adopting 'best practice' in manufacturing, £60bn could be added to the GDP—Daley (1997:4). Furthermore, if the rest of the economy adopted similar principles, £300 bn would be added to the GDP—Daley (*ibid*); an amount that exceeds the budget projected for 1998-1999. This was noted by government—Beckett (1997:14). Technology continues to be crucial in the context of productivity improvements—Daley (1997:25).

In this thesis however, it will be argued that *neither industry nor technology are understood at the level of the critical mass in UK society*. As a consequence, the UK is losing its ability to sustain itself—that is to pay for all the services expected and demanded by society. Does it not behove us to understand why?

05.06 In summary

The relationship between industry and technology is vital in the culture of an industrialised western society. In April 1994, the Central Statistical Office (CSO) provided an example of this crucial relationship when they celebrated 80 years of tracking the cost of living. Among other benefits, the CSO showed that the life expectancy for both sexes had improved by 42% between 1914 and 1994. Contributory factors included new products and services from industry.

New technologies created new industries and jobs. In 1914, food represented 60% of the household budget, and by 1994 it was only 15%. This was possible because of new technology, including increased mechanisation in agriculture. There was a wider choice of affordable products that became progressively better for an increasingly affluent society. So the CSO data should equally be a cause of celebration for technology and industry, but such perceptions require economic awareness and industrial understanding.

The greatest part of human existence has been supported by technology based on mechanical principles 'without much … theoretical understanding'—Cotterell (1990:11). Only recently has science become dominant in the creation of new technology—Cotterell (*ibid*). But technology with a scientific basis depends on practical mechanical technology, and typically through the mastery of precision to achieve utility.

As the generic creative system of humankind, technology has undergone a structural change as knowledge continued to build on knowledge through the ages. The ever-changing nature of technology was evident with the examples in this chapter. They showed how humankind uses technology to support local economic infrastructures. The technology employed in the manufacture of bobbins was essentially practical, and would now be regarded as simple, but it sustained a small community for some 135 years—Ayris (1995:1). Its demise in 1971 was hastened by the new plastics technology—Ayris (1995:17); this should be a cause for serious reflection in society.

The manufacture of an instrument to measure electrical resistance was the direct outcome of new discoveries spawning new technologies and industries. By 1831, Faraday had found the relationship between electrical and magnetic effects—Bowers (1990:4); the basis of the new technology was scientific. Electricity generation and supply were not feasible without the technologies of precision engineering as introduced by Maudslay in the late 18th Century —see Chapter 4, p54. Electricity was yet another example of a new convergent synthesis, and like all technology it was the product of the visual imagination of humankind. As a new technology, electricity supply systems also gave birth to a growing range of electrical and electronic products and industries—Byers (1988:90-96).

Resolving the problems of precision was the key to interchangeable parts and cheap mass-produced goods. The Wee Megger Tester contained many precision parts, including the casing moulded in 'Bakelite'. Tools to produce precision-made parts were expensive, but the investment was recouped with much cheaper parts to a consistent quality standard. The manufacture of tools to produce these parts required skills that were at their best when accompanied by a highly developed visual imagination that also controlled hand/eye coordination. Such qualities were recognised by the Greeks in their goddess Pallas Athene (Minerva to the Romans), and stood for 'the intellectual and moral qualities required in practical work, and for meticulous craft skill'—Pacey (1996:97). *It will be shown that such qualities are not valued in the UK.*

Since technology is as old as humankind so is the design process, but that is not the usual perception. In business and industry, design is perceived as a phenomenon of 'the eighties' —Gorb (1990:15), and considered *now* to be 'an inescapable concern of every company'— Oakley (1990:3). Furthermore, good design is perceived to be essential for manufacturing industry, and important for competitiveness—Roy (1990:49). Design is an intrinsic part of technology. The place of design in our lives would be better served if technology were perceived as the generic creative system that has brought us from the Stone Age to the way we live now. But such perceptions required the introduction of technology as a curriculum subject long before the Education Reform Act of 1988.

For industry, design is a complex process of making choices and/or decisions about product appearance, product functionality, product manufacturing methods, and organisation. Appearance has long been perceived as the essential outcome of the design process—Forty (1992:6), but this is an erroneous perception. A link exists between product form and function with the method of making—Miller (1992:116). For the hydroelectric generation plant at Hoover Dam, the appearance was dictated by terrain and function. Design has to recognise what is feasible in the method of making.

The expectations of consumers have become increasingly significant in product design. In the 18th Century, Wedgwood found it necessary to prepare instructions for every stage of manufacture to achieve 'absolute consistency'—Forty (1992:34). Providing the consumer with cheaper products of a uniformly high standard required different workforce skills. Separating the stages of manufacture paved the way for greater use of machines and further reductions in production costs. But in the mid-19th Century, machine manufacture was considered to have corrupted extant craftsmanship, and it was widely held that 'machines led to inferior design'—Forty (1992:42).

However, what was not perceived during the Victorian era was the change that had already started from an agrarian to an industrial economy, and the growth in population made possible by a variety of factors including new machines—Rolt (1988:136-138). Nasmyth and Whitworth, as great mechanical engineers and practical craftsmen, realised the highest standards of work could be achieved only by machines—Rolt (*ibid*). In the engineering industry, machines were designed not to usurp the skill of hand/eye coordination, 'but to make good its deficiency'—Rolt (*ibid*).

In 1801, the population of England and Wales was nine million, and 2 1/2 million of these lived in towns. By 1851, the comparisons were eighteen and ten million respectively, due to the change from an agrarian to an industrial [technological] economy—Rolt (1988:138).

Definitions of technology make reference to social groups, or people and machines. The material culture of humankind is sophisticated and complex—Cotterell (1990:1), and has been reflected in the social structures through the ages. The type of technology was reflected in the social structures for the manufacture of bobbins, the manufacture of instruments to test for electrical resistance, and organisations to produce cars.

The modern car provides an example of a complex modern product that is utterly dependent on precision technology for interchangeable parts. The technology of precision applies to most parts except the soft trim items. The technologies of precision are used also to make good the deficiencies of hand/eye coordination that prevails in the majority of the population, so making feasible the mass-production of cheap consumer products to a consistent level. The skills of the tool-maker, that reside in the tool rooms of manufacturing industry, are just part of the product development process which underpins the mass production processes.

Complex products require intricate organisations to manage the development process. The type of product influences the organisation, and dictates the range of intellectually driven specialisations and skills that are required. As technology moves on, so do organisational structures. In competitive industry, the aim of the collective product development process is to produce a specification for continuous consistent production. Such a production specification is the modern equivalent of Wedgwood's 'design stage' for 'absolute consistency' as discussed earlier.

However, organisational modes of behaviour or 'cultures' can arise that threaten competitiveness. A culture of protecting the department in the context of meeting the objectives could compromise what was best for the product in the market place. To overcome such problems, when there are many technical responsibilities and functional inputs, 'matrix' organisational designs are recommended—Farish (1995:33). The matrix structure retains strong departmental functional identity, with cross-linking—Wilson (1990:131). Currently, it is perceived to offer 'better' management of the 'turbulent environments' of the complex [technological] innovative processes—Wilson (1990:130).

The government is concerned about the performance of British industry, as highlighted in the DTI's paper *Competitiveness*, November 1997. The National Manufacturing Council of the CBI expressed similar concerns in their publication *Fit for the future*, September 1997.

However, this research will show that industry is disparaged in the UK, and the role of industry as wealth creator for the state is a function that is not understood. The evidence will be discussed in 'Chapter 8 - The perception of technology'. The failure to understand the wealth-creating role of industry has much to do with culture and value judgments. Technology and culture will be discussed in the next chapter.

Chapter 6

Technology and Culture

06.01 Introduction

Researching the historical development of the place and perception of technology in the curriculum, also requires reflection on the nature of culture, and hence one of the aims of this chapter. Learning will be shown to be a cultural process. Repetitive use will be made of the terms that describe the core elements in technological continuity and progression.

The word culture is used in a variety of ways, and conveys different things to different people. Anthropologists use the term 'culture' when making reference to the particular ways of life of early indigenous peoples—Williams (1988:39). Social scientists use this word as a way of distinguishing or separating societies, and in this process they consider:

- the 'language',
- the ways of 'perceiving and thinking',
- 'non-verbal communication and social interaction',
- the 'rules and conventions' that govern reaction 'in different situations',
- the 'moral and other values', faiths and 'beliefs',
- the 'technology and material culture'—Argyle (1976:78).

But the word is also used to lay claim to 'superior knowledge', or to distinguish between '"high" art (culture) and popular art and entertainment'—Williams (1988:92). So it becomes clear that the word 'culture' has a wide range of applications and meanings. Some of the complexity inherent in the word 'culture' will be developed in this chapter, but with the primary purpose of exposing technology as the utterly dependent system manifest in every human society.

This research is based on the viewpoint that the educational system of *the UK has consistently failed to respond appropriately to 'technology'*—Chapter 1, page 1. The pivotal role of tools and technology in the experience and progression of humankind was developed in chapters 3, 4 and 5. They showed how technology was the generic creative system of humankind which has brought us from the Stone Age to the way we live now. In every society, the technology of humankind has evolved alongside humankind, and is culture-specific.

The structure of culture is complex, and is perceived to include 'certain kinds of knowledge, certain attitudes and values'—Lawton (1975:6). A number of concepts will be considered as an aid to understanding the 'place and perception of technology' in our own society. These concepts will include 'the nature of culture', 'the representation of technology within culture', 'the power of culture', and the 'value judgments' within culture.

From the time of *Homo habilis* ('literally, handy man')—Cotterell and Kamminga (1990:1), humankind has always been a tool user. Tool-use maybe found among primates—Schick and Toth (1995:49), and birds such as finches—Cotterell and Kamminga (*ibid*). And although tool-use among certain animals and birds maybe remarkable, it does not compare with the 'sophistication' and variety of artefacts that are the 'hallmark' of humankind—Cotterell and Kamminga (*ibid*).

As artefacts of humankind, Stone Age tools represent the start of a 'material culture' that began some two million years ago—Cotterell and Kamminga (1990:6). The evolution of humankind unfolded through different forms of subsistence from the hunter-gatherer, to the agricultural and pastoral, and for some the industrial—Cotterell and Kamminga (*ibid*).

Concurrently, the tools of humankind evolved from stone, through bronze and more recently to iron and steel—Cotterell and Kamminga (*ibid*). Today, the tools of humankind are multifarious; they encompass an astonishing variety of ingenious technologies and machines which in total have brought us to the way we live now. All those tools and technologies represent a distinct material culture which endows humankind in the western-world with far greater productivity and/or capability. But how well is that understood?

The greatest transition in material culture occurred in western societies; it was aided by the discovery of new elements and materials during the Industrial Revolution, but also precision technology, as discussed in chapter 4. Technology is today seen as important for the competitiveness of the UK—Beckett (1997:6), essential for the existence of 'our culture', and to sustain development of the UK as a viable economy—Adams (1992:3). 'Culture' is a complex word—Williams (1988:87); discussion will show that technology has significantly influenced culture. Equally, the structure of value judgments implicit within culture should be understood, since they too have an influence, often of a threatening nature.

06.02 Early development of the word 'culture'

From the late 18th Century to the first half of the 19th Century, five key words came into general English usage, or gained additional and important meanings; they were *industry*, *democracy*, *class*, *art* and *culture*, and reflected significant changes in society—Williams (1990:xiii). The changes that took place in those five words were inter-related, and have historical significance—Williams (1990:xvii).

Industry with a small 'i' at first described a human attribute meaning 'skill, assiduity, perseverance, diligence'—Williams (1990:xiii). From about 1776, industry with a capital 'I' was used in a collective or institutional sense to indicate manufacturing production—Williams (*ibid*). Such institutions rapidly became important, and in the 1830s they were perceived 'as creating a new system' known as 'Industrialism'—Williams (*ibid*).

The introduction of the word 'Industrialism' recognised two significant groups of changes:

(1) technical changes that were 'transforming … methods of production', and (2) the effect the changes in (1) were having 'on society as a whole'—Williams (1990:xiv). The effect of these combined changes was captured in the term *Industrial Revolution*, and was used first in France in the 1820s; the derivation reflected the social changes due to the French Revolution of 1789—Williams (1990:xiv). The Industrial Revolution in England also wrought a new society—Williams (1990:xiv).

A rapid growth in common English usage of the Greek word *democracy* or 'government by the people', coincided with 'the American and French Revolutions'—Williams (1990:xiv), but many of the references in those days were negative, and reflected the approved perceptions or value judgments of the day.

Before the early 1770s, the term *class* was restricted essentially to the divisions in schools; during the next half-century, the meaning was extended to indicate changes in the character of the divisions in society—Williams (1990:xv). There were many new usages including *higher classes* and *middle classes* which appeared 'in the 1790s', followed by '*working classes* in about 1815', and '*upper classes* in the 1820s'—Williams (*ibid*). These additional meanings have since been attributed to the changes in 'social structure and … feelings' in a society going through the Industrial Revolution, and the changes arising in a burgeoning political democracy—Williams (*ibid*).

Originally, the word *art* referred to 'any human skill', but extensions of meaning occurred about the same time as the other four words—Williams (1990:xv). A specific sub-set of skills came to be represented by *Art* and comprised the '"imaginative" or "creative" arts'; an *artist* was identified as someone with those particular skills—Williams (*ibid*).

Culture is 'one of the two or three most complicated words in the English language'—Williams (1988:87). The early usage was as 'a noun of process'—tending animals or crops —Williams (*ibid*). The original meaning of 'husbandry' was extended by metaphor in the early 16th Century to the process of human development, and was the primary meaning until the turn of the 18th/19th Century—Williams (*ibid*). Extra meaning developed as responses to the 'changes in social, economic and political life' that had influenced the words *industry*, *democracy*, *class* and *art*—Williams (1990:xvii).

More could be said about each of these five important words. However, the purpose here is to show that industry, and hence technology, were influential in the development of meanings in these words, and that culture has relevance in a number of ways.

06.03 The structure and meaning of 'culture'

In the 1970s, among the more traditional fields of sociology, 'culture' was seen as a 'doubtful area' of study—Williams (1981:9). As a neglected area of philosophy, it was often limited to specialist studies in the 'media' or the 'arts'—Williams (*ibid*). In the 18th Century, the word culture was used in an anthropological sense as in the 'whole and distinctive way of life' of some group—Williams (1981:11). So there were two senses in which the word 'culture' was used as a 'dimension of reference': (1) 'a confidently partial' way of life, and (2) a total and 'distinctive way of life'—Williams (*ibid*).

Culture is present 'all the time'—Flinders (1991:88), pervading and determining the whole of human behaviour—Rosaldo (1989:26), but without training it is not easily perceived—Flinders (*ibid*). Grasping the nature of culture is clearly not straightforward. One approach is to consider culture as the basic structure through which people experience life—Flinders (1991:88). Hence, the structure and meaning of culture will be considered in five parts:

- confidently partial ways of life,
- total and distinctive ways of life,
- communication as culture,
- the power of culture,
- the links with technology.

At first sight, the links with technology may appear to be tenuous, but this will be examined.

<u>06.03.01 Confidently partial ways of life</u>

As a dimension of reference, there are many examples of 'partial ways of life'. The term 'material culture' typically describes the mass consumption of manufactured goods in a western industrialised society—Miller (1992:133). As an acquisitive phenomenon of modern times, 'mass consumption' is a different form of 'material culture' from the tool and technology dependency of humankind that was discussed at the beginning of this chapter.

The word 'culture' is suitable for any 'social unit' with a stabilised view of both 'itself and the environment around it'—Schein (1987:8)—a reference to the formative foundation, and there are many examples. Culture is learnt as a process of 'socialisation', which enables individuals to acquire the necessary skills and knowledge for acceptance by their chosen social unit—Dubrovsky *et al* (1986:317). This was concluded by Dubrovsky *et al* when researching *Socialisation to computing in college*. As novices acquired the skills and knowledge needed for acceptance, a change in their status occurred that went beyond the social organisation—Dubrovsky *et al* (*ibid*).

In 'computing', the process of socialisation in one organisation provided a form of preparation 'for encounters with the culture in all subsequent organisations'—Dubrovsky *et al* (*ibid*). This would be evident in computing, since the recently established jargon is a separate language shared only by those trained in information technology, and such training goes beyond the boundaries of any single social unit in the field of computing. What happens in the field of computing, applies equally in other occupational fields, since work-specific jargon would provide a basis for socialisation into similar sub-cultural units. This will be examined further in 'the power of culture'.

Viewed in yet another way, understanding 'culture' is a process of making sense of the reality of ourselves within nature and our environment, as well as the relationships in our respective social units—Fiske (1982:121), and is a key point of argument.

As a 'culture system' in the 19th Century, the school was perceived to be under threat from two different directions, namely the 'literacy of culture' and the 'literacy of communication' —Bantock (1967:19-20). The school culture was structured around 'the printed word', but the rising demands of an 'industrial bureaucratic state' during the 19th Century required the 'literacy of communication'—Bantock (*ibid*). Thus the 'need to learn to read and write' was 'imposed' on the whole population, causing 'a conflict of two cultures'—Bantock (*ibid*). The conflict was between a 'traditional culture of great verbal, emotional, and intellectual complexity', as 'the prerogative of the highly educated and sophisticated classes', whereas 'the culture of the people was essentially … oral' arising out of the 'arts and crafts they practised' —Bantock (*ibid*).

As partial ways of life, the concept of *Two Cultures* was used by C P Snow as the title of his Rede Lecture in 1959. Snow asserted that not only were there 'two cultures' in academia, but that they were polarised. Literary intellectuals as the traditional culture at the one end, with scientists at the other, and between them a complete absence of understanding. At the turn of the century, these 'two cultures were … dangerously' alienated—Snow (1965:17). Because of their failure to communicate and to understand, both cultures were 'self-impoverished'—Snow (1965:13). A failure to communicate between these two important cultures was 'dangerous for our society'—Snow (1965:98).

However, at the scientific end of the spectrum, there was a further divide. Pure science was respectable, but applied science (engineering) was regarded as an 'occupation for second-rate minds'—Snow (1965:32). Snow was criticising the academic scientific community for their failure to understand; this will be discussed further in the next section, and will show that it was a problem even in Plato's time.

Meanwhile, a further example of one particular partial way of life is captured in the reference to a university 'student culture'—Bantock (1967:190). So there are several strands of culture as partial ways of life in a university.

As schools and universities have 'cultures' representing their particular partial ways of life, so do firms in every field of business. One example of the influence of organisational culture in industry was discussed at the end of the previous chapter, and showed how the requirement to meet departmental objectives could compromise the quality of the product in the market place.

Although most individuals function within an enterprise of some kind, the dynamics of life in organisations continues to baffle many—Schein (1987:1). Culture and leadership are perceived as directly related, and furthermore that good leaders are those with the skills to manage culture—Schein (1987:2). Essentially, the function of a leader or manager is to complete tasks through people—Stewart (1986:36). This requires awareness of the problems that can arise within organisational structures, within the networks of cooperation and communication—Stewart (*ibid*).

Discussion about communication will be continued later in this chapter.

06.03.02 Total and distinctive ways of life

Total and distinctive ways of life are represented by many different societies, but the one feature they have in common is how they apply their imagination to use available materials in their technologies for the purposes of survival. Societies interact with their surroundings, and the location influences the evolution of their techniques and technologies. Knowledge is learned and passed down the generations as social cumulation, and it becomes the culture which enables humankind to 'adapt' to 'different environments'—Cotterell and Kamminga (1990:1). In this process, mechanical knowledge was identified and applied throughout most of the life-span of humankind, with little 'theoretical' grasp—Cotterell and Kamminga (1990:11). These concepts will be considered in case studies that are significantly different, to show the central role of technology within culture.

Total and distinctive ways of life are not immune to technology transfer; it takes place between nations through interaction which includes trade. For example, when a few 'white' people began to push into the North American 'arctic' regions, they had to 'learn' from the local people about 'shelter, clothing, hunting and travel'—Pacey (1996:142). Here were the technologies of survival for a severely cold climate.

Through trade, a 'two-way exchange' of technological information took place between the white and local cultures first with the 'Dene' Indians, and subsequently with the Eskimos—Pacey (1996:144). The processes of technology transfer with the local people started in the 19th Century, and continued into the 20th Century—Pacey (*ibid*). People endemic to the region often found innovative ways to adapt the technologies of the west to their 'life-styles' —Pacey (*ibid*). Modification of the 'service and maintenance procedures' of the snow-mobile to cope with the arctic conditions was one example—Pacey (*ibid*). The word 'Anorak', now subsumed into the English language, evinces better protective clothing—Pacey (*ibid*), as well as technology transfer.

The Lapp peoples live in the 'extreme north of Scandinavia', and had a way of life that was entirely dependent on material from the reindeer—Bronowski (1979:48). They ate the meat, drank the milk, used the sinews, furs, bones, and antlers, and they made shelters from the hides—Bronowski (*ibid*). The Lapps have since become dependent on the snow-mobile in order to herd their reindeer—Pacey (1996:2), a further example of western technology transfer.

By about AD 1500, the South American Inca peoples had evolved their own distinctive way of life—Bronowski (1979:96). They developed masonry skills at a significant level, and the quality of their masonry has withstood the test of time—Bronowski (*ibid*)–Fig. 6.01 below.

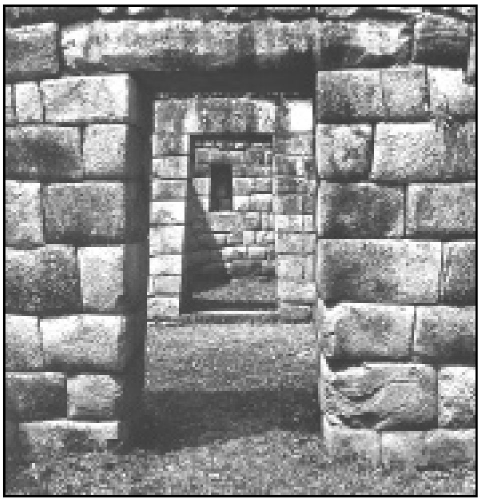


Fig. 6.01 - The masonry skills of the South American Inca—Bronowski (1979:97)

Stone was an ideal material for building walls, but considerable skill in hand/eye co-ordination had to be learned. The Inca masons applied their skills and imagination to make houses. With the addition of further new ideas as knowledge built on knowledge, they extended their skills to plan and make streets which became towns or cities such as Machu Picchu—Bronowski (1979:98-99)–see Fig. 6.02.

Fig. 6.02 - The City of Machu Picchu - see Bronowski (1979: 98-99)

Machu Picchu is over 2400 metres (8000 feet) in the high Andes mountain range—Bronowski (1979:96). It maybe seen that the ground was steeply sloping. So the Inca peoples developed agriculture on terraced hillsides to grow their crops such as the potato and maize; control of irrigation was a primary necessity for the terrace technique—Bronowski (1979:100). With their stone structures and towns, their hillside terraced agriculture, the Inca people exhibited community organisations with divisions of labour in the learned form of behaviour characteristic of their culture—Bronowski (1979:96); in other words their learned response to the problems of survival as a society.

In the period between 1438 and 1532, the Inca culture established an empire bounded by three thousand miles of Pacific coastline and the Andes—Bronowski (1979:100). As in any empire, the authority of the ruling classes was sustained by three key [technological] inventions—'the roads, the bridges and the messages'—Bronowski (*ibid*). The Incas took great care of their inventions, which did not include the wheel or the arch, and their messages were not written, but comprised 'numerical data' as knots on pieces of string known as *quipus* —Bronowski (*ibid*).

The Spanish conquered the Incas in 1532, using the 'terrible horse' to plunder the cities—Bronowski (1979:102). Cities are sophisticated places devised by humankind to live on a larger agricultural base than can be sustained by a village—Bronowski (*ibid*). As such, a city not only provides an administrative centre, but can afford every kind of craft skill as a life-time specialist occupation with opportunities for goldsmiths, coppersmiths, weavers and potters—Bronowski (*ibid*). As a conquered people, the work of these specialists was plundered; with new masters invention ceased, leading to the demise of the Inca empire—Bronowski (1979:103).

The technology of Spain enabled the Spaniards to navigate their way to South America, and to conquer the Inca peoples, but what was the foundation of Spanish technology? The Greek and Roman civilisations were two of the most interesting in 'ancient Europe'—Landels (1997:7), and both provide further examples of distinctive ways of life. Their contributions in the field of social cumulation, or knowledge building on knowledge, were significant in Europe and beyond.

Steel is thought to have been invented in the area of 'Anatolia or northern Syria' about the 13th/14th Century BC—Deshayes (1969:181). The 'ancient' technologies were changed by this invention, and made 'improvements in equipment' feasible—Deshayes (*ibid*). Through technology transfer, these improvements became evident in Greece during the 6th Century BC—Deshayes (*ibid*).

Before the 'classical period', Greece was a 'poor country' with a few isolated plains among barren mountains, a long coast-line, and little 'mineral wealth'—Deshayes (1969:181). The finances available were insufficient to establish an industrially based economy, but since slave labour was abundant and cheap there was no incentive to mechanise—Deshayes (*ibid*). But the 'educated' classes also held 'manual labor' [*sic*] in contempt, and 'mathematicians and scientists' were therefore not encouraged in the field of 'technical progress'—Deshayes (*ibid*). As inventions, their machines were usually of theoretical interest only since use and construction were not considered—Deshayes (1969:181). Nevertheless, the Greeks used a wide range of technologies such as:

- 'construction', 'housing', 'masonry', 'reinforced architecture', 'the roof', and 'arches',
- 'transportation', 'roads', 'vehicles and harnesses', 'ships', 'navigation' and 'ports',

- 'the beginnings of mechanisation', 'the water mill', 'cranes', and 'the beam press',
- 'hydraulics', 'hydraulic machines', 'water supply', 'sewers',
- 'military machines',
- 'industry and crafts', 'mines and metallurgy', 'pottery', 'sculptured vases and statuettes', 'glass and enamel', 'spinning and weaving', 'woodworking', 'the saw and lathe', and 'painting',
- 'agricultural techniques', 'the plow' [*sic*], 'millstones and crushers',
- 'weights and measures', 'coins', 'papyrus and parchment'—Deshayes (1969:181-213).

Greek agricultural and 'craft' technologies 'remained' rudimentary—Deshayes (1969:213). However in transportation technology, the early social cumulation of the Greeks was also structured around ship-borne 'import and export' since 'overland' trade was 'slow and costly'—Landels (1997:133), in the mountainous terrain. The siting of Greek cities was often influenced by the local 'anchorage'—Landels (*ibid*).

For much of the 5th Century BC, Greek naval technology was supreme in the 'Aegean' sea, so-much-so that other 'communities' joined in a 'defensive' association to safeguard trading 'routes'—Landels (1997:133). This alliance comprised a number of trading city-states—Landels (*ibid*). Trade was stimulated as Greek influence spread; in particular wealthy city-states such as Alexandria, Pergamum and Syracuse supported and encouraged science and philosophy—Deshayes (1969:213). These 'factors', briefly described here, were integral in the evolution of Greek technology, but many of the 'inventions' did not come to fruition until peace was achieved with Rome—Deshayes (*ibid*).

The Roman social cumulation of knowledge building on knowledge in technology was considerable, but essentially to do with 'practical application'—Landels (1997:186). The Greek legacy to Rome was a scientific understanding that was already old by the 'second century BC', and the Romans made little further scientific 'progress'—Duval (1969:256), down to the 5th Century AD—Landels (*ibid*).

The 'genius' of Rome was to perfect and circulate 'still-rudimentary techniques' for everyday application in a large empire, but also their organisation of 'collective effort'—Duval (1969:257). 'A Roman project' remains a byword for extraordinary technological achievement—Duval (*ibid*). The Romans communicated techniques of 'economic … mass production' capable of raising the living standard in a large empire—Duval (1969:217).

The technological achievements during the Roman period maybe summarised by three groups of activities:

- techniques 'inherited' from Greece, and 'perfected' for wider application in the empire,
- technology transfer from the barbarians that was 'introduced' without change into 'Latin Western civilisation',
- and the inventions achieved by Rome—Duval (1969:257).

Rome had a 'powerful and complex' system of governance, but there appears to have been no central coordination of 'research and development' to stimulate scientific advance and technological progress—Duval (1969:258). Technological 'progress' was by empirical 'rather than' scientific means—Duval (*ibid*).

Much of the Greek knowledge of machines was 'buried in theoretical treatises', and was not used to mechanise; this maybe partly explained by the presence of 'slave-labor' [*sic*]— Duval (1969:258). The Greek 'engineers' were masterful in their 'public works', but their skills were 'never' applied to raising 'production' levels—Duval (*ibid*). The Romans on the other hand were poor in their use of 'science' to develop machines, to mechanise industry, or the application of science to 'agricultural production'—Duval (*ibid*).

There is one further aspect of culture that should be discussed at this juncture, namely value judgments. This concept is important since 'the perception of technology' to be discussed in Chapter 8 will include a wide range of 'value judgment' statements. Crucially, these statements will show the extent to which the pivotal role of technology in the life of our society is not understood. But it is important to understand how they are manifested, how far back they go within the social cumulation that has been handed down to us, and how they appear in modern times.

Recapitulating, the 'educated' classes in Greece held 'manual labor' [*sic*] in contempt, and 'mathematicians and scientists' were therefore not encouraged in the field of 'technical progress'—Deshayes (1969:181). Cotterell and Kamminga (1990:11) make a similar point when they write:

> Despite their obvious importance to society the constructions of artisans were regarded by Confucian scholars and classical philosophers as unworthy of attention. Plato [4th-5th Century BC] (*Giorgas* 512b–e) wrote of the engineer: 'at times he has no less power to save lives than the general … do you place him in the same class as the advocate … You disdain him and his craft and you would call him engineer as a term of reproach and would refuse … to give your daughter to his son. Plutarch [1st-2nd Century AD] (*Marcellus* XVII, 3–4) claimed that Archimedes held the practical arts in disdain, 'regarding the work of an engineer and every art that ministers to the needs of life as ignoble and vulgar.'

Also, although numerous Roman engineers graduated from a 'technical school', they 'were slaves'—Cotterell and Kamminga (1990:11). Vitruvius was an acclaimed engineer and architect in 'Imperial Rome', but his *'Ten books on architecture'*, revealed his poor Latin and humble background—Cotterell and Kamminga (1990:12).

However, writing about *Engineering in the Ancient World*, Landels (1997), a scholar in the classical languages, offers further insights that influenced certain aspects of Greek 'scientific thought'—Landels (1997:186). The Greeks liked 'stability, rest and permanence', and disliked 'change, movement and what they called *genisis* and *phthora*, "coming-to-be" and "passing-away"'—Landels (*ibid*). Consequently, they understood the 'static' sciences such as 'hydrostatics' and 'mechanical problems not involving movement', but lacked knowledge of 'dynamics and ballistics'—Landels (*ibid*).

Comprehending the static, but failing to understand the dynamic sciences was an obstacle that distracted the early Greek philosophical enquiry about the 'physical nature of the universe'—Landels (1997:187). Although 'a century later', the same problem troubled Plato, his reactions reflected traditional Greek philosophy—Landels (*ibid*). Plato also argued that when 'physical objects' were subjected to 'perpetual movement, change and destruction', they could never be 'truly … known or understood'; this viewpoint was seen as an 'anti-physical trend'—Landels (*ibid*).

In his *Timaeus*, Plato examines the 'physical world and its creation', but 'elsewhere' he encouraged the 'true philosopher to … rise above' such matters 'in the pursuit of true wisdom and knowledge'—Landels (1997:187). Those who admired Plato saw this as an 'honest logical conclusion', but his 'enemies' perceived an aristocratic 'snobbish contempt' for contempories occupied by working on 'physical objects all their lives'—Landels (*ibid*).

Centuries later, this contentious issue was made worse when some of Plato's admirers took the 'anti-physical attitude' beyond what he had intended—Landels (1997:187). Comprehending neither the Greek psyche from which it came nor Plato's thinking, 'they exalted the pure and theoretical sciences (such as geometry and astronomy), and disparaged mechanical research or 'practical application'—Landels (*ibid*). C P Snow tried to address the modern manifestation of this problem in his Rede Lecture of 1959, but it was perceived as divisive. However, all value judgments carry the risk of being divisive.

Reflecting on the Lapp, Aborigine, Inca, Greek, and Roman peoples, their distinctive ways of life were culture-specific, and were founded on the same evolving format of technology for all societies, for all civilisations as discussed in Chapter 4. However, culture is also considered to be communication—Hall (1990:3), and will be discussed next since at first sight it appears that technology is not represented.

06.03.03 Culture as communication

As a process learnt through socialisation, the teaching of culture should be feasible—Hall (1973:37). With the exception of language as a subject paramount in all cultures, there has been 'little success'—Hall (*ibid*). But some idea of the complexity of culture maybe gained by examining Hall's assertion that 'culture is communication'. To gain recognition 'as a cultural system', three key elements have to be collectively satisfied; every system has to be:

'A. Rooted in a biological activity widely shared with other living forms, and … no break with the past.
B. Capable of analysis in its own terms … , and paradoxically—
C. So constituted that it reflected all the rest of culture and was reflected in the rest of culture'—Hall (1973:38).

These requirements were determined by operational observation of language as a cultural system—Hall (*ibid*). The communication process was represented by no fewer than ten 'Primary Message Systems' (PMS), including:

'1	Interaction	6	Temporality
2	Association	7	Learning
3	Subsistence	8	Play
4	Bisexuality	9	Defense [*sic*]
5	Territoriality	10	Exploitation (use of materials)'—Hall (1973:38)

Three significant characteristics emerged with regard to the structure of each PMS:

'1 … biology pervades each PMS,
2 … each can be examined by itself,
3 … each gears into the over-all network of culture'—Hall (1973:39).

The complexity of language and hence culture maybe further understood by a brief look at each PMS in turn:

1. *Interaction* - people interact with their 'environment', for which one has to be 'alive'— Hall (1973:39). Interaction includes living in groups which requires 'speech', a complex form since it includes 'tone of voice and gesture'—Hall (*ibid*). Interaction occurs in 'time' and 'space', and includes particular forms such as 'teaching, learning, play and defense' [*sic*]; interaction is at the centre of culture for humankind—Hall (*ibid*).

2. *Association* - living in groups is association by definition, and introduces the complexities of 'pecking order'—Hall (1973:39). Living things usually have a structure of association that maybe observed—Hall (1973:40). One example of the complexity of association through language is manifest in the range of 'dialects among the social classes'—Hall (1973:41). 'The tone of voice' [and language] used by individuals in hierarchical structures would reflect their status, that is whether they were subservient or not—Hall (*ibid*).

3. *Subsistence* - is fundamental and goes back to the earliest days of humankind—Hall (1973:41). This PMS is also extremely complex since it encompasses everything from individual dietary traditions to the 'economy of a country'—Hall (*ibid*). The intricacies include the formalities of communications at mealtimes, and constraints about what maybe discussed—Hall (1973:42).

Another component of *subsistence* is work in all its forms; different kinds of work have matured around every type of employment or occupation, each with a distinctive language—Hall (1973:42). Types of work are 'always ranked', and what is held with some esteem 'in one culture', may have very low esteem in another—Hall (*ibid*). For example, to work with one's hands in the USA attracts no 'stigma', whereas in many cultures physical work is indicative of 'low status' and is 'undignified'—Hall (*ibid*). Such value judgments can have serious consequences; for example nursing as an occupation in the countries of 'Latin America' was ranked so low that 'only uneducated girls' could be recruited—Hall (*ibid*). Culturally driven value judgments similarly threatened 'industrial safety' training in 'Latin America'—the safety engineers were required to wear overalls to demonstrate the 'safety measures on machines in the plant'—Hall (*ibid*).

4. *Bisexuality* - reproduction of the species and the differences of 'form' and 'function' were separated on bisexual lines long ago; genes are part of the bisexual PMS—Hall (1973:42). Animal behaviour is usually along bisexually separated lines, and this has given rise to some misconceptions about the physiology of humankind—Hall (1973:43). What is regarded as manly behaviour in one culture maybe regarded as 'feminine' in another—Hall (*ibid*). In Iran for example, the cultural norm is for 'men … to show their emotions'; a failure to do so indicates 'lacking a vital human trait', and lacking dependability—Hall (1973:44). On the other hand, Iranian women are regarded as 'coldly practical', and 'exhibit many of the characteristics' associated 'with men' in the USA—Hall (*ibid*). Such forms of behaviour can come as a 'shock' since they were attributed to 'human nature', rather than a learned form of behaviour that was 'particularly complex'—Hall (*ibid*). Comparisons between masculine and feminine forms of behaviour differ 'widely' from one national culture to another—Hall (*ibid*). The concept of culture as a learned form of behaviour has not been easily accepted, since it challenges established ideas—Hall (*ibid*).

5. *Territoriality* - the equilibrium of the whole of life is centred around a 'delicate' territorial relationship since humankind uses space for all its 'activities'—Hall (1973:45). Much of the history of humankind refers to competitions for territory with descriptions of the wresting and defence of space—Hall (*ibid*). We learn the language of space as part of our respective cultures; examples include the distance people sit from the most senior person at formal meetings, and is a recognition of their status—Hall (1973:46). Space is set aside for all types of activity including 'work', 'play', 'education', and housing—Hall (*ibid*). Such spaces have been purpose designed, and they each have rules that govern personal behaviour—Hall (*ibid*).

6. *Temporality* - has to do with the life and nature of humankind, and often in conjunctions of time and association—Hall (1973:46). Examples include the age divisions in a society that separate the school population, the working population and the retired—Hall (*ibid*).

7. *Learning* - is a PMS of considerable complexity. In one context, it is the 'adaptive mechanism' of the evolutionary process that allows 'birds, mammals and insects' to cope with change in their environments—Hall (1973:47). As the 'adaptive mechanism' of humankind, learning became more influential with 'language' since what had been learnt could travel across 'time' and 'space'—Hall (*ibid*). The reaction of a deer to a man with a rifle may teach a fawn how to react, but without a symbolic method of 'storing' the potential danger for future use, the fawn cannot be taught across time and space—Hall (1973:48).

However, people brought up in disparate cultures have different methods of learning—Hall (1973:48). The method of learning in some cultures is by memorising and repetition, but without 'reference to logic'; in others, students learn from teacher demonstrations without active practical participation—Hall (*ibid*). 'Doing' is an important element in the educational methodology of the USA, whereas hardly any 'pragmatic' content appears in the educational systems of other cultures—Hall (*ibid*).

These different ways of learning become apparent for people who go overseas to train 'local personnel'; comparisons of national educational systems can generate 'emotion'—Hall (*ibid*). The emotions released in this way happen because people are defending how they have been educated, so there are value judgments at work. Individuals are taught to learn in ways that are representative of their particular culture, and trying to learn the methods of another culture becomes exceedingly difficult—Hall (1973:48). However, culture is 'learned and shared behaviour', and as such it 'reflects' not only the way we learn, but what we have learnt; learning is a crucial and fundamental part of life—Hall (*ibid*).

Hence learning has a role both 'as an agent of culture', as well as within the 'mechanism of survival'—Hall (1973:49). But the agents of culture that provide learning include parents as well as schools—Hall (1973:50). Adults who have learned to learn, as well as what to learn, impart their knowledge together with their 'prejudices and convictions' in various ways, so passing on the culture—Hall (*ibid*).

8. *Play* - As an area of learning this is yet another 'adaptive mechanism' of humankind, and is woven into all the other PMSs—Hall (1973:52). Humour is part of the PMS of play for people as expressed through laughter and the telling of jokes; those able to 'learn the humour of people' and to 'control it', are adept at exerting influence in many fields—Hall (*ibid*).

9. *Defence* - The animal and human species exhibit defensive mechanisms, and they are hugely important—Hall (1973:53). The defensive mechanisms of humankind have evolved with significant imagination, and they fall essentially into two groups: (1) to counter the 'potentially' destructive powers of 'nature', and (2) to counter the destructive forces in the societies of humankind—Hall (1973:53).

10. *Exploitation* - is the PMS adopted by all animals, including humankind, to use the environment in which they live—Hall (1973:56). Animals other than humankind have changed over time and developed specialised equipment to help them live and survive in their habitat—Hall (*ibid*)–see also Chapter 3, p24. Some living 'organisms' have evolved 'specialised' functional systems as extensions of their bodies to enhance survival in their environments—Hall (*ibid*). Examples include the spiders web, the cocoons of certain insects, and arguably the 'nests of birds'—Hall (*ibid*).

Using extensions of the body was an activity that evolved in particular with humankind, and is one of the primary threads of the argument contained in this thesis. With imaginative application, humankind not only excelled with hand tools, but after the relatively recent discovery of precision, humankind has regularly added new technological systems to its inventory of tools. Although it is claimed that physicists, mathematicians and engineers have taken to looking at 'events as aspects of communication'—Hall (1973:97), there was no reference to a dependency on tools or technology in any of the PMSs.

06.03.04 The power of culture

Individuals experience life through many social organisations, starting with the family and continuing in schools; subsequent organisational experience differs, and may include a college, the armed forces, and/or employment—Handy (1987:17). In the processes of socialisation, individuals come under pressure 'to adopt' the 'values and customs' of each organisation—Handy (1987:142). 'Strong organisations … have strong cultures' that influences the whole structure; organisations develop their own cultures, and one has to be a psychological and physical part of the organisation in order to work in it—Handy (*ibid*).

The process of socialisation into any group entails 'the … informally organised social production and reproduction of sense, meaning and consciousness'—O'Sullivan *et al* (1983:57). Social groups develop unique guidelines to handle their problems of external and internal relationships, and they do so from what has proven satisfactory in the past— Schein (1987:9). These guidelines are taught to new members as the right way 'to perceive, think, and feel in relation to their problems'—Schein (*ibid*). These experiences are powerful; collectively they shape not only our perceptions of authority, but our expectations and relationships with people, and how we behave as individuals—Handy (1987:17).

Living through the different sub-cultures of life, each individual builds a portfolio of value-judgments and expectations based on their internal and external organisational relationships. The power of these sub-cultural experiences, and the hold they have over our reactions, expectations and value judgments may sometimes prove difficult when confronted by a totally different sub-culture. For example, Peter Gould as a former secondary school headteacher became manager of education/industry liaison at Nortel Networks, a multi-national company in telecommunications. Peter described his experience as 'the hardest thing he had ever done'; he was not referring to the whole of his time at Nortel, but:

> … to the change I had to go through from my own prejudices about Industry. Also the different mindset of Industry and to many people working in it. Also their inaccurate understanding of what is going on in schools. It's something to do with two way ignorance and misconception. Also management differences.

The power of culture is such that barriers can be created in cross-cultural meetings, but how widely is this phenomenon recognised? In the context of education/industry liaison, a CBI Task Force reported (1988:9):

> First, there must be better mutual understanding of what business and education should expect of each other; at present there is too much ignorance and prejudice on both sides.

The ignorance and prejudice on the part of members from both sides stems directly from the different routes in the processes of organisational socialisation for the individual. These two sides have distinctly different 'cognitive structures', different 'informational content', with different 'opinions and attitudes'—Festinger *et al* (1963). These differences are powerful, and comprise a phenomenon we are rarely taught to expect. Hence, when disparate cultures come together, as in education/industry link activities, while they may share a common mother tongue, they do not share a common language—Owers (1994:69). A detailed development of this argument appears in Fig. 6.03.

	How they respond	
ISSUE	INDUSTRY	EDUCATION
MANAGEMENT DIRECTION	From the top, has to be unambiguous.	By committee, more diffuse, enforcement structure is weak other than by professional sanction or moral authority. Dissent encouraged on all issues affecting the life of the organisation.
FINANCIAL:		
Wealth creation	Essential for investment in new product programmes, which in turn is essential for survival.	Not a requirement for state funded schools. Many teachers are provoked by the concepts of ‘wealth creation’ and ‘profit’ - see Owers (1993:12)
Costs	Of paramount interest and importance, directly affects survival.	Of less importance, immediate survival not threatened. Continued existence not dependent on profits.
TIME	Time is money.	Time is not money.
FUNCTIONAL OBJECTIVES	Centred around producing competitively priced, good quality products that people want to buy.	For state schools - to deliver an educational service that satisfies the requirements of the national curriculum.
WORK PROCESSES	Stress on efficiency, currently creating a great deal of pressure	No comparable ethos, but teachers are under a great deal of pressure
MARKETING	Essential for business and industry	‘Morally offensive’ to the world of education'
CLIENT GROUPS	The buying public, businesses, government departments etc	School children/ pupils / students
CULTURE		
Value judgments	A sub-set exclusive to industry	A sub-set exclusive to education
Opinions	A sub-set exclusive to industry	A sub-set exclusive to education
Perceptions of what is important	A sub-set exclusive to industry	A sub-set exclusive to education
‘Norms’ of acceptable behaviour	A sub-set exclusive to industry	A sub-set exclusive to education
CONCLUSIONS	The response of industry to all these issues, leads to regular use of specific terms, the development of jargon to the point whereby the language is exclusive.	The response of education to all these issues, leads to regular use of specific terms, the development of jargon to the point whereby the language is exclusive.
	Industry does not share with education a common language, only a common mother tongue.	**Education does not share with industry a common language, only a common mother tongue.**

Note: From *Meetings and effective communication*, (1994) unpublished MA (Ed) thesis, by Owers, S

Fig. 6.03 - How education and industry respond to the primary resources and other issues

Fig. 6.03 shows how the responses made by education and industry, in the context of the primary resources for organisations, are significantly different and would be a source of friction between the sub-cultures.

The sub-cultures of education and industry have each developed their own fields of knowledge. The application of knowledge within organisations requires discernment, judgment and performance; these are skills acquired through understanding the beliefs, values, and attitudes of the organisation—Hirst *et al* (1983:11). Culture is a 'matrix' of human patterns of behaviour, including beliefs, perceptions and attitudes, and empowers the 'decision making' processes in any society—Schmidt (1988:14). Those who are culturally insensitive may experience 'culture-shock'—Schmidt (*ibid*), a sign of the power of culture.

06.03.05 The links with technology

Cultural systems embrace communication and the 'activities' and 'products of groups'—Poyatos (1983:3). These concepts are shown in Fig. 6.04 overleaf—Poyatos (1983:27).

The reference by Poyatos to the 'activities' and 'products of groups' is an important distinction, since it encompasses all the products of technology by which any group is surrounded as part of its culture. Such products are the outcome of the social cumulation of knowledge that is handed down in every society as technology for the purposes of survival. Technology is traditional in the culture of every society. But as with Hall (1973), Poyatos (1983:27) argues that culture is essentially about communication—Poyatos (*ibid*).

From Fig. 6.04 below, the composition of culture is 'multifaceted', and grouped into two system domains through which culture is experienced—Poyatos (1983:27). These system domains are defined as 'Sensible' and 'Intelligible', and describe experiences achieved respectively through the 'senses' and through the 'mind'—Poyatos (*ibid*). But the imaginative and creative technological activity of humankind is also represented; examples include vehicles, architecture, town and settlement layouts. These examples have followed the pattern of technology from the Stone Age to the Space Age. The pattern whereby humankind has consistently applied inventive capability on the materials by which it was surrounded in order to remake its environment—Bronowski (1979:20).

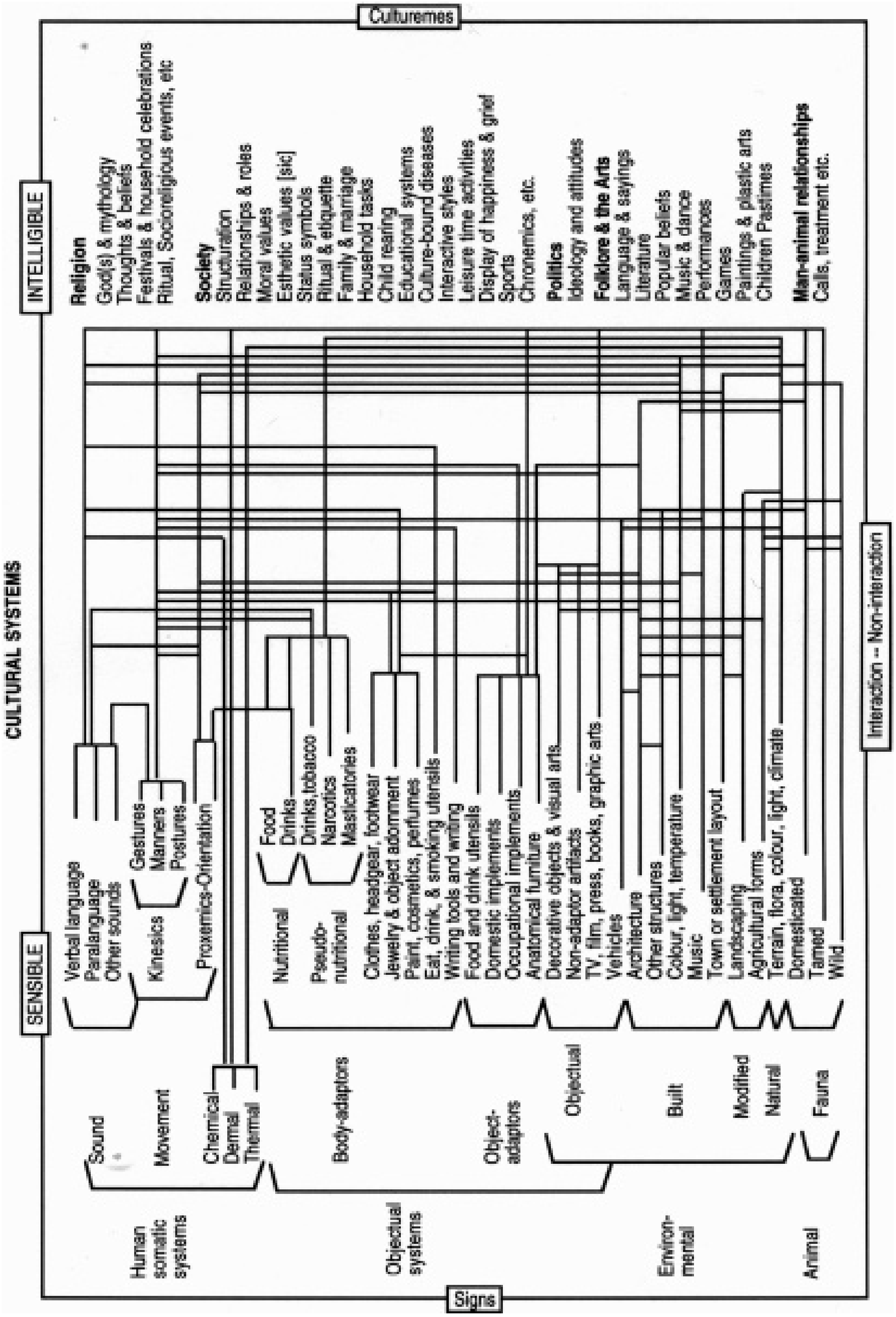


Fig. 6.04 - Sensible and Intelligible Systems in Culture - Poyatos (1983:29)

So, although technology is the generic creative system of humankind, it is not listed as an 'intelligible' system in Fig. 6.04. Furthermore, much of the communication of humankind would be to do with tools and/or technology, mostly as users but some as creators or inventors. Modern systems of communication would not exist without technology.

06.04 In summary

The primary purpose in this chapter has been to show that technology is a system intrinsic in every society. As a response to 'biological drives' and other instincts, every society develops its own 'solutions'; these 'alternative solutions' are known as 'cultures'—Argyle (1976:78). Technology is inherent within the survival solution of every society, and hence in culture.

By the 1830s, the technical changes that had transformed the methods of manufacturing production were described as *Industrialism*—Williams (1990:xiii). But the changes due to *Industrialism* also changed society as a whole, hence *Industrial Revolution*—Williams (1990:xiv).

The new technologies of the *Industrial Revolution* enabled cheaper products. Through entrepreneurial drive, these products were sold in new markets in greater quantities, so creating more employment, wealth and prosperity for the UK—the dynamics of societal change. The word culture acquired extra meaning as a response to the 'changes in social, economic and political life' that had influenced the words *industry*, *democracy*, *class* and *art*—Williams (1990:xvii). Since technology had influenced the nature of industry, it had similarly influenced the development of meaning in these words. And as children walk into the classroom to engage in the National Curriculum for Technology, they carry with them a wide diversity of meaning in the word 'culture'—a diversity acquired through socialisation.

Communication is also culture, and is represented by no fewer than ten 'Primary Message Systems'—Hall (1973:37). They include *Interaction*, *Association*, *Subsistence*, *Bisexuality*, *Territoriality*, *Temporality*, *Learning*, *Play*, *Defense [sic]*, and *Exploitation*—Hall (1973:38). Humankind has been dependent on tools since the Stone Age. The evolutionary process of humankind has born witness to increasing levels of dependency on technologies as the tools of a modern era. The tools inventory of humankind has expanded significantly by all the new technologies; in one way or another they appear in all the PMSs. Every generation was born into a level of technology that was taken for granted through socialisation, but neither these processes nor the dependency on tools and technology are understood.

Since the Stone Age, the knowledge of humankind has built on knowledge as social cultural achievement, and yielded an inventory of tools and/or technologies that is astonishing in its breadth and depth. Technology has evolved alongside humankind as a primary intelligible system, but this is not widely understood.

Culture is present 'all the time'—Flinders (1991:88), pervading and determining the whole of human behaviour—Rosaldo (1989:26), but without training it is not easily perceived—Flinders (*ibid*). Culture is the basic structure through which life is experienced—Flinders (1991:88). Equally, for a western industrialised society, technology is present all the time, pervading and influencing the whole of human behaviour, and provides a basic structure through which life is experienced; without appropriate education and training this is also not easily understood.

Culture is powerful. Contrary to popular belief, culture is a learned form of behaviour acquired by informal group socialisation. Value judgments are similarly acquired through group socialisation, and shocks can be caused when disparate sub-cultures come together. Damning occupational value judgments were evident in the time of Plato. More recently, in Latin American countries, value judgments impinged on the quality of nursing and industrial safety training.

Culture is used in reference to 'intellectual' and 'artistic activity'—Williams (1988:90). For humankind, the eloquence of imaginative expression appears not only in music, literature, painting and sculpture, but also in the tools and technologies of humankind which have brought us to the way we live now. Mechanical knowledge was identified and applied throughout most of the life-span of humankind, with little 'theoretical' grasp—Cotterell and Kamminga (1990:11). The Greeks exalted the pure and theoretical sciences while disparaging mechanical research or 'practical application'—Landels (1997:187). But it was practical application, driven by the imagination of humankind, that has brought us to the way we live now, and in every field of human experience. In early 17th Century Britain, 'mechanical' was used regularly to refer to 'routine, unthinking activity', an example of 'social prejudice'—Williams (1988:201).

The perception of technology in the UK will be discussed in Chapter 8. The research data will include examples of value judgments and social prejudice. These examples will show that many influential opinion leaders do not understand the pivotal roles of technology and industry in society. However, the processes of socialisation that lead to the formulation of those value judgments should also be understood, and will be discussed in the next chapter 'Technology in Education - statutory considerations.'

Chapter 7

Technology in Education - statutory considerations

Today we study the day before yesterday, in order
that yesterday may not paralyse today
and today may not paralyse tomorrow
F W Maitland

07.01 Introduction

The aim in this chapter is to ascertain the quality of esteem attributed to maths, science and industry during the formative years of the educational system. During the evolution of the system of education there were many difficulties and competing priorities, including the development of courses of study. Maths and science are components of technology, as discussed on page 56, and manufacturing industry is totally dependent on a continuous stream of new and evolving technologies to remain competitive. The difficulties encountered with the development of education, and the value judgements of those times, became intrinsic parts of the processes that moulded the educational system, the courses of study, and the attitudes displayed towards industry. Hence the past is in the present.

The government now seeks to encourage industry to be more competitive 'to deliver the wealth that we need for our public services, to provide good jobs for all our people and to maximise quality of life'—Beckett (1997:3). However, before the Education Reform Act of 1988, technology was not part of the nationwide curriculum—why? In response to this question, it will be argued that the value judgements brought to bear on the development of the educational system and the courses of study will provide an explanation. Examples of text will be quoted from reports of the period, and they provide damning evidence of value judgements that even today threaten our economic viability.

07.02 The forces of change

The growth of a public system of education in England and Wales may have followed an 'uneven course', but it has been well 'documented'—Maclure (1986:1). Every few years, an educational issue was a cause for concern in the domain of public debate, leading to an inquiry and a report—Maclure (*ibid*). Many of those inquiries were initiated by parliament, and the collection of reports provide a rich source of comment on many aspects of 'educational thought and practice'—Maclure (*ibid*).

Those early reports had a 'refreshing freedom' of expression—Maclure (*ibid*). Readers may today conclude that they were couched in terms no longer politically correct, but they reflect the value judgements of the time. Students imbued with the value judgements of the early part of the 21st Century may find provocation in the language. But this valuable library should not be overlooked by those seeking to understand the issues—Maclure (*ibid*).

The enormity of the task to establish a public system of education is not widely known; a starting point from which to consider some of the difficulties is the early 19th Century—Maclure (1986:2). Then, there was a lack of knowledge about the numbers of children in any type of school; such information was obtained only when the apparatus of 'central and local government' was 'painfully and often reluctantly' established—Maclure (1986:3).

The reluctance to establish local or central government was just one of the problems facing those seeking to make change. Typically, change is perceived as threatening. Among all the early difficulties, not only was there an absence of numerical data, there was an 'absence of government'—Maclure (1986:3); trying to introduce change in this setting would have taxed the minds of many people.

The key issues associated with founding a public system of education appear in some 65 reports published between 1816 and 1986—Maclure (1986:v-ix). Many of these issues may still be found in education—Maclure (1986:3). These reports stimulated change both through legislation, and 'without legislation', a huge achievement by 'government institutions' that were administratively 'inadequate'—Maclure (*ibid*).

But there were other forces causing change in society. The 'Industrial Revolution' had introduced new manufacturing 'methods' that 'disrupted the old social order'—Bishop (1971:4). Previously, young people were subjected to the 'educative influences' of the 'peasant culture'—Bishop (*ibid*). The Industrial Revolution created 'an urban proletariat' without 'roots'; people were having to contend with the problems of a new and 'less healthy environment', and at a time when the 'civilizing effect of education' was sorely needed—Bishop (*ibid*).

Hence because of economic expansion, the 'inadequate … institutions' were struggling also with 'public health and factory legislation, with road and bridge building, with reform of the Civil Service, law reform, penal reform and electoral reform'—Maclure (1986:4). Better-educated people could have made a critical difference, but here was the problem to which Bantock referred when discussing cultural conflict (this thesis p94), and reproduced here:

> As a 'culture system' in the 19th Century, the school was perceived to be under threat from two different directions, namely the 'literacy of culture' and the 'literacy of communication' —Bantock (1967:19-20). The school culture was structured around 'the printed word', but the rising demands of an 'industrial bureaucratic state' during the 19th Century required the 'literacy of communication'—Bantock (*ibid*). Thus the 'need to learn to read and write' was 'imposed' on the whole population, causing 'a conflict of two cultures'—Bantock (*ibid*). The conflict was between a 'traditional culture of great verbal, emotional, and intellectual complexity', as 'the prerogative of the highly educated and sophisticated classes', whereas 'the culture of the people was essentially … oral 'arising out of the 'arts and crafts they practised'—Bantock (*ibid*).

Here were the problems created by the growth in national prosperity through the Industrial Revolution. England was confronted in mid-19th Century by the nascent dilemmas of a 'modern state' needing administrative improvisation—Maclure (1986:4). The want of an 'administrative machine' in the 19th Century was significant in 'English educational history'—Maclure (*ibid*). And here was the setting in which the development of the educational system took place.

07.02.01 Changes in education and industry

Early in the 19th Century, as the system of public education in England and Wales started to develop, changes continued in industry, and consequently in society as a whole. A census in 1801 revealed that there were 'nine million people' in England & Wales, and 'only 2 1/2 million lived in towns'—Rolt (1988:138). By 1851, the comparisons were eighteen and ten million people respectively, due wholly to the change from an agrarian to an industrial [technologically driven] economy—Rolt (*ibid*).

Thus in the first half of 19th Century, two significant social changes took place; the population doubled, and the proportion living in towns rose from 28% in 1801, to 55% in 1851. Here was the background against which there was a lack of knowledge about the numbers of children in any type of school—Maclure (1986:3), and government institutions of the day were inadequate.

The Industrial Revolution started in the UK in about '1760'—Rubinstein (1994:1). 'By 1850', Britain was 'the workshop of the world', the leading 'manufacturing and industrial power'—Rubinstein (*ibid*). Britain's economic peak occurred between 1850 and 1870, since when a sustained period of 'economic decline' has prevailed lasting into the 1990s—Rubinstein (*ibid*). The Industrial Revolution was made possible by the fusion of entrepreneurial drive and the ongoing emergence of new technologies and methods. But how much were the societal benefits of the Industrial Revolution recognised in the evolution of the system of education?

07.02.02 Changes in meaning of the word 'education'

The verb 'to educate' originally meant 'to rear or bring up children', and this wider meaning 'has never quite been lost'—Williams (1988:111). Since the early 17th Century, the verb 'to educate' has been applied to 'organised teaching or instruction', especially since the late 18th Century—Williams (1988:112). When 'organised instruction' was not available to the 'majority of children', the difference between 'educated and uneducated was reasonably clear'—Williams (*ibid*). However, 'this distinction' has been more in evidence since the provision of 'organised education', and has a 'strong class sense'—Williams (*ibid*). In this sense, what is meant by 'educated' has been continuously revised 'to leave the majority of people who have received an education below' that level—Williams (*ibid*).

07.03 The years 1800–1850

The development of a national system of education in the 19th Century was influenced by the economic circumstances of the latter half of the 18th Century—Curtis and Boultwood

(1976:1). Population movement, stimulated by the developing industrial centres, left 'many districts' poorly served 'with any kind of school'—Curtis and Boultwood (*ibid*).

The 'war with revolutionary France' had caused 'food and clothing' to be more expensive, but 'wages were low'—Curtis and Boultwood (1976:1). When children reached their fifth or sixth birthdays, 'they were sent to work in mines and factories … to supplement' the family income—Curtis and Boultwood (*ibid*). 'Very few' working-class children attended school until they were 'nine or ten years of age'; their contribution to the family budget was 'imperative'—Curtis and Boultwood (*ibid*).

At the turn of the 18/19th Centuries, public opinion held that education of 'the people' was not a suitable 'task' for government—Bishop (1971:1). By the close of the 19th Century, there was 'growing acceptance' that education was a 'function of government' and required 'central co-ordination and unified control'—Bishop (*ibid*).

> Note: As an 'educational' movement, the 'mechanics' institutes' were significant in British history, and developed from 'lectures (open to the public) … by a professor of natural philosophy in Glasgow … John Anderson …'—Ashby (1958:51).
>
> In 1799, Anderson was succeeded by George Birkbeck; his primary responsibility was 'to give courses of lectures and demonstrations to a middle-class clientele prepared to pay …'—Ashby (1958:52). But Birkbeck also took it upon himself to deliver a series of 'lectures' on 'Saturday evenings' for 'working men', and 'without' charge—Ashby (*ibid*). 'Five years later', in 1804, Birkbeck moved to 'London … and founded the London Mechanics' Institution'—Ashby (*ibid*).

Early in the 19th Century, 'few children of the poorer classes' attended school for 'more than … three years', but some educational enthusiasts were 'on their guard against teaching the children too much'—Hadow (1926:1). Attempts to establish 'primary schools' were strengthened by the 'Sunday School movement'; 'reading' was necessary for 'the Bible'—Hadow (1926:2). For those with a conscience who could afford to subscribe, educating the poor was a 'religious duty'—Maclure (1986:3). Not only was support for the 'educational charities' a 'religious duty', 'but religion was the basis of education'—Maclure (1986:4).

Two major charitable organisations were concerned with education:

- 'National Society for Promoting the Education of the Poor in the Principles of the Established Church, formed in 1811, and
- British and Foreign School Society (BFSS), formed in 1812'—Curtis and Boultwood (1967:8-10).

Education of the young was 'claimed' by the 'Established Church' as their 'exclusive' responsibility, and 'state interference' intruded on lawful 'preserves'—Bishop (1971:2). This was unacceptable to the 'dissenters' as represented by the BFSS; earlier 'authoritarian intolerance' meant that 'government control of education' was also not acceptable—Bishop (*ibid*). The mixture of 'clerical pretensions' with 'sectarian rivalry' was a serious obstacle to the achievement of a national educational system 'financed and guided by the state'—Bishop (*ibid*).

Peel's Factories Act in 1802, showed that 'the State' had begun to understand 'its social responsibilities' so far as 'education'—Hadow (1926:2). The legislation was drafted to preserve 'the health and morals of apprentices and others employed in cotton … and other factories'—Hadow (1926:1). Apprenticeships lasted seven years, and employers were required to 'provide adequate instruction in reading, writing and arithmetic' for the 'first four years'—Hadow (*ibid*).

> Note: By 1815, Britain had developed a firm industrial base, and the subsequent period of sixty years 'was incomparably greater' in terms of economic expansion than any previous similar period—Pollard and Crossley (1968:190).

The period from 1815 to the 1870s coincided with agricultural 'expansion'; 'more land' was turned over to 'crops', and 'fallow land … [largely] disappeared'—Blunden and Curry (1985:26). 'New land' in the 'hills' and on the 'moors', as well as land captured by 'embanking coastal marshes', enabled agricultural production to be expanded—Blunden and Curry (*ibid*). 'By the 1860s', there was 'possibly' as much as 'three or four million [more] acres' under crop production than at 'the end of the 18th Century'—Blunden and Curry (*ibid*).

In 1816, Parliament commissioned an inquiry into the 'Education of the Lower Orders in the Metropolis', extended subsequently to the whole country—Maclure (1986:18). Parents appeared to think education was desirable, but a 'large number of poor Children' [*sic*] were without any 'instruction'—Maclure (*ibid*). Poverty was a significant problem—Maclure (1986:18). In Southwark, London, some 2000 children were unable to attend 'school for want of clothing'—Maclure (1986:27). One family of six children had 'only one suit of clothes', which they took turns to wear to go into the street—Maclure (*ibid*).

In the first decades of the 19th Century, some leading educationalists thought 'school life' should be prolonged, and subjects other than reading, writing and arithmetic should be taught—Hadow (1926:2). Some industrialists 'began to acknowledge' the benefits of 'a rudimentary education' among their workforce—Bishop (1971:4). Apprenticeships gave a form of 'technical training', but with the advent of 'machinery', 'a new system of general and technical education' was required—Bishop (*ibid*).

> Note: During the '1820s and 1830s', as the 'agricultural implements industry' took-off, more new or improved tools such as 'ploughs, harrows and seed drills', and 'clod-crushers and horse hoes' became available—Blunden and Curry (1985:26).

By 1833, new primary schools were 'established in large numbers' supported entirely by 'voluntary contributions and school fees'—Hadow (1926:3). The first grant by government for the 'erection of school houses' was made 'in 1833', and distributed through the two main voluntary societies—Hadow (*ibid*).

In 1834, a further parliamentary committee report was published 'on the State of Education'—Maclure (1986:28). Evidence was given on many issues including 'poverty', 'school fees', 'training and payment of teachers', 'inspection', 'training colleges and the … status of teachers'—Maclure (1986:30-38). 'Lord Brougham', 'the Lord Chancellor' was among the chief witnesses; he opposed a system of 'compulsory free schooling'—Maclure (*ibid*). He thought that 'legislative interference' could 'produce mischievous effects', and the costs 'a most heavy expense'—Maclure (1986:39).

A 'Committee of Council for Education' was created in 1839; the founding of a national teacher training college was a primary task for which Parliament approved £10,000 in 1835—Maclure (1986:42). But conflict between the established church and the 'dissenters' prevented 'agreement'—Maclure (*ibid*). Denominational issues had similarly 'defeated' a number of earlier 'attempts' to 'promote' educational 'legislation' including 'Whitbread's Bill in 1806, Brougham's Bill in 1820, [and] Roebuck's Bill in 1833'—Maclure (*ibid*).

'Denominational' issues became a factor in the 'relationship between … Government and … Church of England'—Maclure (1986:46). Among other issues, there were 'long and bitter battles' over the 'Inspection of Schools'; this was resolved by a 'Concordat' between the 'Committee of Council on Education' and the 'Archbishop of Canterbury' at Buckingham Palace in August 1840—Maclure (*ibid*). 'After 1847', the 'Government' introduced similar 'procedures' for the 'appointment and control of inspectors' for schools of other faiths, 'including the Roman Catholics'—Maclure (*ibid*).

> Note: By 1841, as an educational movement, there were more than two-hundred mechanics' institutes with 'some 50,000 members'—Ashby (1958:52).

Up to 1843, there was 'no compulsory schooling'; poorer families sent their children to 'work in the mines and factories'; 'their earnings were' a needed 'addition'—Curtis and Boultwood (1967:61). The 'amended Factory Act of 1844' required children from 'eight' to 'thirteen' years to attend school for 'three days or six half-days'; employers had to 'obtain a certificate from the schoolmaster' confirming attendance—Curtis and Boultwood (*ibid*).

07.04 Educational development 1851-1900

> Note: In 1851, 'The Great Exhibition' housed in the new 'Crystal Palace', was a demonstration of technological and 'industrial supremacy'—Ashby (1958:51-53), and Britain won most of the prize categories. The exhibition was essentially a 'pageant of self-congratulation', but 'discerning people' could see that the 'Continent' was 'already' rivalling 'Britain in many manufactures'—Ashby (1958:30). A 'core of cultural opposition' was evident 'within the Great Exhibition itself'—Wiener (1987:28).

07.04.01 Reports on the Universities of Oxford and Cambridge: 1852–3

There were two Royal Commissions, with identical terms of reference—'To inquire into the State, Discipline, Studies and Revenues …' of the universities—Maclure (1986:63). They represented the first of an important series of 'mid-century … inquiries into education at all levels'—Maclure (*ibid*). Brief comments on courses of study are relevant here.

Oxford at first 'refused to cooperate', arguing that the revisions made 'two centuries' earlier 'in 1636', were 'admirably arranged'—Maclure (1986:63). 'Cambridge … welcomed' the Commissioners; the two reports were distinctly different—Maclure (1986:64). Cambridge received favourable comment for removing 'unwanted traditional restrictions' and their 'new courses of study'—Maclure (*ibid*).

Oxford 'held' that training the 'powers of the mind' was wholly the responsibility of the University, and the classics were the 'best means of refining and invigorating the mind'—Reports from Commissioners, Oxford University (1852:70-71).

07.04.02 The mechanics' institutes

After the Great Exhibition in 1851, the mechanics' institutes in Yorkshire formed 'a Union, with 20,000 members in 100 affiliated branches'—Ashby (1958:52).

In 1853, James Hole was 'secretary of the Yorkshire Union' when he published a paper suggesting that the 'mechanics' institutes' should form the 'constituent parts of a national industrial university'—Ashby (*ibid*). The 'Society of Arts' supported these proposals; they arranged 'conferences on technical education', they established 'examinations' and awarded 'diplomas', and sought 'to organise a nation-wide union of 'mechanics' institutes'—Ashby (*ibid*).

However, the 'soil of general education' was spread too thinly in those times to support a 'system of technical education', and the mechanics' institutes failed to make any impact on contemporary technology—Ashby (1958:53). The failure happened because:

- the instruction in the mechanics' institutes 'catered for a class' that 'was too illiterate, and too overworked to absorb scientific education in the evenings',
- 'industry offered no inducements to the few students who did survive the Society of Arts examinations',
- 'many institutes' ceased 'systematic instruction in scientific principles of various trades in favour of popular science, entertainment, and the amenities of a working men's club 'in order to retain their membership'—Ashby (*ibid*).

However, there was some influence in British education due to the mechanics' institutes by 'the foundation of such great institutions as the Royal College of Science and Technology in Glasgow, the Heriot-Watt College in Edinburgh, and the Manchester College of

Technology'—Ashby (1958:53). But in their time the 'mechanics' institutes' did not cause technology to be adopted by 'the formal educational system'—Ashby (1958:53).

07.04.03 The Newcastle Report: 1861

The Commissioners were required 'To inquire into the … state of Popular Education in England, and … report what Measures … are required for the extension of sound and cheap elementary instruction to all classes'—Newcastle (1861:1).

'Providing elementary instruction for all classes' was now seen as important—Newcastle (1861:15). To indicate how opinions had changed, an example from Gloucester was quoted where 'towards the end of the' 18th Century, a number of Sunday schools were established in 'which poor children were taught to read'—Newcastle (1861:16). These schools were popular since they were 'the principal means of … elementary instruction to the class for which they were intended'—Newcastle (*ibid*).

Fig. 7.01 shows the growth in 'elementary' educational provision in the early 19th Century, and was a source of great satisfaction for the commissioners—Newcastle (1861:294).

Year	No. of day scholars	Day scholars as proportion of population or ratio = 1 in	Day scholars as percentage of population	Indicated total population
1803	524 241	17.50	5.71	9 174 218
1818	674 883	17.25	5.80	11 641 732
1833	1276 947	11.25	8.89	14 365 654
1851	2144 378	8.36	11.96	17 927 000
1858	2535 462	7.70	12.99	19 523 057

Fig. 7.01 - The growth in provision of elementary education from 1803 to 1858.

Fig. 7.01 also shows the rapid growth in population, as well as the increasing proportion attending school. In 1803, 5.71% were attending school, rising to 12.99% by 1858. However 'mere … numbers' receiving 'instruction' gave no indication of the 'state of education'—Newcastle (1861:294).

Many students attended school for 'less than 100 days in the year', and 'a large proportion' with a better attendance record failed to obtain a 'serviceable … education'—Newcastle (1861:295). Absence from school was addressed by the Prince Consort at an Educational Congress on 22nd June 1857; he thought the children of the working man 'were part of his productive power'; 'daughters … the handmaids of the house … assistants of the mother … nurses of … younger children … aged … and … sick'—Newcastle (1861:188).

In 1861, the 'Commissioners' considered there was still 'much … to be done' to improve 'elementary education in England and Wales' to attain a 'desirable' level in 'reading, writing and cyphering [arithmetic]'—Newcastle (1861:295-296).

The Commissioners recognised that 'a single central authority responsible for all forms of state-aided education was desirable'—Bishop (1971:49). A need for legislative intervention had become evident, but all the attempts by 'Parliament' foundered on 'denominational grounds'—Maclure (1986:70). Bills put before Parliament to 'extend public elementary education through church schools' were no more successful—Maclure (*ibid*).

Only one 'recommendation' in the Newcastle report was 'adopted' namely 'payment by results', but this too was influenced by denominational issues—Maclure (1986:71). The submission of draft legislation to put part of the educational costs 'on the rates', threatened further debate on 'every kind of denominational issue', a risk the Government were not prepared to take—Maclure (*ibid*). Hence 'payment by results', intended as a means of 'distributing supplementary grants by local authorities', became the method of providing 'central Government grants for elementary school running expenses'—Maclure (1986:71). This method, known as 'The Revised Code', was introduced in 1862—Maclure (*ibid*).

The Revised Code allowed schools to claim various sums of money from '2s. 6d' to '8s' [12.5p to 40p] 'per scholar', subject to age, attendance, examination, and 'report by inspector' —Maclure (1986:79). 'Introduction' of the code was delayed twice because of severe opposition, but was finally implemented on 'August 1, 1863'—Maclure (*ibid*).

In 1867, the requirements of 'the Revised Code' were made less demanding; further reductions were made during 'the next thirty years'—Maclure (1986:79). The principle of payment by results was finally dropped in 1897, but it took years to 'overcome' the poor relationships 'between teachers and inspectors'—Curtis and Boultwood (1967:72).

07.04.04 The Clarendon Report: 1864

Published in 1864, the Clarendon report considered the 'Revenues and Management of Certain Colleges and Schools, and the studies pursued and instruction given therein'. The inquiry resulted from 'well-informed criticism' by a 'member of the Newcastle Commission' and 'others'; their concerns related to nine public schools: *Eton*, *Winchester*, *Westminster*, *Charterhouse*, *St. Paul's*, *Merchant Taylors*, *Harrow*, *Rugby*, and *Shrewsbury*—Maclure (1986:83). These schools 'were founded' between the late '14th Century' and early '17th Century'—Clarendon (1864:4).

The Commissioners focused upon: (1) a report on each of the nine schools, for which 'revision of their statutes, and the powers of Governing Bodies and headmasters' were advised, and (2) 'recommendations on the subject of curriculum'—Maclure (1986:83). The Commission's comments on the curriculum are relevant here to show the difficulties of trying to make change.

The nine schools were seen as good examples 'to which most Englishmen of the higher class

… wish to send' their sons—Clarendon (1864:11). Since the earliest days in 'these schools', the curriculum 'remained substantially unaltered', and the 'classics' were seen to hold 'intrinsic excellence as an instrument of education'—Clarendon (1864:12). Education 'alters slowly', and remains in 'the same groove' for a long time—Clarendon (*ibid*). Teachers 'can only teach what' they have learned, and consequently they 'set the highest value on the studies' that have occupied their own lives—Clarendon (*ibid*).

Attempts to make curriculum change had started, but they had to contend with a strong 'tradition and habit'; consequently 'mathematics' and 'modern languages' were made subservient to the 'classical school'—Clarendon (1864:13-15). Mathematics had gained some esteem 'as a mental discipline', but not 'modern languages'—Clarendon (*ibid*).

The Commissioners' held that the 'classical languages and literature should continue to hold … the principal place in public school education'—Clarendon (1864:30). 'Every school' perceived 'arithmetic and mathematics' as important, but more effective teaching was required; 'applied mathematics' should be introduced to 'advanced students'—Clarendon (1864:31).

In England, 'natural science … is practically excluded from the education of the higher classes'—Clarendon (1864:32). 'Education' was 'narrower than it was three centuries ago'; the 'exclusion' of science was 'a plain defect and a great practical evil'—Clarendon (*ibid*). This exclusion damages the 'mental training of the young'; while many 'men … have little aptitude or taste for literature', there are many with 'an aptitude for science', particularly with the 'science [of] external and sensible objects'—Clarendon (*ibid*).

There was strong opposition to the inclusion of natural science in the courses of study. As counter arguments, claims were made for the benefits of training the mind, enhancing the powers of observation, while learning about 'cause and effect'—Clarendon (1864:32). Contrary to 'the eminent Schoolmasters', the Commissioners were 'convinced that the introduction of natural science' was 'desirable, and … practicable'—Clarendon (*ibid*). Nevertheless, the Commissioners recommended that the 'classical languages and literature should continue to hold the principal place in the course of study'—Clarendon (1864:53).

07.04.05 The Taunton Report: 1868

By 1864, after the Newcastle and Clarendon reports, secondary education had become a cause for concern—Maclure (1986:89). The Royal Commission had 'wide terms of reference'; secondary schools were defined as 'endowed', 'private' or 'proprietary'—Maclure (*ibid*). The Commission's evidence was presented under two headings: (1) what witnesses thought education was, and (2) what they thought it should be—Taunton (1868:14). What education should be was considered first, and used to assess the provision—Taunton (*ibid*).

Parental 'indifference and ignorance' were great obstacles to the education of poor children —Taunton (1868:15). The time that parents were prepared to 'keep their children under instruction' defined the groups of educational provision—Taunton (*ibid*). There were three groups—up to 'about 14', up to 'about 16', and up 'to … 18 or 19'; these were classified as 'Third', 'Second' and 'First-grade of Education respectively'—Taunton (*ibid*). These equate approximately 'to the gradations of society'; generally, those who could afford to pay kept their children at school longer—Taunton (1868:16).

Schools that provided the First-grade of education were patronised by 'two very distinct classes' of parents—Taunton (1868:16). 'One class' were similar to those parents who favoured the public schools covered by the Clarendon report—Taunton (*ibid*). This class were wealthy, and had no wish to 'displace classics' from the 'forefront of English education' —Taunton (*ibid*). But they considered that English education should be widened 'to cultivate mathematics … to add modern languages and natural science'—Taunton (*ibid*).

Parents took a keen interest in the attempts to modernise English education, but they were unwilling 'to put their own boys into it'; their boys were not to be 'marked off as peculiar' —Taunton (1868:16). Often, 'modern departments' were 'a refuge for boys' of 'inferior ability or diligence [that] prevented their success in classical studies'—Taunton (1868:17).

When the 'chief interest of the master' was devoted 'to one set of studies', it was unlikely that 'true success' would be obtained with a 'different and rival set in the same school'—Taunton (1868:17). Also, many 'parents' in this 'rank' were against their sons receiving an education unsuitable for University entrance—Taunton (*ibid*). Parents required 'modern departments' to stand high in 'social' esteem, enabling university access—Taunton (*ibid*).

The second class (in the First-grade) who wished to keep their children at school to 18 or 19, were the 'majority of professional men' and 'poorer gentry'; having had a 'cultivated education', these men did not wish 'their sons' to 'fall below them'—Taunton (1868:17). As a first priority 'this class' of parent required cheaper education rather than education made wider to include modern subjects—Taunton (*ibid*). Although parents would appreciate 'more than classics and mathematics', they nonetheless valued them 'highly for their own sake', and the 'value … assigned to them in English society'—Taunton (*ibid*). These parents thought education was the only way 'to keep their sons on a high social level'—Taunton (1868:18).

For boys up to 16 years in the Second-grade, parents required a different education—Taunton (1868:18). These parents comprised 'two classes': (1) those who accepted Latin as useful for certain 'professions' as well as its 'social value', and (2) 'the mercantile classes' who 'barely … tolerate Latin'—Taunton (*ibid*). This second group thought 'mathematics, modern languages, chemistry' and 'physical science' were 'essential'—Taunton (1868:19). 'Classical culture' was an acceptable 'instrument of education', provided the modern subjects 'considered indispensable' were not excluded—Taunton (1868:20). Education in subjects with a 'practical use in business' was thought 'absolutely essential', and parents would 'not allow any culture'—Taunton (*ibid*). 'Some' parents were 'not insensible to the value of culture' and the advantages of 'sharing the education of the cultivated classes'—Taunton (*ibid*).

Both the First and Second grades of education satisfied 'all the wealthier part of the community'—Taunton (1868:20). The last and Third-grade of education which stopped at 'about 14', belonged to a 'class distinctly lower', 'but so numerous as to be … as important as any'—Taunton (*ibid*). The requirement 'of this class' was 'described … by Cannon [*sic*] Mosely' as 'very good reading … writing … arithmetic'; if they care for more, 'they merely wish to learn what their betters learn'—Taunton (*ibid*). Such education was perceived as not 'aiming at much'; it was hoped 'that parents even of this rank should learn the value of … higher cultivation'—Taunton (*ibid*). But 'parents' demands were considered 'thoroughly sensible'; their wishes should 'be secured before anything else' was added—Taunton (*ibid*).

'All civilisation' rises in 'human intercourse', so the 'study of human speech' was the 'most efficient instrument of education'—Taunton (1868:22). Nothing hindered 'true cultivation' so much, nor was 'so unreasonable as excessive narrowness of mind'—Taunton (*ibid*). However, it was 'admitted' that 'cultivation' would occur by 'the ordinary intercourse of life', but if the 'material studies' were 'not regularly taught' they would 'probably' never be learned —Taunton (1868:23). This argument must be given great 'weight' where the 'time assigned to education' was 'short'—Taunton (*ibid*).

The Commissioners concluded 'many … parents' had no access to 'suitable schools' for their children—Taunton (1868:660). 'Middle-class … youth', were thus unprepared for life's 'duties' or the 'intelligent acquisition of … technical instruction' allegedly so necessary for 'our great industrial interests'—Taunton (1868:661). They further concluded that 'incompetent' schools could not be distinguished from 'successful' schools which was 'unjust … and injurious to the country …'—Taunton (*ibid*).

<u>07.04.06 Report of a Select Committee: 1868</u>

The reason for this Select Committee should be made clear. After the Great Exhibition in 1851, Paris staged the 'International Exhibition of 1867', where Britain's fading industrial supremacy was 'alarmingly revealed'; 'Britain took only ten of ninety prizes'—Barnett (1986:99). This dire 'performance' created shock waves, and prompted the House of Commons to appoint a Select Committee, 'the first of repeated … official analyses of defective British education and training for technological success that were to follow over the next century …'—Barnett (*ibid*).

In 1868, the Select Committee was appointed 'to inquire into the provisions for giving instruction in theoretical and applied Science to the Industrial Classes'—Parliamentary Papers 24th March 1868. Note the link between Science and the 'Industrial Classes'.

The Select Committee called witnesses from many different institutions, including industry —Select Committee (1868:iii). Their evidence was presented under two headings:

1. The state of scientific instruction of,
    - (1.) The foremen and workmen engaged in manufactures.
    - (2.) The smaller manufacturers and managers.

(3.) The proprietors and managers-in-chief of large industrial undertakings, …

2. The relation of industrial education to industrial progress—Select-Committee (1868:iii).

Many key points were made in evidence; selected statements show the stage of technological development in 1868, while other remarks serve to illustrate the concerns of manufacturers:

- 'The industrial system of the present age is based on the substitution of mechanical for animal power; its development is due in this country to its stores of coal and of metallic ores, to our geographical position, and temperate climate, and to the unrivalled energy of our population. …
- … nearly every witness speaks of the … rapid progress of Continental nations in manufactures, and attributes that … to the scientific training of the proprietors and managers in France, Switzerland, Belgium, and Germany, and to the elementary instruction which is universal amongst the working population of Germany and Switzerland—Select-Committee (1868:vii).
- All the witnesses concur in desiring similar advantages of education for this country, and are satisfied … that nothing less will suffice, in order that we may retain the position … we now hold in the van of all industrial nations'—Select-Committee (1868:viii).

The Committee made some fifteen recommendations, partly summarised here:

- for 'the working class to benefit by scientific instruction it is of the utmost importance that efficient elementary instruction should be within the reach of every child. …
- … the reorganisation of secondary instruction and the introduction of a larger amount of scientific teaching into secondary schools are urgently required, and ought to receive the immediate consideration of Parliament and of the country. …
- … certain endowed [secondary] schools should be reconstituted … as science schools,
- … the education of higher science teachers should be encouraged by the granting of degrees in science at Oxford and Cambridge as at other Universities,' … —Select-Committee (1868:ix).

Evidence was also given by T H Huxley, an 'eloquent protagonist for scientific education' —Ashby (1958:35). He was asked to comment on reforming 'the system of education at the universities' and responded:

> '… my ideas on that subject are so revolutionary, that I should almost startle the Committee if I were to state them fully; … my conception is that our present system of education should be turned up-side down. At present the universities make literature and grammar the basis of education; and they actually plume themselves upon their liberality when they stick a few bits of science on the outside of the fabric. Now that, … , is not real culture, nor is it what I understand by a liberal education. The thing you … have to do is … invert the whole edifice, and to make the foundation science, and literature the superstructure and final covering'—Ashby (1958:37).

07.04.07 Elementary Education Act: 1870

This was an instrument to establish 'school boards … in areas' that were 'short of schools'—Maclure (1986:98). The country was divided into 'school districts', and the 'Education Department' were required to form 'boards where necessary'—Maclure (*ibid*). The Bill provided a 'compromise' on religious issues—a right to withdraw 'from instruction on the grounds of conscience in all public elementary schools including those run by churches, was guaranteed'—Maclure (*ibid*).

'Voluntary schools' could claim a '50 per cent grant' from the 'Education Department' but 'building grants' ceased; however 'school boards' could raise rates to 'finance their activities'—Maclure (1986:98).

> Note: About the same time, in spite of the agricultural expansion, 'England and Wales could no longer feed themselves'; fifty percent of the 'wheat', and twenty percent of 'all food supplies' were 'imported'—Blunden and Curry (1985:27).

07.04.08 The Devonshire Report: 1872-75

'The Royal Commission on Scientific Instruction and the Advancement of Science' reported between 1872 and 1875—Maclure (1986:106). Their reports provided a 'survey of scientific education at … universities … institutions [of] higher education', 'public and endowed secondary schools … elementary schools and training colleges'—Maclure (*ibid*).

Before the 'Revised Code' of 1861, 'scientific instruction' in the teacher training colleges was highly regarded, and thought to increase the 'intelligence of the teacher'—Devonshire 2nd report (1872:xi). Such training enhanced scientific instruction in Elementary Schools; in the best schools 'lessons' included 'domestic and social economy which affect the health of families and communities'—Devonshire (*ibid*).

The Revised Code, as a form of payment by results based on the outcome of examinations in 'Reading, Writing and Arithmetic', had a 'prejudicial effect on the education of the country'; teacher training colleges abandoned 'applied mechanics, physical science, and … higher mathematics'—Devonshire 2nd report (1872:xiii).

With regard to 'Public and Endowed Schools', though 'some progress' had been made, the Commission considered the '… Present State of Scientific Instruction' was 'extremely unsatisfactory'—Devonshire 6th report (1875:10). '… Liberal Education' was missing 'a great branch of Intellectual Culture', and was '… a matter for serious regret'—Devonshire (*ibid*). 'Science' has become increasingly important 'to the Material Interests of the Country'; the 'almost total exclusion' of Science 'from the training of the upper and middle classes' was 'a national misfortune'—Devonshire (*ibid*).

In 1877, because of the Devonshire Report, the 'London City Livery Companies' appointed 'a committee to draw up a national scheme of technical instruction'—Curtis and Boultwood (1967:284). Thus the 'City and Guilds of London Institute' was founded to encourage 'teaching of applied science in schools and evening classes'—Curtis and Boultwood (*ibid*).

> Note: About now, a 'depression' fell upon 'farming', and was created by cheap imports —Blunden and Curry (1985:27). A fall in 'ocean freight rates', and railway freight costs in the USA allowed Midwest farmers to 'undercut the home farmer in cereal crops'—Blunden and Curry (*ibid*). After the 'invention of refrigeration', 'meat, butter and cheese' were imported 'from Argentina, Australia and New Zealand—Blunden and Curry (*ibid*). Hence in the period from '1875' to '1895', 'wool and wheat' prices fell by half while cattle and sheep prices fell up to 'one-third', and there was 'little increase' in domestic agricultural production from the '1860s' to 1914—Blunden and Curry (*ibid*).

07.04.08 The Samuelson Report-1882-4

'The Royal Commission on Technical Instruction' was formed in 1881 because of two concerns: (1) the ability of 'English industry' to withstand 'European competition', and (2) the uncoordinated development of 'technical education in England'—Maclure (1986:121). Their terms of reference: 'to inquire into the Instruction of the Industrial Classes of Certain Foreign countries in technical and other subjects, for … comparison with … corresponding classes in this Country; and … the influence of such Instruction on manufacturing and other Industries at home and abroad'—Samuelson (1884:14). Relevant extracts include:

'Deficiencies'—The education of 'certain' employees in 'industry abroad' was 'superior' in two ways: (1) the '… instruction in drawing' received by 'adult artizans' particularly in 'France, Belgium and Italy', and (2) 'the general … education in Switzerland and Germany'—Samuelson (1884:511).

'Spread of Technical Education'—Until recently, 'argument' prevailed whether 'our managers, … foremen, and … workmen' needed to 'combine theoretical instruction with their … practical skill', for 'this country' to retain its 'high position … in the industrial arts'—Samuelson (1884:513). This 'argument' no longer prevails, as shown by the 'great industrial centres' of London, 'Glasgow, … Manchester, Liverpool, Oldham, Leeds, Bradford, Huddersfield, Keighly, Sheffield, Nottingham, Birmingham, [and] the Potteries …'; they all have 'schools of science and art' that 'influence … the productions' of their 'localities'—Samuelson (*ibid*). 'Surely' but 'slowly', 'natural science' appears in the 'curriculum of our older English universities, and … secondary schools'—Samuelson (1884:514).

'Need for local sources of revenue'—Only France among 'European' countries of 'the first rank' has an 'Imperial budget for education comparable … with our own'—Samuelson (1884:515). In the UK, half 'the cost of elementary education' is borne by 'Imperial funds', while 'the State' supports 'almost' wholly the 'instruction of artisans in science and art'; thus 'the further development of technical instruction in this country' must come from 'local resources'—Samuelson (*ibid*).

'Gaps in secondary education'—'Good modern secondary' schools such as 'Manchester Grammar School, … Bedford Modern School, and … Allan Glen's Institution' in 'Glasgow', offer the 'best preparation for technical study'—Samuelson (1884:516). 'Unfortunately, our middle classes' have a 'disadvantage compared with … the Continent for want of … sufficient … such schools'—Samuelson (*ibid*). 'When … the child enters … elementary school the teaching of science practically ceases'—Samuelson (1884:517).

'Specialist institutions of high rank'—'Only a few' such 'institutions' were required, but the 'Commissioners' argued there was no more important 'national expenditure' than 'education … in the scientific culture of the leaders of industry'—Samuelson (1884:525).

Samuelson made three 'recommendations for secondary and technical schools'; two are summarised here:

- the 'Charity Commissioners' should provide for 'the establishment … of schools or departments of schools, in which the study of natural science, drawing, mathematics and modern languages shall take the place of Latin and Greek.'
- empower 'local authorities, if they think fit,' to 'establish' and 'maintain … secondary and technical … schools and colleges'—Samuelson (1884:538).

07.04.09 The Cross Report: 1888

This Royal Commission was appointed 'to inquire into the working of the Elementary Education Acts, England and Wales'; their findings were published as 'The Cross Report' in 1888—Maclure (1986:128). The Commission was set-up due to denominational issues with 'voluntary schools' that were the subject of 'complaints' by both Roman Catholic and Church of England communities—Maclure (*ibid*).

The twenty-three Commission members came from 'divergent' backgrounds, so preventing a 'united report'—Maclure (1986:128). The members differed on nearly every issue; eight commissioners wrote a 'minority' report—Maclure (*ibid*). The majority report required that more inspectors should 'know some natural science'—Maclure (*ibid*). There was disagreement on the training of teachers; the minority report signatories thought the 'pupil-teacher system … the weakest part' of the 'educational machinery'—Maclure (1986:129).

The report recommended the 'transfer of technical institutions from the Science and Art Department to the Education Department'; all the commissioners 'agreed' that 'payment by results' should eventually be abolished—Maclure (1986:130).

'Denominational tension' was not only the reason for the Cross Commission, it was responsible for the majority and minority reports; those tensions did not diminish 'in the years' after 'publication'—Maclure (1986:130).

07.04.10 The Bryce Report: 1895

The Royal Commission was required 'To consider … the best methods of establishing a well-organized system of secondary education in England …'; their report was published in 1895—Maclure (1986:140). The reason for the Commission 'was … the confusion' created by the existing 'hydra-headed administrative structure'—Maclure (*ibid*).

There were three main recommendations:

- 'A central authority for secondary education under a Minister of Education taking over the educational function of … the Educational Department, … Science and Art Department, the Charity Commission.
- An educational council to assist the Minister …
- Local Authorities for Secondary Education …'—Maclure (1986:140).

The first recommendation was the subject of an Act in 1899, when the establishment of 'the Board of Education' was authorised—Maclure (1986:141).

The Commission found that the 'classical languages' were 'taught more extensively'; they were 'the supreme instruments of the higher culture', but 'they do not now stand alone'—Maclure (1986:142). 'Certain physical sciences' had grown remarkably in education, and 'technical and manual instruction' had 'assumed … large proportions' in 'some localities'—Maclure (*ibid*). The concept of 'technical instruction' as the means whereby 'citizens' could create wealth 'has taken hold, … and hence has come a concern for that kind of education that we might otherwise have looked for in vain'—Maclure (*ibid*).

The Commissioners concluded that 'those who could afford to pay' received a 'one-sided' education that stimulated 'certain types of mind'; 'but the great body of … commercial and professional classes' had to accept 'a teaching … usually limited in range and … poor in quality'—Maclure (1986:148).

07.05 Educational development 1901-1950

07.05.01 The Education Act: 1902

The bill was put before Parliament by Prime Minister Balfour, on March 24th 1902—Parliamentary Debates (4th Series:846). Balfour spoke of the 1870 Elementary Education Act, when 'Schools Boards' were set-up to provide education where 'voluntary effort' was absent—Parliamentary Debates (*ibid*:847). That legislation was successful, but there were 'two unforeseen consequences', 'three considerable omissions' and a number of 'defects'—Parliamentary Debates (*ibid*:848/9).

The government in 1870 thought that three-pence on the local rates would suffice for the School Boards, but their expenditure had been 'wholly unexpected'; the 'voluntary schools' were subjected to competition neither foreseen nor 'desired' by those who had drafted the legislation—Parliamentary Debates (*ibid*:848). 'Local finances' had been strained since a 'body' [School Boards] with some accountability for education in the 'community', did not manage 'general expenditure' for which 'the local authority' were responsible—Parliamentary Debates (*ibid*).

Balfour summarised the omissions: although the 'Act of 1870' enabled 'the organisation of board schools' by the 'School Boards', no similar arrangement existed for 'voluntary schools'; they were 'isolated and unconnected'—Parliamentary Debates (*ibid*:849). Secondly, there was insufficient provision for the education of 'teachers'—Parliamentary Debates (*ibid*). Thirdly, there was no cogent relationship between the 'primary' and 'secondary' educational systems, through to the University systems—Parliamentary Debates (*ibid*).

Speaking to Parliament, Balfour asserted that the defects had to be remedied; briefly they included:

- insufficient 'supply of secondary education',
- 'you have given … County Councils and Borough Councils the right … to intervene in respect of technical instruction … alone, the normal and healthy growth of a true scheme of secondary education has been … warped. Higher technical instruction can … only … work well … when based on … sound general secondary education.'
- Within education there are 'two elective authorities … in rivalry' around which ' … are scattered independent endowed schools and independent voluntary schools …'
- '… imperfect co-ordination of educational effort above … elementary education.'
- '… the School Boards … have exaggerated their capacity for dealing with … secondary education.'
- '… the education of teachers … . Any child who wishes to become a teacher gets made a pupil teacher, … when he has reached that *status* half his time goes to teaching and the other half … to learning … What is the result? … 36% … never got through the examination for the certificate, and 55% of … existing teachers have never been to a training college …'—Parliamentary Debates (*ibid*:850/3).

The reforms required 'one authority' for 'technical, secondary', and 'primary' education, to 'enable … adequate' teacher training, and 'the welding of higher technical and higher secondary education onto the University system'—Parliamentary Debates (*ibid*:856/7). The new system 'should … not encourage … the perpetual introduction of denominational squabbles'; 'the educational authority should have … all the educational skill which the district over which it presides can supply'—Parliamentary Debates (*ibid*:857).

Balfour considered 'no apologies' or 'excuses' were necessary 'to the educationalist' who had witnessed a great 'expenditure of public money', but education in this country was still 'behind all its Continental and American rivals'—Parliamentary Debates (*ibid*:867). The educationalist 'has seen technological institutions which I am afraid do not yet rival those which Germany and America have produced, …'—Parliamentary Debates (*ibid*:868).

Balfour sought support for 'a really national system of education', 'to … close … these barren controversies', and 'terminate the present system of costly confusion'—Parliamentary Debates (*ibid*).

07.05.02 Education Act: 1918

This Bill was introduced by Mr Fisher, President of the Board of Education, on August 10th 1917—Maclure (1986:173). He considered that 'opinion' in 'Government' had moved on, and a 'considerable … advance in education' was now essential—Maclure (*ibid*).

No certainty existed that children would receive the 'higher education' most suited for their 'needs'—Maclure (1986:173). The 'Act of 1902' may have 'contemplated area schemes for higher education', but the responsibility for doing so was not assigned—Maclure (*ibid*).

'Industrial workers' were now 'entitled to be considered … as citizens and … fit subjects for any form of education from which they are capable of profiteering [*sic*]'—Maclure (1986:173). 'They do not want' better education to 'rise out of their own class, … a vulgar ambition', but to 'become better technical workmen', to enhance 'the treasures of the mind', and find 'refuge from the … clanging machinery in our hideous cities of toil'—Maclure (1986:174).

There were six proposals, only the first, second and sixth are briefly mentioned here:

- '… improve the administrative organisation of education,
- … secure for every boy and girl … an elementary school life up to … fourteen … unimpeded by the competing claims of industry,
- … to make an effective survey of the whole of educational provision and … bring private educational institutions … closer … to the national system'—Maclure (1986:174).

Education was 'one of the good things of life that should be more widely shared'; ' … the life of the rising generation can only be protected against the injurious effects of industrial pressure by a further measure of State compulsion'—Maclure (1986:175).

Fisher argued that the 'compulsion proposed in this Bill will be … a larger and more enlightened freedom … to stimulate the civic spirit … promote general culture and technical knowledge … to diffuse … steadier judgment and … better informed opinion through the whole … community'—Maclure (1986:175).

> Note: During the 'First World War, 'agriculture … revived', but 'prices' declined again in the '1920s … reaching their lowest point in 1932'—Blunden and Curry (1985:29). But there were encouraging 'signs'; new 'plant breeding' methods that began before '1914' were producing 'higher yielding, hardier … disease resistant varieties'—Blunden and Curry (*ibid*). The 'research' outcomes on 'grassland and animal feeding' were also being used 'by some farmers'—Blunden and Curry (*ibid*). The technology of ploughing with a

> team of oxen and men, that had 'persisted to the end of the 19th Century', was slowly replaced by the tractor with much lower 'maintenance' requirements—Blunden and Curry (1985:25-30).

07.05.03 The Hadow Report: 1926

This Consultative Committee reviewed ''The Education of the Adolescent'; their terms of reference included: ' … consider and report upon the organisation, objective and curriculum … suitable for children up to … 15, …'—Hadow (1926:iv).

The 'nature of the problem' was discussed at length—Hadow (1926:36-45). Reports before 1918 showed that the instruction of children 'between 11 and 15 or 16' was a growing concern; those reports all made 'far reaching' 'educational recommendations'—Hadow (1926:41). In 1917, a report on 'Juvenile Education in relation to Employment after the War', discussed the existing 'educational and industrial chaos'—Hadow (*ibid*). The Hadow Report goes on:

> '… school and industry are different facets of a single society, and the habit of mind which isolates them from each other is a habit to overcome. Education fails in part of its aim, if it does not prepare children for a life of active labour and of social co-operation; industry fails no less, if it does not use and strengthen the qualities of the mind and character which have been cultivated by education'—Hadow (1926:41).

In an 'industrial society', unless the 'educationalist' builds 'castles in the air', he must 'take into account' the likely 'future' for children—Hadow (1926:42).

Recommendations were made that 'primary education' should end at the 'age of 11+', and instruction after 11+ should be known as 'secondary education'—Hadow (1926:71). These were attempts to overcome the confusion of 'educational terminology' arising from historical precedence—Hadow (*ibid*).

For the majority of children between 11+ and 15+, the Committee thought a less 'academic' curriculum, and more 'practical work' was desirable—Hadow (1926:83). 'At … 11 or 12', children start to become aware of the 'world' around them, and 'to think' about 'their future occupations'—Hadow (*ibid*).

'Many' children are uncomfortable with 'books and lessons', and wish for 'some form of practical work' to be 'not merely learners, but doers, and … creators'—Hadow (1926:84). This is a 'natural and healthy' phase in the development of children which must not be rejected if 'education is to retain their interest'—Hadow (*ibid*). The school function must appear not 'the antithesis of "real life"', but 'the complement of it'—Hadow (*ibid*).

07.05.04 The Primary School: 1931

In 1928, the 'Board of Education' required the 'Consultative Committee' to '… inquire into … the courses of study suitable for children (other than … in Infants' Departments) up to the age of 11 in Elementary Schools, …'—Maclure (1986:188).

Published in 1931, this was one of the 'more important', but 'most neglected' Committee reports—Maclure (1986:188). Reflecting on the 'last forty years', particularly the 'twelve years since 1918', the Committee thought the 'primary school' 'outlook' had 'broadened and humanized'—Maclure (1986:189). A 'medical service' looked after the 'physical welfare' of children, and although 'still inadequate', the school offers 'opportunities for practical activity' —Maclure (*ibid*). The 'curriculum' was treated not 'as lessons to be mastered', but a way to offer 'new and interesting experiences to be explored'—Maclure (*ibid*). The school should be treated not as the 'antithesis of life, but as its complement and commentary'—Maclure (1986:190).

On the curriculum, the Committee argued that 'industrialization' had changed 'social life', and so 'schools' had had to 'broaden their aims' and 'teach children how to live'—Maclure (1986:192). This deep shift in function was 'accepted', but with 'unconscious reluctance' and hence slow compliance—Maclure (*ibid*). In their function, schools felt comfortable 'with the … familiar business of imparting knowledge', but without grasping clearly the 'proper relation to the whole'—Maclure (*ibid*).

07.05.05 The Spens Report: 1938

In 1933, the 'Board of Education' required a 'Consultative Committee' to '… consider and report upon the organisation and inter-relation of schools … which provide education … beyond the age of 11+; …'—Maclure (1986:193). Published in 1938, the report's title was ' … Secondary Education with Special Reference to Grammar Schools and Technical High Schools'—Maclure (1986:193). The Committee 'recommended … expansion of technical schools … continued development of secondary education in separate grammar, technical and modern schools'; 'comprehensive' schools were 'rejected'—Maclure (*ibid*).

The 'Board' had taken the established 'Public … and Grammar Schools' as the model for all 'secondary schools'—Maclure (1986:194). However, during the last twenty-five years 'of the 19th Century', different secondary school types had emerged; they included 'Higher Grade', 'Organized Science' and 'Day Technical'—Maclure (*ibid*). Such schools were now 'discouraged', and 'new secondary schools were compelled to take as their model the curriculum of the existing Public … and Grammar Schools'—Maclure (*ibid*).

The Committee criticised the 'Board'; it had done 'nothing' to encourage partially vocational 'secondary schools' for those wishing 'to enter industry or commerce' at 16 years of age, although this need in a 'highly industrialised society' was clearly demonstrated—Maclure (1986:194).

07.05.06 The Norwood Report: 1943

Set up in 1941, this Committee's 'terms of reference' included consideration of '… suggested changes in the secondary school curriculum …'—Maclure (1986:200). The Committee's report provided 'one of the most explicit descriptions of the tripartite division of secondary education into grammar, technical and modern schools'—Maclure (*ibid*).

'English education has recognised … the pupil interested in learning for its own sake, who can grasp an argument …'; 'such pupils' are typically 'educated by the curriculum' of the 'Grammar School'—Maclure (1986:201). The development of 'technical education' shows the 'importance of recognising the needs' of pupils with an affinity for 'applied science or … art'—Maclure (*ibid*). Technical schools 'were not' established 'to satisfy the intellectual needs … of children, but 'to prepare' them 'for taking up certain crafts'—Maclure (1986:202). Such remarks disparaged and under-rated the intellectual challenge of technical education, and were born of a failure to understand that technology has brought us from the Stone Age to the way we live now. Such remarks also indicate the failure to understand the creative links between the imagination and the necessity for highly developed practical skills.

'Parity of esteem' between these three types of secondary education, 'can only be won' by the schools themselves—Maclure (1986:203).

07.05.07 Educational Reconstruction: 1943

This White Paper anticipated the '1944 Education Act'—Maclure (1986:206). Government sought a 'happier childhood' for children, a 'better start in life', and the opportunity for them to develop their 'various talents … so enriching the inheritance of the country …'—Maclure (*ibid*). The 'youth of the nation' was the 'greatest national asset', and should be developed for the 'greatest national advantage'—Maclure (*ibid*).

Only secondary educational issues will be discussed here. The Government proposed to 'recast' the 'national education' system, and introduce 'compulsory school attendance … extended to 15 without exemptions …'—Maclure (1986:206); this did not happen until 1947—Maclure (1986:222).

Various types of 'secondary education' of 'equal standing, will be provided for all children' —Maclure (1986:207). 'The child' will be the 'centre of education'; to be 'manifest', 'conditions in different types of school must be broadly equivalent'—Maclure (1986:208). 'Secondary grammar' schools enjoy a 'prestige … which … overshadows all other types'… Inheriting … a distinguished tradition … it offers … advantages of superior premises and staffing and a longer school life… But … an academic training is ill suited for many … who find themselves moving … into a limited field of opportunity—Maclure (*ibid*).

'Senior schools have a recent history … Their future is their own to make … They offer a general education for life, …'—Maclure (1986:209). 'Junior Technical Schools … hold out great opportunities for pupils with a practical bent …'—Maclure (*ibid*).

07.05.08 The 1944 Education Act

This Act did not lay 'down national guidelines for the organisation of secondary education', but the recent 'White Paper and the Norwood Report' clearly favoured the 'tripartite system' of grammar, technical and modern schools as policy—McCulloch (1994:33). 'Technical schools were never popular; 'secondary moderns were widely regarded as a second-rate alternative to the grammar schools'—McCulloch (*ibid*).

Norwood was influential in the adoption of the 'tripartite system', perceived subsequently to be founded 'on social antagonisms and the maintenance of social inequality'—McCulloch (1994:52).

07.05.09 The Percy Report: 1945

This was the product of a special committee appointed to examine 'the future of higher technological education after the war'—Maclure (1986:226). The Committee found 'serious shortcomings in the training of technologists affecting both quality and quantity'—Maclure (1986:226). They recommended 'a limited number of … Colleges of Technology' should be established, and these 'should build up full-time courses of degree standard'—Maclure (*ibid*).

However, no agreement could be reached on 'the qualification to be awarded'; 'one group wanted … Bachelor of Technology … another State Diploma in Technology …', while the '… Chairman wanted to make the selected colleges 'Royal' institutions awarding Associateships and Fellowships'—Maclure (1986:226). The failure to agree deferred 'action on the main recommendation'; three groups were involved: (1) universities had an interest in degrees, (2) professional institutions sought protection, (3) another group campaigned for a 'technological university' similar to 'MIT' [Massachusetts Institute of Technology]—Maclure (1986:227).

In '1951', agreement was finally reached; a 'Royal College of Technologists' was proposed as 'a national body', and accepted by the 'Labour Government'—Maclure (1986:227). The qualifications would have been 'Associateship and Fellowship'—Maclure (*ibid*). Before implementation a General Election was called; a Conservative Government was returned, and the whole debate 'reopened'—Maclure (*ibid*).

07.05.10 The Barlow Report: 1946

The Committee's terms of reference were 'To consider the policies which should govern the use and development of our scientific manpower and resources during the next ten years, … —Maclure (1986:230). As with the Percy Committee, the Barlow Committee was formed because of concerns about the technological basis of industry—Maclure (*ibid*).

The Committee's 'main recommendation' was to expand the university system so as to 'double the output of scientists', which the Government accepted—Maclure (1986:231). In '1938-9', the university population was some '50,000'; by '1958-9', the population exceeded '100,000'—Maclure (*ibid*).

07.06 Educational development since 1951

<u>07.06.01 White Paper on Technical Education: 1956</u>

In late 1955, although no longer Prime Minister, Sir Winston Churchill expressed concern about the 'Russian advances in technology and technical education'; the subject paper 'appeared shortly after'—Maclure (1986:239). Reference was made to the two-fold increase in university students taking 'science and technology', the building of 'more schools and technical colleges', 'more teachers recruited', and 'more interest … in education by parents and employers'—Maclure (*ibid*).

However, this was 'nothing like enough'; events in the 'USA, Russia and Western Europe' required that 'our system of technical education' should be examined—Maclure (1986:239). Comparison was difficult since educational systems 'vary so much', 'but it is clear … we are in danger of being left behind'—Maclure (*ibid*). The White Paper sought 'to strengthen the foundations of our economy, to improve the standards of living of our people, and to discharge effectively our manifold responsibilities overseas'—Maclure (*ibid*). 'Success … will turn largely on … a steady increase in industrial output, … productive investment, … exports of goods and services of the highest quality at competitive prices'—Maclure (*ibid*).

The country faces an increasing need for 'scientific manpower', and not only 'with the highest qualifications'—Maclure (1986:240). Technologists at the highest level depend on 'technicians and craftsmen' for their product designs to become reality; thus the output of technologists and technicians at every level of competence and skill becomes equally crucial, and cannot be ignored—Maclure (*ibid*). Technologists at the higher levels frequently obtain their experience by functioning at lower levels of technological responsibility, thus gaining further qualifications—Maclure (*ibid*). So 'the base' of the technological 'pyramid' has to be strengthened by 'improving' technical 'education in the schools', and encouraging more school leavers to succeed in the 'courses offered at technical colleges'—Maclure (*ibid*). For companies to be internationally profitably competitive in manufacturing, their technological skills pyramids requires a foundation in a range of highly developed practical skills that are driven by the imagination—see also p72 this thesis. But the broad concensus in education could see little value with practical subjects in the curriculum.

Technological education encompasses not only 'materials and mechanics', but 'accountancy, costing, salesmanship, commercial skills … foreign languages'; they are all 'equally important to a great trading nation'—Maclure (1986:241). Technological 'progress' is dependent on the 'common foundation of language'; the 'teaching of good plain English' demands 'more attention'—Maclure (1986:241). Without clear communication 'bridges are hard to build', not only between senior technologists and between 'experts in specialised subjects', but with the 'general public'—Maclure (*ibid*). A technological education 'must' include a 'liberal education'; 'We cannot afford to fall behind in technical accomplishments or to neglect spiritual and human values'—Maclure (*ibid*).

07.06.02 The Crowther Report: 1959

This report dealt with 'The education of boys and girls between … 15 and 18'—Maclure (1986:245). The Committee found that 'Most of them are not being educated', and further that a 'firmer educational base' was required to achieve 'a higher standard of living – and … higher standards in life'—Maclure (1986:247). The Committee were unanimous that 'the school leaving age should be raised to 16 between 1966 and 1968'—Maclure (1986:246).

The Committee also examined 'part-time technical education' and found little co-ordination between school education and what students 'receive in the technical colleges'—Maclure (1986:253). 'Only one student in 11' attending the technical colleges climbs 'the National Certificate ladder', and 'only 1 in 30' in the 'time' planned for the course—Maclure (*ibid*). Set 'against' the nation's demands 'for trained manpower', 'these wastage rates are shocking'—Maclure (*ibid*). Those who are successful, become so by giving up all 'their spare time' and for 'many years'; 'Nowhere else in our educational system do we expect such sacrifices for success'—Maclure (*ibid*).

07.06.03 The Robbins Report: 1963

Prime Minister, Harold Macmillan, announced 'the Committee' on 'Higher Education' in late 1960; it was established 'early in 1961'—Maclure (1986:288). The Committee's task was 'To review the pattern of full-time higher education in Great Britain … in the light of national needs and resources …'—Maclure (*ibid*). Making adjustments for population differences, there were more opportunities for 'higher education' in the USA, 'Soviet Union and certain Commonwealth countries' than in 'our own' country—Maclure (1986:289).

On technical and 'further education', more 'first-class talent' should be recruited on 'courses in technology'—Maclure (1986:292). The establishment of 'five Special Institutions for Scientific and Technological Education and Research' were 'recommended', 'comparable' to the 'great technological institutions' of the USA and 'the Continent'—Maclure (*ibid*). The 'Colleges of Advanced Technology' (CAT's) should receive 'charters as technological universities'—Maclure (*ibid*).

The academic achievement of the individual should determine their 'academic grading' and not the 'status' of their 'institution'—Curtis and Boultwood (1976:420). Differences between institutions based on 'adventitious grounds' either 'historical or social', were entirely 'alien' to the ethos that 'should inform higher education'—Maclure (1986:298). The Committee were concerned that the esteem in which institutions were held should be related to the 'work done'—Maclure (*ibid*). Also, that such recognition did not imply a difference in institutional value 'to the nation'; all institutions 'were needed' to 'supply' both 'national needs' and 'appropriate educational opportunities'—Maclure (*ibid*).

07.06.04 The Dainton Report: 1968

This Committee was formed 'in 1965', in response to concerns about the 'swing away from science in the sixth forms of secondary schools' that did not match the growth of 'science and technology departments in the universities'—Maclure (1986:327). The Committee's report 'the Flow of Candidates in Science and Technology into Higher Education' was published in '1968'—Maclure (*ibid*).

The Committee required 'changes in the sixth form, less specialisation and some mathematics for all'—Maclure (1986:328). 'The recommendations' were poorly 'received'; there was a shortage of the necessary 'specialist teachers' to implement the 'changes proposed', and 'the grammar and public schools' were determined 'to defend the Crowther concept of sixth-form study in depth'—Maclure (*ibid*).

The Committee found that although the 'output' from 'sixth-forms' continued to 'grow rapidly', there was no comparable growth in science specialists—Maclure (1986:328). The exceptional expansion of 'sixth-form education' during the 'past decade' was in 'studies' that do not 'qualify for higher education in science and technology'—Maclure (*ibid*). But 'science and technology' becomes 'increasingly important' in our lives and 'the economy'; scientific and technological 'discovery and invention', followed by 'exploitation' depends on the 'effective' use of 'scientists and technologists'—Maclure (*ibid*). The lack of 'good quality' candidates for 'industry and … schools', was 'likely to prove critical'—Maclure (*ibid*).

Between the Dainton Report in 1968, and the Consultative Document in 1977, there were a number of educational events, but they are largely outside the remit of this chapter.

07.06.05 - Education in Schools – A Consultative Document: 1977

The subject document, a Green Paper, was prepared by the Department of Education and Science, and represented the outcome of the 'Great Debate' prompted by the speech of James Callaghan as Prime Minister in October 1976—Maclure (1986:394). His speech was delivered at Ruskin College Oxford, and set out to 're-open' the education debate 'which had become "professionalized"'—Maclure (*ibid*). He referred to public concern about 'standards and priorities', and specifically rejected criticisms made by the 'radical conservatives'—Maclure (*ibid*). Mr Callaghan argued that the educationists 'had tried to keep control of the curriculum', and they had resisted explaining 'themselves and their actions to their paymasters and clients'—Maclure (*ibid*).

A memorandum 'entitled *School Education in England – Problems and Initiatives*', prepared by the 'Department of Education and Science', provided the impetus for Mr Callaghan's speech—Maclure (1986:394). The memorandum argued that 'the DES should be allowed to give "a firmer lead" and that the Inspectorate should "have a leading role to play" in bringing forward ideas on curricular matters'—Maclure (*ibid*).

By 1981, the influence of government 'policies and new technologies' had not only changed the face of agriculture and farming, but there was a real growth in 'self-sufficiency' for certain food products as summarised in Fig. 7.02—Blunden and Curry (1985:39).

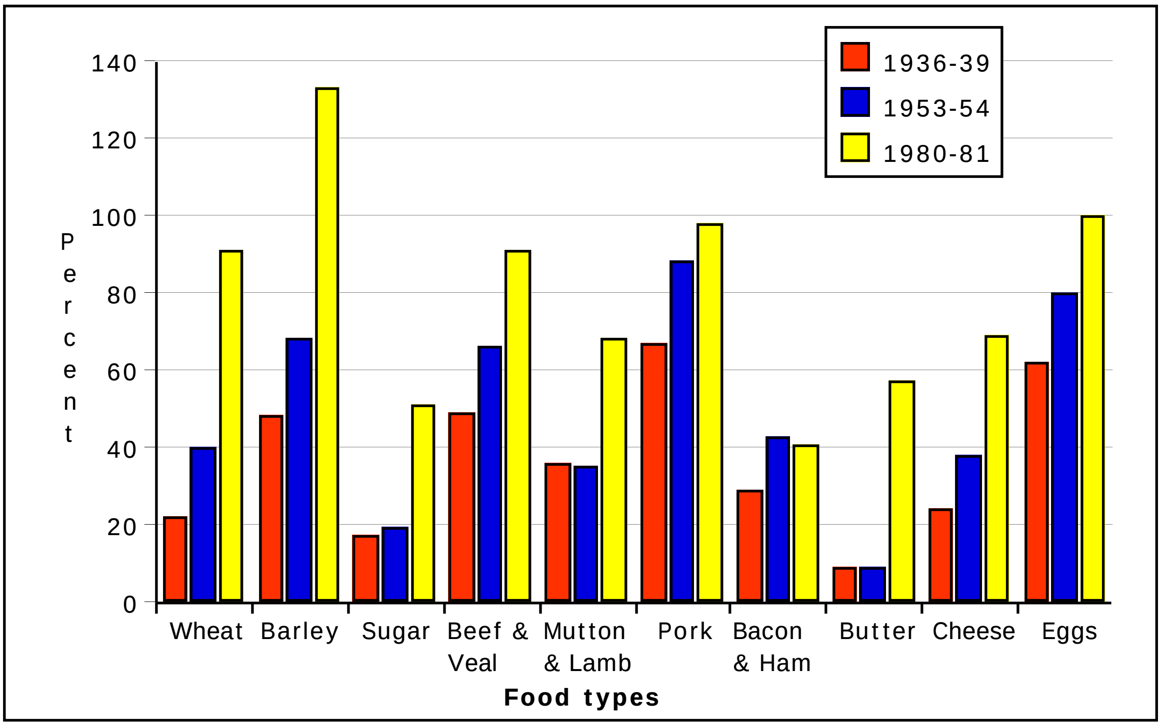


Fig. 7.02 - The growth in self-sufficiency in the production of certain foods in England and Wales between 1936 and 1981—Blunden and Curry (1985:39)

The growth in 'self-sufficiency' shown in Fig. 7.02 maybe only an 'indirect' indicator of 'efficiency', but it shows how the industry responded to government requests for increased 'production'—Blunden and Curry (1985:39).

07.06.06 The Technical and Vocational Education Initiative (TVEI)

'In November 1982, the Prime Minister [Margaret Thatcher] announced' the subject 'initiative to encourage the provision of technical and vocational education for young people'—DES (1991:1). After a controversial start, TVEI became a nationwide 'ten year development programme' that eventually cost £1 billion—Holland (1997:137); the size of the budget was an indicator of its importance.

The TVEI initiative sought to help young people between 14 and 18 as follows:

- '… encouraged to stay at school or college and achieve nationally recognised qualifications that will be of value to them – and which they see as valuable – in their adult and working lives …
- experience a balanced education involving modern approaches to science and technology
- apply their skills and qualifications to real life problems
- improve their self confidence, independence and adaptability
- obtain planned work experience and are prepared for the world of work
- develop positive attitudes towards industry, commerce and the community'—TVEI-L13 (1987:2).

However, there were concerns about creating a 'divided curriculum' that perpetuated 'Victorian views of knowledge and social class'—McCulloch (1994:60). But did anyone ever listen to the views of students such as:

> My son has been involved with TVEI and he likes it, but you can't fool the kids, they know that those qualifications are not as good as A-levels—Chairman of Board of Governors at a secondary school, and an accountant in a multi-national manufacturing company, 1989.

Although the TVEI budget amounted to £1 billion, it was always a bolt-on initiative, and therefore most unlikely to change the mainstream educational philosophy and culture.

<u>07.06.07 Education Reform Act: 1988</u>

The Education Reform Bill [5-16] was 'designed' to provide 'a radical break with the past'; the aims included the creation of a '"social market" in education', so that education became 'more responsive to economic forces …'—Tomlinson (1988:9).

The *'Principal provisions'* were a 'National Curriculum' structured around three 'core' and six 'foundation' subjects—Education Reform Act (ERA) 1988 (1989:2). In England, the 'core' subjects included 'mathematics, English and science', while the 'foundation' subjects comprised 'history, geography, technology, music, art, and physical education'—ERA (*ibid*).

For technology, the National Curriculum document was entitled 'Design and Technology for ages 5 to 16'—DES (1989:iii), and contained many key statements including:

- 'the development of design and technological capability "to operate effectively and creatively in the made world" as the overall objective for the subject;'
- 'attainment targets which reflect the holistic nature of design and technology;'
- 'to understand the significance of design and technology to the economy and to the quality of life.'
- '… pupils' design and technological activities should be undertaken in a suitably broad range of contexts, covering home, school, recreation, community, business and industry'—DES (1989:1).

- 'Design and technology has a special relationship with science and mathematics. Although its aims are different from those of science and mathematics, it is intimately associated with them, …
- This special relationship needs to be fostered in the school curriculum …'—DES (1989:2).

So technology appeared for the first time as part of the curriculum on a national basis, and was introduced in 1989 as Design and Technology.

Note: 'Since 1983, the UK has become a net importer of manufactured goods'—The Engineering Council (March 1988:1). 'If more companies are to compete effectively in world markets, we need to ensure that our best resources are used to achieve forward-looking leadership to meet future needs'—The Engineering Council (*ibid*). 'Our leading industrial competitors … appear to make better use of qualified leadership in the running of their industries'—The Engineering Council (*ibid*). These data shown in Fig. 7.03 below support the argument—The Engineering Council (March 1988:9).

Country	Percentage of top managers who have degrees	Number of qualified accountants 000s	MBAs per annum
Britain	24	120.0	1 200
USA	85	300.0 (est)	70 000
West Germany	62	3.8	0
France	65	20.0 (est)	0
Japan	85	6.0	60

Fig. 7.03 - Some international comparisons of qualified leadership in industry—The Engineering Council (March 1988:9).

Fig. 7.03 shows that in 1988 Britain had the lowest proportion of top managers in industry with degrees, and Britain had the second highest number of qualified accountants.

07.06.07 Technology curriculum revisions: 1992

However, there were difficulties with the subject of Design and Technology as introduced in 1989. Consequently, in June 1992, a 'review was commissioned because … teachers … experienced significant' difficulty 'interpreting the statutory requirements' for 'attainment targets 1 to 4'—DFE (1992:iii).

After the review, 'the number of attainment targets' were 'reduced from four to two', and the 'statements of attainment' were 'reduced from 117 to 59'; these changes were planned 'to simplify the demands upon schools'—Sutherland (1992:v-vi). However, 'a central place in the revised Order' was given to:

- 'work with construction materials as well as electronic and mechanical components …
- … making a manageable range of high quality products, and the specification of the essential knowledge and skills should help to ensure pupils' work is rigorous and intellectually demanding'—DFE (1992:vi).

Within the review, the consultation process disclosed that 'there was considerable variation in respondents' views on the nature of D&T and what it should contain'—DFE (1992:4). However, there were many proposals including '… pupils should … appreciate the impact of technology on everyday life'; also, there was recognition that 'D&T' draws 'on … art, mathematics and science'—DFE (1992:5).

<u>07.06.08 National Curriculum revisions: 1995</u>

In April 1993, 'the Secretary of State for Education invited' Sir Ron Dearing to carry out a 'Review of the National Curriculum'—Dearing (1993:3). The 'terms of reference' included:

- 'the scope for slimming down the curriculum;
- how the central administration of the National Curriculum and testing arrangements could be improved'—Dearing (*ibid*).

An Interim Report was published in July 1993, that 'made a number of recommendations … which were accepted by Government' including:

- 'Action on changes … for English and technology … should be delayed so that these Orders could reflect the recommendation emerging from the wider Review. …
- … the revised Orders should come into force … for the school year 1995/96'—Dearing (1993:82-3).

For D&T, the 'slimming down' process included the following changes:

- 'The number of design and make assignments to be taught at each key stage is no longer specified …
- Key Stage 2 … The requirement to learn about the work of distinguished engineers, designers and technologists and the historical development of familiar products has been removed'—SCAA (1995:6); there were also reductions in content.

The revised Order for Design and Technology in the National Curriculum was published in January 1995—DFE (1995:ii).

07.07 In summary

The purpose in this chapter has been to discover how maths, science and industry were regarded as the system of education unfolded. The discovery process has taken place by examination of documents which define the developmental history of the education system including the courses of study; by any standard it is an atrocious story. For UK (Technology) Limited it has been an absolute disaster.

From the analysis in this chapter, the education system has the appearance of a collection of solutions to specific problems. Such 'piecemeal' development is 'the weakness of our education system'—Curtis and Boultwood (1976:418). Within this piecemeal development, this research discloses that there were strong value judgements at work on many issues, including the courses of study and industry.

Our educational system was designed around the requirements of the upper classes, and since they were wealthy the economic demands of the nation came second. By design, the economic needs of the nation were left in the hands of the industrial classes. The social gap between the upper classes and their educational systems, by comparison with the industrial classes and the education specified for them, ensured that there was no esteem attached to working in industry; this prejudice still exists, as will be shown in the next chapter.

Attempts to change the curriculum to reflect the economic needs of the nation have been on-going for more than a century. There has been a great deal of legislation and debate of the issues, but in reality not much has happened in the context of changing the education system (or the culture) so that sustaining ourselves as a society became a matter of priority. Well-intentioned legislation has generated on-going debate, but it has served merely as a catalyst to shroud the economic needs of the country in an eloquent fog.

The Taunton Report of 1868 on secondary education found that:

> As all civilisation really takes its rise in human intercourse, so the most efficient instrument of education appears to be the study which most bears on that intercourse, the study of human speech—Taunton (1868:22).

This was a seriously inadequate assessment, and completely overlooks the contribution made by technology as the generic creative system of humankind that has brought us from the Stone Age to the way we live now. Such an assessment also overlooks the contribution to the continuity and progression of humankind through knowledge building on knowledge. However, the Taunton Commission made certain amends when they stated:

> … the "material studies," if not regularly taught, will probably never be learnt at all; and this consideration must be allowed much weight where the length of time assigned to education is very short—Taunton (1868:23).

So the material studies were seen as important, but only for the industrial classes. There was no comprehension of the relationship between the images visualised through the imagination, and the realisation of those images by skilled hand/eye coordination into the tools and technologies upon which we are now so dependent. The tools and technologies of humankind have always enhanced the productivity and/or capability of humankind, and we are surrounded by the artifacts of our technological processes and progress.

Ever since the Stone Age, humankind has been tool dependent, and the necessity for practical skills has always been at the core of that dependency. As the technologies of humankind have become more sophisticated, so the demands for highly developed practical skills has become greater. However, from the earliest days 'practical subjects' have had 'low status' in the 'academic hierarchy'—Penfold (1988:20). For more than a century, there has been 'official obeisance to the educational value of practical subjects' in the curriculum—Penfold (1988:20), which our opinion leaders undermine with statements such as:

> The report sets out a coherent and persuasive view of design and technology as an essentially practical activity … letter from Kenneth Baker Secretary of State for Education to Lady Margaret Parkes Chairman, referring to Interim Report on D&T, dated 23.11.1988 - see page 99 of the 1989a Orders.

There is a cultural obsession with the practical aspects of technology, and a failure to see the intrinsic intellectual content as a necessary precursor of the practical content. Baker's assessment typifies a culture unable to see that technology at the leading edge enhances our productivity and/or capability. The 'educational value of practical subjects' propounded by Hadow, Crowther, Newsom *et al*—Penfold (1988:20), was never under-pinned by a change in educational philosophy and culture in conjunction with empowering legislation. Contrast this incomplete educational philosophy with that of the Japanese:

> In 1960, the Japanese Economic Council of the Economic Planning Agency, which drafted the National Income Doubling [5 year] Plan, underlined the importance placed on education when it stated "economic competition among nations is a technical competition, and technical competition has become an educational competition …" The Engineering Council (May 1988:3).

The UK had the chance to maintain the momentum of the Industrial Revolution through its educational philosophy, but the broad concensus in education was unable to make the necessary cultural adjustments and hence allow the opportunity to be seized.

The developmental process of the system of education has been one of seeking change every few years, and for the best part of two centuries. This change process was usually authorised by parliament or government departments, and their terminology also attributed value to curriculum subjects such as the classics, science and maths. Equally, it was their terminology that attributed value to industry. 'Textual materials that survive over long periods often reflect an elite bias'—Weber (1990:11).

When prominent opinion leaders apply value judgements, they disclose their cultural preferences, and they establish standards for others to follow. When defining the direction to be taken by education, these opinion leaders employ terminology that provides 'statutory sanction' for disparagement. Such values have cascaded through the sub-culture of education and on into society, and the lessons have been learnt all too well, as will be shown in the next chapter - 'The perception of technology'.

Meanwhile attempts to change the curriculum continue. The Department for Education and Employment have published *All our futures:Creativity, Culture & Education*, in which the following was stated:

> We live in a fast moving world. … Many businesses are paying for courses to promote creative abilities, to teach the skills and attitudes that are now essential for economic success but which our education system is not designed to promote—DfEE (1999:13).

In the absence of an educational system that provided an holistic approach to sustaining ourselves as a society, our educational system has fallen back on the value judgements associated with a philosophical and cultural failure to understand the purpose of technology and industry at the highest levels in our society. Worse, this failure to understand included a determination to associate industry and technical education with the 'lower orders', with the 'industrial classes' for whom there was no intellectual challenge.

Thus in our society there is no social esteem attached to working in industry, even though the products and services of industry are the life blood of society. Without exception we are all users and consumers of technology, and furthermore we are totally dependent on technology. Most critically, since our society is 'technically illiterate'—Sharon (1989:55), our dependency on technology and industry is just not understood. But it is significant that little social stigma attaches to being 'technologically illiterate', and therefore 'only partially educated'—Penfold (1988:21). From this state of being only partially educated, it maybe argued that sustaining ourselves as a society has never been a matter of high priority within the culture of our opinion leaders.

Chapter 8

The perception of technology

Man is a tool-using animal … . feeblest of bipeds! …
Without tools he is nothing, with tools he is all.
Thomas Carlyle (1795-1881)

08.01 Introduction

Technology is paramount in competitive industry; as an industrialised society, it is also paramount in our lives. But in our society, there has been a crucial failure to understand and value these pivotal relationships as discussed in the previous chapter. The purpose in this chapter is to examine the perceptions of technology by various groups. However, before embarking on the presentation of the evidence, it is necessary to:

- recapitulate the pivotal place of technology in our lives, and
- demonstrate the existence of serious cultural problems before the formative years of education as discussed in the previous chapter.

So this chapter has been structured to consider:

- the crucial place of technology in our lives – recapitulation—[08.02]
- the origins of hostility towards industry and business, as a cultural issue—[08.03]
- anecdotal evidence of a prejudicial culture—[08.04]
- the perceptions of technology and/or industry based on research before and after the 1988 Education Reform Act by:

1	Student teachers and teachers	Based on an introductory exercise on 'economic and industrial understanding'—[08.05]
2	A-level students	Based on a questionnaire survey—[08.06]
3a 3b 3c 3d	Teachers Parents Student teachers A-level students	From recorded interviews based on a common schedule—[08.07]

Anecdotal evidence is presented together with the outcome of systematic research, and it is timely to reflect on the broader thesis driving this research:

> The general purpose is based on the viewpoint that the educational system of *'the UK has consistently failed to respond appropriately to 'technology'* (hence our economic decline), and to test the hypothesis that *'this failure has contributed to the problems associated with the place and perception of 'technology' in the National Curriculum'.*

The evidence is offered not as exhaustive proof, but as a strong indicator of my thesis.

08.02 The place of technology

In this thesis, technology has been shown to be the generic creative system of humankind, and is characterised by the way humankind has constantly applied its imagination to the available materials for the purposes of creating tools to enhance productivity and/or capability. Humankind evolved because of its toolmaking skills; humankind has always used tools, and much more recently technologies, as extensions of itself. Arguably, the underlying purpose has always been sustainment, and this applies with every type of nation, whether hunter/ gatherer or industrialised. Technology is a large and dominant part of the culture of any society as discussed in chapter 6, and particularly in an industrialised society.

In the quotation at the beginning of this chapter, Carlyle defines clearly what separates humankind from all other animal species. However, while without exception humankind has always been a tool user, and much more recently a technological tool user, not everyone has been endowed with tool or technological toolmaking skills. In other words, the imaginative hand/eye coordination skills required to make reality of the imaginative concepts by which to enhance productivity and/or capability for humankind.

As the generic creative system of humankind, technology at the most basic level in either hunter/gatherer or industrialised nations may be represented as shown in Fig. 8.01:

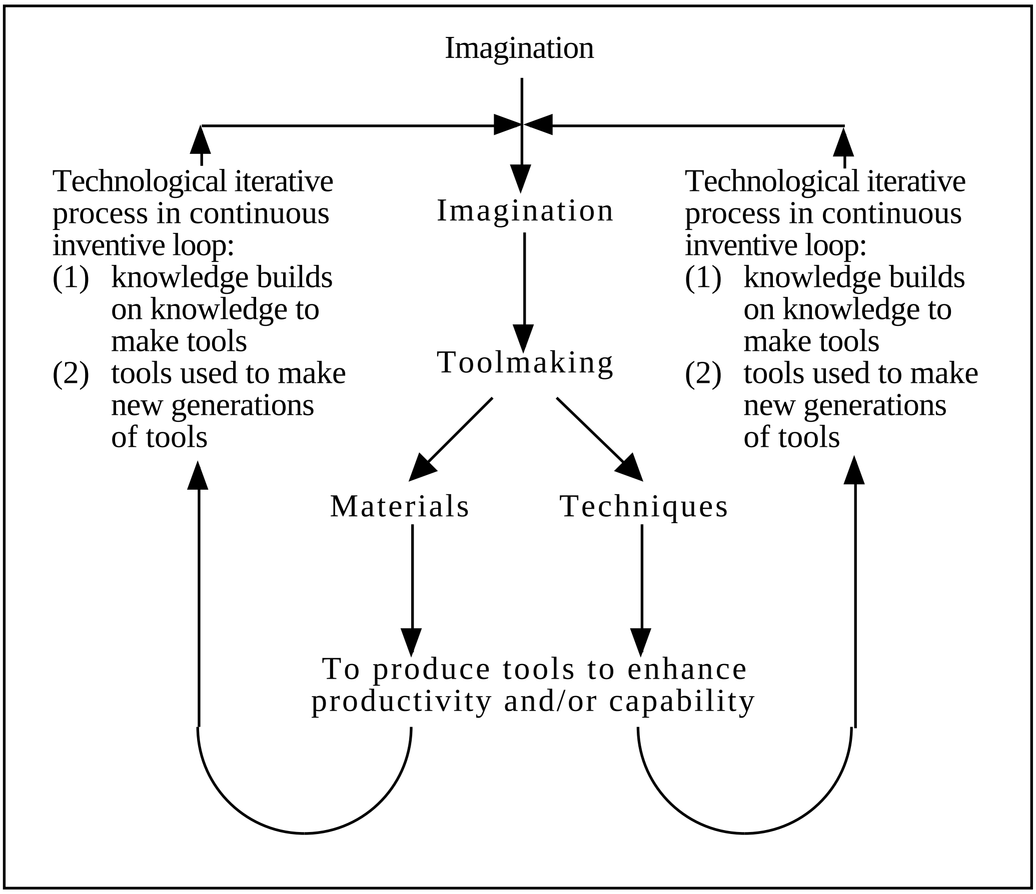


Fig. 8.01 - The generic creative system of humankind at the most basic level of process

Referring to Fig. 8.01, this raises questions about how much the iterative creative process has informed the curriculum.

As tool users, but particularly toolmakers, humankind has long been the most powerful animal on earth. By comparison with all other animal species, the present-day power of humankind was derived by imaginative activity; specifically, new methods (techniques) were visualised that used available materials to create tools, and more recently technologies as tools, to enhance human productivity and/or capability. This process started in the Stone Age, and has been on-going ever since. On page 24 the following was stated:

> With the first acts of stone tool-making, the human species made not one but two inventions that were crucial to its evolution and its technology. The first, a simple blow by a hammer stone put an edge on another pebble to form the working tool. This basic working tool changed little over the next two million years. The second was the deliberate act of preparing and storing pebbles for later use—Bronowski (1979:40). The first Stone Age tools became standard implements, and this implies a long tradition of skill gradually learned—Oakley (1972:5). Making tools for both immediate and future use, indicates an ability for 'conceptual thought'—Oakley (1972:3). The suitability of stone as a material for the tools of early humankind was indicated by the duration of the Stone Age. This included the choice of material, how to fashion the tool, and how to use it—entirely imaginative activity.

Stone endured as a material suitable for tools because it would provide a durable cutting edge, and could be used for other applications such as the technique of hammering, or used to provide weapons.

The processes of sustainment for any nation may be divided into two parts: (1) obtaining food, and (2) developing tools. At the core of these two distinctly different processes is how humankind applies its imagination on the available materials, and they are often inter-twined, as demonstrated for example by the progressive mechanisation of farming.

Farms may be perceived as factories designed by humankind for the purposes of producing food. Since the invention of the plough as a tool—page 25, the food-production processes in societies with an industrial capability, have been supported by further evolutionary developments in tools and/or technologies that come under the heading of 'mechanisation'.

The tools of the hunter/gatherer nations are also culture-specific, and include items such as the bow and arrow (a technological system), the kayak (with the paddle a technological system), the igloo or, say, the tepee. These are just some of the tools invented by humankind, and like all tools or technologies, they extend the productivity and capability of humankind; the tepee extended the capability of the North American Indian to provide a system of shelter. The tools and artifacts of humankind have always been influenced by the available materials, but depended on imaginative ideas in order to make use of those materials.

What distinguishes industrialised nations from say hunter/gatherer nations resides in the types of tools and materials employed. Today, competitive industrialised nations use an astonishing variety of sophisticated technologies and materials, but those technologies are nevertheless tools that have been designed to extend the productivity and/or capability of humankind. The computer is a recent example, but it could not have been designed and produced without precision technology; recognition of precision technology was built into the design. Only sophisticated industrialised societies have precision technology derived as a process of knowledge building on knowledge in materials, as well as the techniques of identifying and working materials that would retain precision measurements—pages 40-48.

The early industrialised nations achieved their status by prior developments in farming and agriculture. On page 25 in this thesis, the following was stated:

> The biological evolution of the human species, which separated us from our ape ancestors, was a process that took millions of years … … However, the cultural evolution that now distinguishes us from our foraging and hunting/gathering predecessors, started 10,000-12,000 years ago—Bronowski (1979:59). By 10,000 years ago, the human species had begun to give-up the nomadic way of life associated with the hunter/gatherer. In some parts of the world it began the domestication of certain animals and the cultivation of plants—Asimov (1990:10), Bronowski (1979:59). And so started the agricultural way of life, 'the change from which civilisation took off'—Bronowski (1979:60).
>
> Land used for herding and agriculture could support a larger population—Asimov (1990:11). The nomadic way of life was such that only the simplest of technologies could be carried from place to place on a daily basis—for example a goatskin bag on a simple wooden frame, for making yoghourt [*sic*]. Settled agriculture, on the other hand, was a deviation from the hunter/gatherer way of life; it was the deviation that laid the foundation for technological evolution, and eventually physics and science—Bronowski (1979:61-74).

By far the greatest part of human existence has been supported by technology based on mechanical principles 'without much … theoretical understanding'—Cotterell (1990:11). Only recently has the vital place of science in the creation of new technology been understood—Cotterell (*ibid*). The knowledge of mechanical understanding continues to grow, and is now aided by the development of scientific theory. And here but briefly described is yet another step in the imaginative and intellectual development of humankind.

But if we dismiss the imaginative hand/eye coordinated toolmaking skills of the past, we do so at our peril, since we will never understand the roots of technology, nor the fact that it is older than human awareness of science. Also, as an industrialised society, we will not easily appreciate that the standard of living we enjoy today is dependent on our collective productivity and capability achieved through our tools and technologies.

Although the first tools were rather elementary, we could not have progressed as toolmakers and eventually 'graduated' as technologists without them, and the way we live now would not have been realised. The first tools represented imaginative and inventive achievements by humankind. The only limitations were those imposed by the lack of knowledge of techniques, lack of knowledge of the materials available, and the properties of those materials including how to work them. Time had to elapse for the knowledge of humankind to build on knowledge, and provide the technology that brought us to the way we live now.

Developments in tools and technologies emerge because of the inner compulsion that exists among people with the knowledge to make tool and/or technological change happen. And technological change happens as an outcome of a new convergent synthesis of knowledge as discussed on pages 29-30 in this thesis. The ability to think in pictures has always been inherent in this process, and is an integral part of the 'intellectual history of technological development'—Ferguson (1977:827).

Accumulation of experience and knowledge is possible in human societies because of their life span—Usher (1954:67). Since the Stone Age, this cumulative acquisition has been a social cultural achievement, the enormity of which was long overlooked—Usher (1954:68). This process was summarised on page 31 in Fig. 4.02, now reproduced as Fig. 8.02.

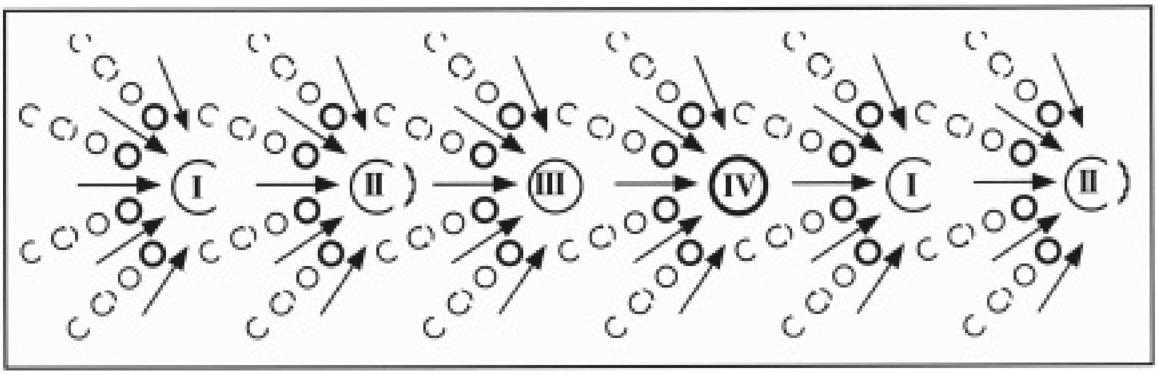


Fig. 8.02 - The process of cumulative synthesis

So the progression in technology since the Stone Age, has been marked by the continuous expansion of the imaginative activity of humankind as knowledge continues to build on knowledge. This is particularly so with industrialised nations where societies are now totally dependent on the latest innovations in technology, including the UK; one example is the computer, which has significantly raised our productivity and capability. But when another invention of humankind, namely electrical power, is lost, the computer is a useless artifact. Thus the sophisticated technological systems upon which industrialised societies are today dependent, are themselves dependent on earlier technologies. Indeed there is a law of prior dependency, as will be explained.

Earlier generations were born into a level of technological productivity and/or capability that was soon taken for granted as the way in which 'things had always been done'. Once productivity and/or capability have been raised, there is no going back to an earlier level of productivity or capability. Indeed younger people are often excited by new products, and embrace them without hesitation; examples from recent times include the Walkman radio-cassette player, computers, and mobile phones—all dependent on electricity supply systems.

Whereas the greatest part of human existence has been supported by technology based on mechanical principles, the refinement of mechanical principles in the lathe (and other machine tools) enabled the refinement of precision technology and thus made feasible the generation of electricity. Electricity generation and supply was a new strategic invention, a new convergent synthesis that contained the following new knowledge:

- precision technology – up to the 18th Century, and then as a recent phenomenon, the technology for producing parts with precision was limited to the clock and instrument makers. However, Maudslay (1771-1831) designed and constructed lathes precise enough to produce industrial workpieces with precision—page 47.
- electrical generation – by 1831, Faraday (1791-1867) had 'established … the relation-ship between electrical and magnetic effects'. Other inventors worked on the dynamo so that by 1870, the basic 'winding' variations were defined. By 1880, the actions necessary to achieve 'lighting, power production, and traction' were feasible—page 70.
- electricity supply – in 1931, fewer than half the homes in Britain were connected—p70.

Electricity generation and supply could not have been achieved without the technology of precision, and the technology of precision was founded on mechanical principles (including the lathe) that began thousands of years ago. The invention of electricity brought about a revolution in the home with all the domestic appliances, and a revolution in communication. Many new industries have been created based on domestic electrical products as well as communication products; they are all dependent on the technologies of precision, as well as the technologies of electrical supply systems—a dependency matrix.

Another characteristic of technology is how very ancient concepts exist alongside modern examples; we are simply not aware of the breadth and depth of the technological evolution that has been a constant companion to the evolution of humankind. The idea of the cutting edge stems directly from the Stone Age, and has been used down the millennia by humankind in many different ways, including for example the knife and the precision metal-cutting tools to produce electricity generating machinery. As an ancient invention, wheeled carts go back to 3600BC, but the rubber tyre was not invented until 1887—Asimov (1990: see time line). The modern car tyre (without inner-tube) is a marvel of technological engineering product design, product development, and manufacturing process development, but these are all disciplines which are at their best when driven by the imagination.

In the total evolutionary process, humankind has striven constantly through imaginative application, and developed an ever-increasing inventory of tools and technologies that enhance our collective productivity and capability. All these achievements are taken utterly for granted, and indeed by many they are disparaged because they are not understood, but without exception we are all users of technology, and wholly dependent on technology, even the technophobes.

As an intellectual subject, technology has many component parts including maths and science. The previous chapter showed how the incorporation of maths and science in the curriculum was resisted for many decades, particularly by the middle and upper classes. Furthermore, technical education was for the 'industrial classes' or 'the lower orders'. So there was a lack of social esteem, indeed stigma, associated with technical education and industry, and particularly among the opinion leaders of society.

In reality, this stigma undermined the activities associated with enhancing the productivity and capability which underpinned the standard of living for our society. However, the critical mass of influential opinion leaders were blind and ignorant of such damaging sentiments, and therefore, the author contends, they were also effectively technically illiterate—see also Sharon (1989:55).

But other sources of stigma played an important part in the value judgments of our society, and before the formative years of the educational system; these will be considered in the next section.

08.03 Anti-industry and anti-business sentiments

Before 1760 there was no concerted hostility towards industry and business in the UK, but that changed in the period up to 1790. This change was driven by forces outside education, but the cultural context and associated value judgments have significance here.

The origins of hostility towards business in modern Britain have been studied by Raven (1985). His dissertation, entitled *English Popular Literature and The Image of Business 1760–1790*, considers two aspects—Raven (1985:1). Firstly 'the commercial growth of the book trade and the social impact of popular literature', and secondly, the 'attitudes' and 'prejudices' in the literature 'promoted' by the 'writers' and 'booksellers'—Raven (*ibid*). Popular literature in the 16th Century showed no disapproval of 'merchants and tradesmen' although they 'certainly indulged in fashionable conspicuous consumption'—Raven (1985:134). Until the early 17th Century, the portrayal was usually 'generous' depicting 'mercantile pride and self-esteem'—Raven (*ibid*). Early 17th Century 'Jacobean drama' challenged the 'profit-making' aims of the merchant classes so producing 'the first indictments'—Raven (1985:135). The attacks were forceful making 'dramatic use of the Avarice figure' [*sic*], but the 'benevolent image of the merchant rode the storm', the criticisms fading after the 1630s—Raven (*ibid*). By the late 17th Century, however, there was a return to 'stage-led satires' demonstrating opposition to the 'avaricious cit [derogatory abbreviation for citizen—OED] and the social pretensions of the financier and self-made merchant'—Raven (1985:135). 'Such portrayals' became popular, causing the 'trader' to be embarrassed by 'his profession', seeking to hide 'his origins'—Raven (*ibid*).

There was yet another change by 1740; the 'mercantile contributions to civilization [*sic*], exploration, learning, economic and political strength, civic virtue and humanitarian practices, [had] reached new heights of confidence'—Raven (1985:136). During the early years of the 18th Century, the satirical targets were the 'City wives, skinflint merchants and dishonest financiers', while the 'prosperous' 'man of Commerce' was portrayed as 'patriotic, benevolent and … liberal'—Raven (*ibid*). Before 1760, 'concerted … hostility towards businessmen' did not exist—Raven (*ibid*).

But 'after 1760' there was a significant change; writers of popular fiction developed 'a … new range of stock characters' depicting 'the wickedness, absurdity and frivolity of traders, trading families and nouveau-riches'—Raven (1985:136). 'The heroic merchant figure … was overshadowed by an array of caricatures of the vulgar petty trader, the arrogant returned nabob and the parvenu estate-owner'—Raven (1985:137). 'By the end of the 1780s, northern manufacturers were added to the gallery of rogues'—Raven (*ibid*).

'The businessman was made a scapegoat for a wide range of alleged social and economic ills and [he] became a target of abuse as a means of illustrating, preserving and extending specific class values during a period of marked social upheaval and readjustment'—Raven (1985:137), caused by the Industrial Revolution.

08.03.01 Taking samples of literature

Sampling the popular literature at five-year intervals between 1760 and 1790 provided a clear picture of the growth 'of anti-business sentiment'—Raven (1985:139). Over this thirty-year period, an 'escalating sharpness and vindictiveness' in the attacks 'upon traders, nabobs', and subsequently 'manufacturers', may be discerned—Raven (*ibid*).

By 1770, businessmen were portrayed in ways that were conspicuous with 'commonly shared caricature and innuendo'—Raven (1985:139). The 'petty trader and vulgar nouveau-riche' appeared in humorous satirical sketches—Raven (*ibid*). Disparaging terms of reference included 'nabob', 'parvenu' and 'arriviste'. 'The attack upon nabobs' 'can be dated specifically … from 1768'—Raven (1985:140), and was a term reserved for those with newly acquired wealth returning from the East India Company.

Between 1760 and 1780, 'popular commercial literature' provided an ongoing 'fictional milieu of country gentlemen and provincial nobility' that contrasted sharply with 'the representation of the men of trade'—Raven (1985:140). 'New representations of … dress, behaviour, language, houses and expenditure of the arriviste businessman were well developed by 1780', becoming 'more elaborate in successive seasons'—Raven (*ibid*).

'By 1790 the subjects' backgrounds' were exemplified with liberal 'detail', and specific 'reference to the outlandish social ambitions of the parvenu'—Raven (1985:140). The popular literature of the 1790 season, by comparison with 1770 and 1780, 'displayed intense concern with the origins of the self-made and trading families and of the morals and activities of their dependents'—Raven (1985:141).

The literature of the 1790s, displayed 'much fiercer' malediction of 'trading families'; heroine figures were portrayed 'struggling … against arranged marriages with men of recently acquired' wealth—Raven (1985:141). These 'parvenu vulgarians' were 'courted by indebted and unscrupulous intending' fathers-in-law, while 'the heirs of impoverished estates' were 'forced to make disastrous alliances with the unschooled daughters of the City and … East

India Company'—Raven (*ibid*). 'Invariably, both spouse and in-laws' were 'found to be small-minded, foolish, extravagant and proud'—Raven (*ibid*).

The 'imaginative literature' of 1760 to 1790, also attacked the unworthy 'social deviance of redundant aristocracy' while highlighting the 'approved values of economy, charity and a proper stewardship of wealth and position'—Raven (1985:142). The misuse of aristocratic wealth was accompanied by even more 'devastating attacks upon the vulgarity of parvenues and the [social] ambitions of traders and industrialists'—Raven (*ibid*).

Popular literature exhibited an 'underlying fear' of 'social, economic and political dislocation threatened by upstart traders'—Raven (1985:142). Many among the popular readership exhibited the 'money-lust, fashion-craving and social pretension' found in the 'best-selling works'—Raven (*ibid*). Hence the menace of 'fashion and materialism' were 'crafted to define and condemn apparent excesses and to do so by judgments upon correct taste, good breeding, and the legitimate and illegitimate aspirations of rank'—Raven (*ibid*).

In 1785 and 1790, the popular fiction 'produced far more dramatic fates' for the 'fictional' transgressors than in '1775 or 1780', and there were 'more evil characters to receive them' —Raven (1985:147). The 'instructional utility of the novel' was enriched when those who transgressed the norms of 'correct behaviour' received a 'ghoulish' end—Raven (1985:149).

08.03.02 Some contributory factors

The Industrial Revolution started in the UK in about '1760'—Rubinstein (1994:1), and also triggered a commercial revolution. By adopting the 'novel technique' of selling from samples or catalogues in showrooms, Josiah Wedgwood was part of that commercial revolution in the 18th Century—Forty (1992:29)—page 77 of this thesis.

However, the 'literary reception of the commercial revolution', as exemplified by the contrived 'published outrage' in popular fiction, was pivotal in the 'formation of hostile images of the businessman and business activities'—Raven (1985:153). The 'literary reaction to new consumer behaviour' was characterised by the 'condemnation of luxury and fashion'—Raven (*ibid*). 'Often', these reactions to 'fashion … parvenu wealth and conspicuous consumption' were 'out of pure social jealousy'—Raven (1985:154).

But the 'cause' of these 'outcries' warrants further examination—Raven (1985:154). Some uncertainty 'remains' about the 'economic effects of the growth in home demand for manufactured goods', but the steep 'rate of change in fashions … is unquestionable'— Raven (1985:155).

As 'consumer industries' proliferated, ethical 'concerns' were aroused over the consumption of 'inessential extravagancies', and 'commercial products' were identified 'with bad taste, parvenu spending and vulgarity'—Raven (1985:155). Comparing the popular literature of 1790 with the cohort of 1760, the 'development of the attack upon fashion … the association of luxuries with irresponsible parvenu wealth and the gaudy philistinism of overweening traders and nabobs', may be clearly seen—Raven (*ibid*).

However, there was a sharp contrast between 'popular' literature, and the 'growing intellectual appreciation of the consumer boom'—Raven (1985:157). 'Economic works' found 'progressive levels of spending … a stimulus to economic growth', contrasting sharply with the 'letters to editors and the verdicts' on 'novels and tales'—Raven (1985:158). The 'consumption of manufactured goods', although 'intellectually' acceptable, 'was regarded with splenetic hostility by the [popular] fiction … industry'— Raven (*ibid*). The fiction industry could draw upon 'a vast stock of characters and storylines' to show 'the evils of luxurious conspicuous consumption'—Raven (*ibid*).

First-generation traders and industrialists were cognisant of the attitudes of 'polite society'. The second-generation sons who inherited the businesses sought to become more acceptable in society. They exhibited 'gentlemanly values' and 'country seat' aspirations, and 'modern Britain … lost out on the technological revolution'—Raven (1985:4).

This brief review in the growth of hostility towards industry and business, shows clearly that serious cultural problems existed before the formative years of the educational system. However, the anecdotal evidence in the next section, from a wide range of sources, will reveal that the value judgments exhibited in the popular literature still exist.

08.04 Anecdotal evidence of an anti-industry and anti-business culture

The anecdotal evidence runs into more than 4000 words, so it is presented in Appendix 5. Those anecdotes provide examples of what was learnt in the absence of positive instruction about the pivotal roles of technology, industry and business in our society. What was learnt, was almost entirely negative, and poured widespread scorn with statutory sanction on the intellectual and practical hand/eye coordination skills associated directly with enhancing our productivity and capability. Yet our collective standard of living and quality of life is influenced directly by the collective technological productivity and capability of our society.

Although the standard of living we enjoy today has come about because of technological knowledge building on knowledge, this process was never understood by the influential opinion leaders in our society. In particular, they never understood the contribution made by Maudslay (page 47), Whitworth, Roberts, Clement, Fox and Nasmyth (page 49). And neither did they understand that these were great engineers whose imagination brought about a revolution in machine-tool making which created the platform for the development of steam power (page 49), and maintained the momentum of the industrial revolution.

Through their vision, these brilliant engineers founded the technology of precision, which was the key to low-cost interchangeable parts and mass-production (page 49). But engineers and engineering skills are also damned in our anti-industry culture, although engineers are at the forefront of the constant quest to raise technological productivity and capability, thereby enhancing the standard of living for our society.

Once the idea of the anti-industry and anti-business sentiments has been comprehended, the prejudices are easy to recognise. These prejudices are endemic in our society, so the bulk of our population would not be able to spot such damaging sentiments. Worse still, they would see nothing wrong with such sentiments when they have been pointed out to them, since they have not been taught to understand and value the role of industry or technology.

However, anti-industry sentiments are not the same as anti-business sentiments, but they are both anti-enterprise in their construct, and hugely damaging in the context of sustaining ourselves as a society; that is to pay for all the services we expect and demand from the state. Anti-industry sentiments have consistently undervalued the role of industry, technology and engineering, even though engineers are at the forefront of the constant quest to raise productivity and capability within many industries in our society. Raising our collective technological productivity and capability underpins the difference in the quality of life we enjoy as a society by comparison with the rest of the world. See for example anecdotes 13, 14, 18, 19, 20, 22, 23, 24, 25, 26, 27 and 28.

Anti-business sentiments, on the other hand, have more to do with disdain for newly created wealth through trade-related enterprise—for example anecdotes 12, 55, 56, and 57. Finally, both the anti-industry and the anti-business sentiments are often influenced by snobbery. For example, people who participate in industry or business, or become professional engineers are perceived not to be 'gentlemen'—see anecdotes 9, 10 and 11.

There are some 65 anecdotes in Appendix 5; they are presented not as criticism, but as examples of what was learnt in the absence of positive instruction about industry, technology, and business. They include examples to do with industry, business and education; some show the cultural problems faced by young women both in education, and industry because of their pursuit of a technological career.

In isolation, many of the anecdotes are not remarkable; this serves to shroud the prejudice endemic in our society, but when they are considered collectively, a picture of societal prejudice and ignorance towards industry, trade, business, profit, wealth creation, and engineering emerges from almost every walk of life, including education. **It is this societal prejudice that undermines our technological creativity, productivity and capability, and threatens our standard of living as a society.**

There have been many attempts and initiatives aimed at changing our culture, and these will be discussed in greater depth in Chapter 9. Attempts to change our culture were also incorporated in the 1988 Education Reform Act. One particular strand known as Economic and Industrial Understanding (EIU) will be discussed next; it will demonstrate in yet another way not only what has been learnt in the absence of positive instruction about the role of industry and technology, but the enormity of the cultural problems to be overcome by our society.

08.05 Economic and industrial understanding

The Education Reform Act 1988 sought 'a balanced and broadly based curriculum which—

(a) promotes the spiritual, moral, cultural, mental and physical development of pupils at the school and of society; and
(b) prepares such pupils for the opportunities, responsibilities and experiences of adult life'—The Education Reform Act (1988:1).

These statements were used by the National Curriculum Council when they published 'Curriculum Guidance 4: Education for Economic and Industrial Understanding'; the introduction stated:

> Education for economic and industrial understanding is clearly required if schools are to provide a curriculum which promotes the aims defined in the Education Reform Act. It makes an important contribution to the personal and social development of pupils. It is a cross-curricular theme which can be taught through foundation subjects and other areas of the school curriculum.

This philosophy was also carried into various curriculum subject orders; for example the National Curriculum subject of 'Design and Technology for ages 5 to 16' stated:

> … to understand the significance of design and technology to the economy and to the quality of life—DES (1989a:1).

And the National Curriculum subject of 'Mathematics for ages 5 to 16' stated:

> New technology is a powerful tool which opens up new areas of mathematics and changes the way in which society makes use of mathematics in the factory, office and home—DES (1988:2).

New regulations for teachers were published, and required the demonstration of 'knowledge and competences' in '… cross-curricular themes eg economic awareness, …'—DES Appendix 2 (1989b:1).

Revised criteria were published for initial teacher training including the 'approval of courses', and required that the work of the teacher in training should include:

> … the significance of links between schools and the wider community; including those between schools, local businesses and the world of work—DES Annex A (1989c:7).

So the approach to enhancing economic awareness in the curriculum was holistic. Indeed, with the 1988 Education Reform Act, there was a concerted effort to recognise the need for economic and industrial understanding. The extracts from various curriculum documents shown in Appendix 6, demonstrate a significant concern, expressed in considerable breadth and depth. In total, these extracts exceed one thousand words, and Appendix 6 is worth reading as an act of understanding for the uninformed, and reflection, and recapitulation for those familiar with the subject of Technology. All these changes were symptomatic of a national movement to raise the profile of sustaining ourselves as a society, and it was reflected in many different ways as will be discussed in the next section.

08.05.01 Support for EIU

To help teachers with the requirement for EIU, the National Curriculum Council published a number of guidelines. One example was *Managing Economic and Industrial Understanding in Schools*, and an extract from the Foreword states:

> EIU is an essential part of every pupil's curriculum. It helps them understand the world in which they live. It prepares them for life and work as producers, consumers and citizens in a democracy which is part of a complex and rapidly changing world. It is needed in all stages of their education—Graham (1991:1).

Teacher training was similarly influenced as demonstrated by DES Circulars 24/89 and 18/89. The Teacher Training College at Anglia Polytechnic University, revised their courses to include sessions on EIU. The purpose here is to demonstrate the enormity of the cultural problems faced by teachers in their attempts to grapple with the bolt-on subject of EIU as part of their training.

Industry and commerce have been pro-active in the context of EIU in education for many years, and the range of organisations and initiatives will be considered in greater depth in Chapter 9 - Summary and discussion. Meanwhile one particular example will be considered pertaining to courses offered by the British Plastics Federation. These courses were known as Polymer Study Tours, and for the writer, they offered further opportunities to test for understanding of the role of industry in the absence of positive instruction.

In July 1989, there were two Polymer Study Tours, each lasting a week with 25 places for qualified teachers. One tour was based at Trowbridge College through Bath University, and the other was at Manchester Polytechnic. The schedule for both weeks included the subject 'Why we need Industry/Education Liaison', which began with a workshop session both as an 'ice-breaker' and to discover teachers' perceptions of industry.

For the workshop exercise, the teachers were split into sub-groups of four or five. The sub-groups were asked to reflect on their perceptions of industry, to reach consensus, and commit their 'collective view' to a flip-over chart. The exercise outcomes were reviewed in plenary sessions, and the perceptions from the two tours were summarised as follows:

<u>Negative</u> Dirt, pollution, environmental damage, toxic waste, waste, acid rain, dirty factories, down-trodden workers, strikes (but to a lesser extent now), competition (said with negative intonation), profits (said with negative intonation).
One sub-group drew pictures of factories on a landscape with tall chimneys belching smoke—Owers (1989:2).

<u>Positive</u> Wealth creation, makes useful artifacts—Owers (1989:2).

As shown here, the overwhelming reaction was negative, and negative perceptions dominated subsequent discussions. With regard to the sub-group who drew pictures of factories on a landscape with tall chimneys belching smoke, their reaction was later to become a commonplace experience. Positive reactions were voiced by very few on both tours, even though some teachers had previously worked in industry.

One teacher admitted to frequent use of the prospect of working in industry as a threat to encourage greater scholarly achievement by pupils—Owers (1989:4), see also anecdote 24, Appendix 5. However, to remain competitive, industry has to be driven by people with a range of personal qualities including scholarly achievement and knowledge that supports the skills pyramid appropriate to their industry, but which is led by technological visionaries. This is crucial for every socio-economic community.

Manufacturing industry has long been a core activity in the processes by which societies sustain themselves. The 'Stone Age cultures' were 'named after the localities where their industries' became 'well known, or were first recognised'—Oakley (1972:91-93). Archaeologists seek to disclose 'the past history of humanity', and the 'geosciences' consider the problems of 'discovering how … earth works' produced 'not only the mineral deposits … of gold', but also 'provided humans with the necessities of their daily life'—Morteani and Northover (1995:ix)—see *Prehistoric gold in Europe: mines, metallurgy and manufacture.* 'Mesolithic and neolithic flint tool-manufacturing' was discussed by Rogers (1990:227). So manufacturing and industry are not recent cultural phenomena.

<u>08.05.02 Experience with EIU in teacher training</u>

Recalling the experiences from the Polymer Study Tours, a similar workshop exercise was used as an introductory topic for economic and industrial understanding with student teachers in training during 1994-96. The student teachers were either on a two-year Licensed Teacher Training programme, or a Four-year BEd degree course. With the exception of two sub-groups in 1996, the initial reactions were negative. Eight examples of negative reactions appear in Figures 8.03 to 8.10 starting on the next page, continuing to page 159. Discussion resumes on page 160.

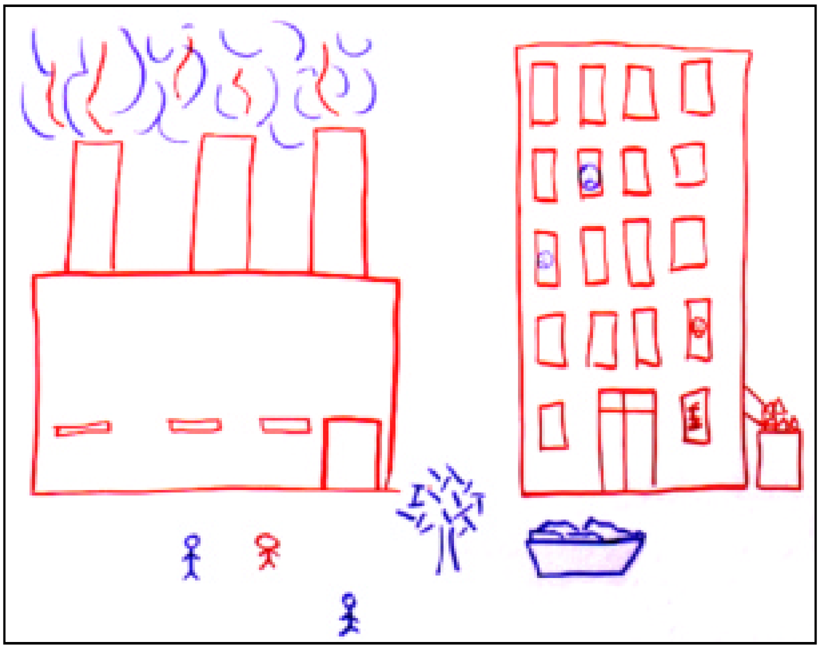


Fig. 8.03 - Collective view of industry by a student teacher sub-group

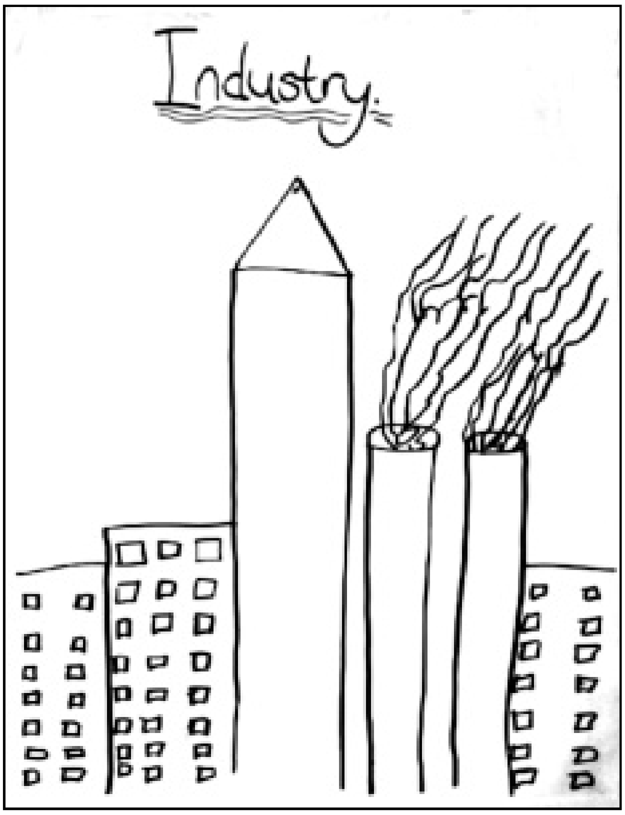


Fig. 8.04 - Collective view of industry by a student teacher sub-group

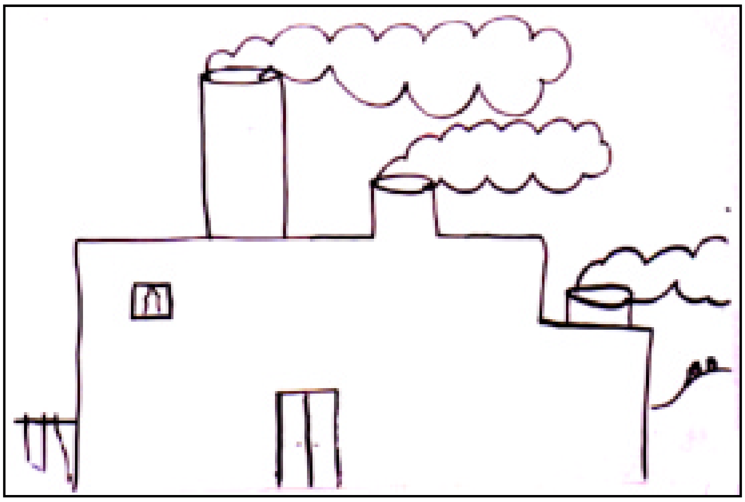


Fig. 8.05 - Collective view of industry by a student teacher sub-group

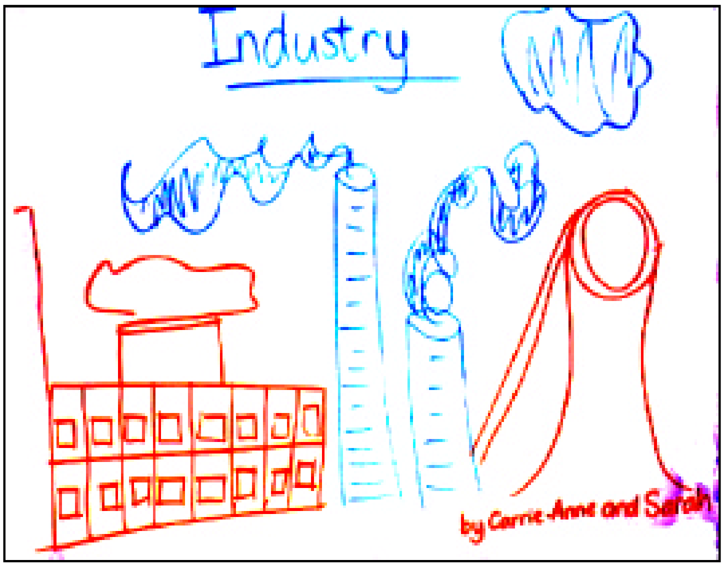


Fig. 8.06 - Collective view of industry by a student teacher sub-group

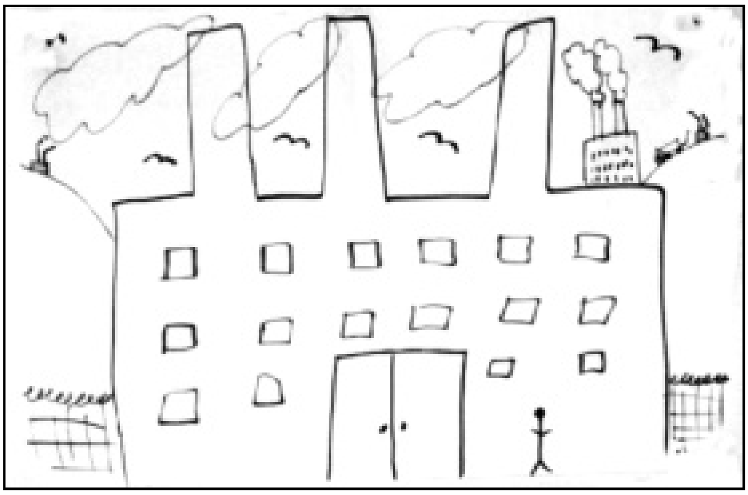


Fig. 8.07 - Collective view of industry by a student teacher sub-group

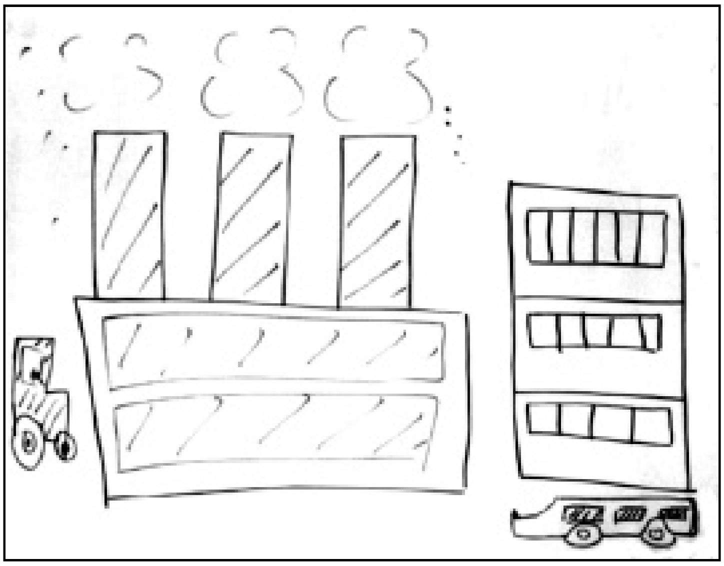


Fig. 8.08 - Collective view of industry by a student teacher sub-group

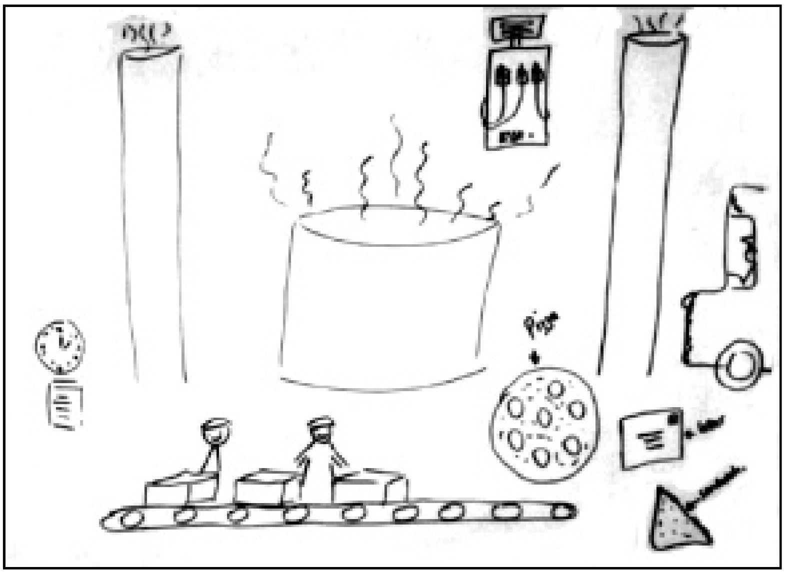


Fig. 8.09 - Collective view of industry by a student teacher sub-group

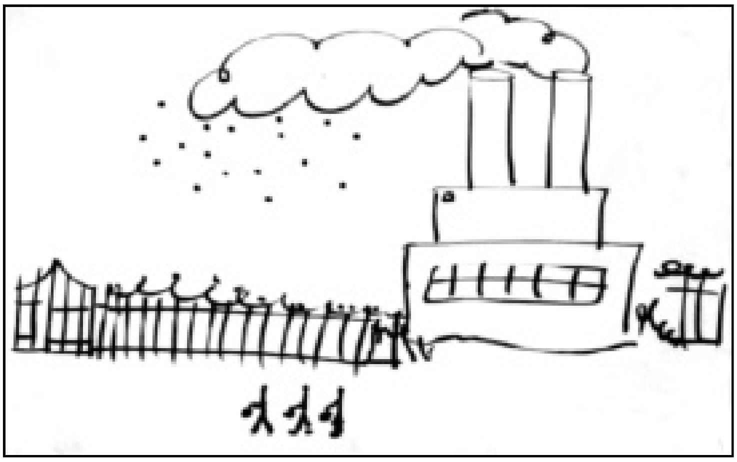


Fig. 8.10 - Collective view of industry by a student teacher sub-group

What is clearly common to all the images in Figures 8.03 to 8.10 are the chimneys discharging smoke, although with the decline of manufacturing industry, as well as technological changes, there are far fewer chimney stacks on any horizon in the UK.

When teachers and student teachers have had the opportunity to explore beyond their first negative reactions, the scenario changes. But the predominantly negative reactions are traditional, and part of the culture that has been handed down and absorbed by the critical mass in our society, and hence most difficult to change.

Traditional views such as those expressed in Figures 8.03 to 8.10 may come as a surprise to the majority, but the positive benefits of industry have never been taught as part of the curriculum or teacher training. Indeed as shown in the previous chapter, disparagement of industry by statutory sanction has filled the void in the absence of positive instruction about the role of industry or technology in society, a role in which:

- The products and services of industry are the life-blood of society.
- If at a stroke the benefits of technology could be removed, not only would this paper disappear, but we would be sitting without shelter, without heating, without either an organised system of food provision or medical care, unclothed on the mud, looking for cover to hide our embarrassment—Owers (1993b:7).
- Manufacturing industry is part of the economic activity that contributes to the Gross Domestic Product (GDP) from which all the services we expect and demand from the state are funded.
- Society demands consumer products of every kind from cars to computers, from cotton reels to clothes, from kitchen knives to refrigerators, to micro-wave ovens and washing machines. And when the price and/or quality is not right, imports flourish causing a loss of indigenous wealth creation, as well as the associated creative technological disciplines and skills.
- Society demands services such as water-on-tap, drainage and sewage disposal, energy supplies such as gas, electricity, fuel oil, petrol, coal, transportation systems, and cheap communication systems—the list is endless.

The exception of the two student-teacher sub-groups in 1996, as mentioned on page 156, arose because a lecturer on a Licensed Teacher Training course had reported sick. With only half an hour's notice, the lecturer for EIU was asked to accommodate some eight second year student teachers; normally there was no EIU session in the second year. Thus an opportunity was presented to determine whether the EIU session of the previous year had made any headway against traditional prejudice.

The cohort of first- and second-year students were asked to form sub-groups of four or five, and they chose to remain with their year-group colleagues. The perceptions of the first-year students were included with Figures 8.03 to 8.10. Figures 8.11 and Fig. 8.12 below show the perceptions of the second-year students after completing the introductory EIU exercise a second time.

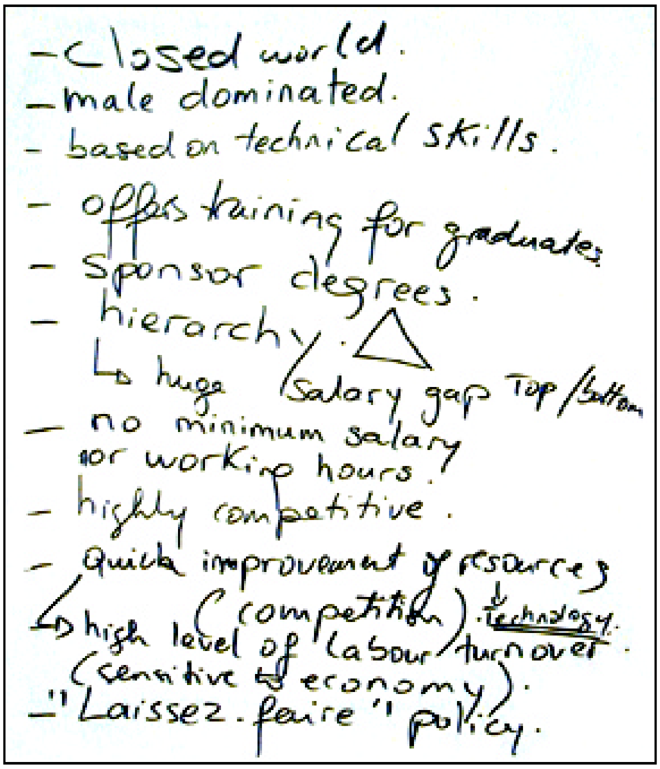


Fig. 8.11 - Collective view of industry by a student teacher sub-group

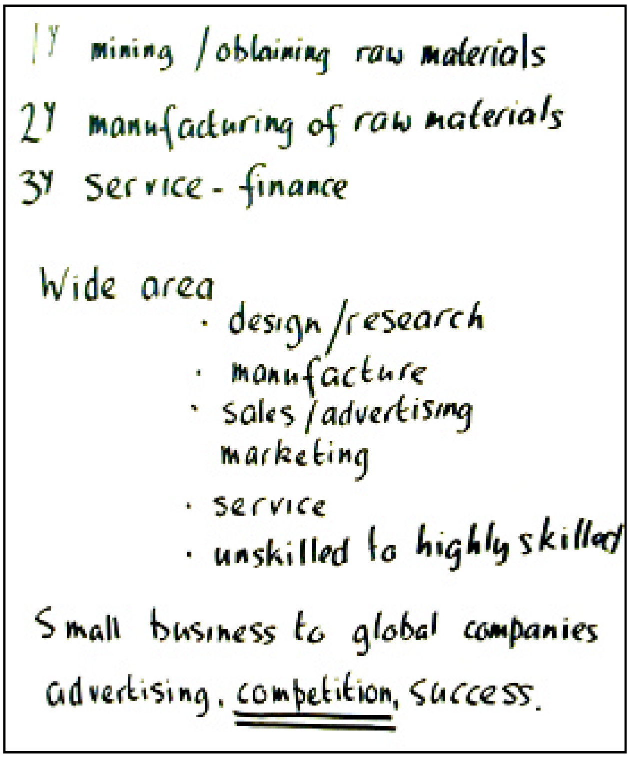


Fig. 8.12 - Collective view of industry by a student teacher sub-group

Both Figures 8.11 and 8.12 show more thought than the usual images of pollution. The commentary in Fig. 8.11 is more negative than positive. Fig. 8.12 shows another sub-set of responses that are essentially factual. However, 'competition' appeared as a problematic concept in both Figures 8.11 and 8.12, and was encountered during the Polymer Study Tours. Such concerns are in sharp contrast with those of the government which has become increasingly concerned to encourage the competitiveness of British industry—Beckett (1997:3), Byers (1999:3).

08.05.03 Further EIU exercises in teacher training

In 1996, student teachers on a Four Year BEd course had a choice of minor study options which included 'The Contribution of Industry to the School Curriculum.' Hence further opportunities were presented to analyse traditional cultural responses to industry in the classroom. Seventeen students were enrolled on this minor option course.

For the purposes of an exercise, a particular experience of one of the EIU lecturers was recounted to the class. The experience related to the testing of a data-gathering instrument with a group of second-year licensed student teachers in 1993.

After completing the test, one licensed student teacher referred to an issue that was a source of considerable personal concern. A teacher (the Mentor to the licensed student teacher) took a class of primary school children on an outside trip. As the whole group were passing a factory in which prototype cars costing more than £100 000 were made, the teacher paused, gathered the pupils around and said: 'Now if you don't do well at school that is where you will finish up.'

The licensed student teacher was horrified by this remark, but chose to say nothing because of concern to qualify as a teacher. It was this experience that was troubling the licensed student teacher; in particular that the children could be learning to disparage the occupations of their parents, and hence the parents. The EIU lecturer told the licensed student teacher that what had been witnessed was a commonplace event, and was symptomatic of the anti-industry culture that prevails in our society.

This was the experience that was used as the basis for an EIU related exercise in the classroom with students on the Four Year BEd course, and at a point about 25% into their Minor Option course. On this occasion, the seventeen students were asked to split into sub-groups of four or five, and without being told about the traditional anti-industry culture, the students were asked to reflect on 'what was concerning the student licensed teacher', and to commit their consensed responses to a flip-over chart. The outcomes are shown in Figures 8.13 to 8.16 below.

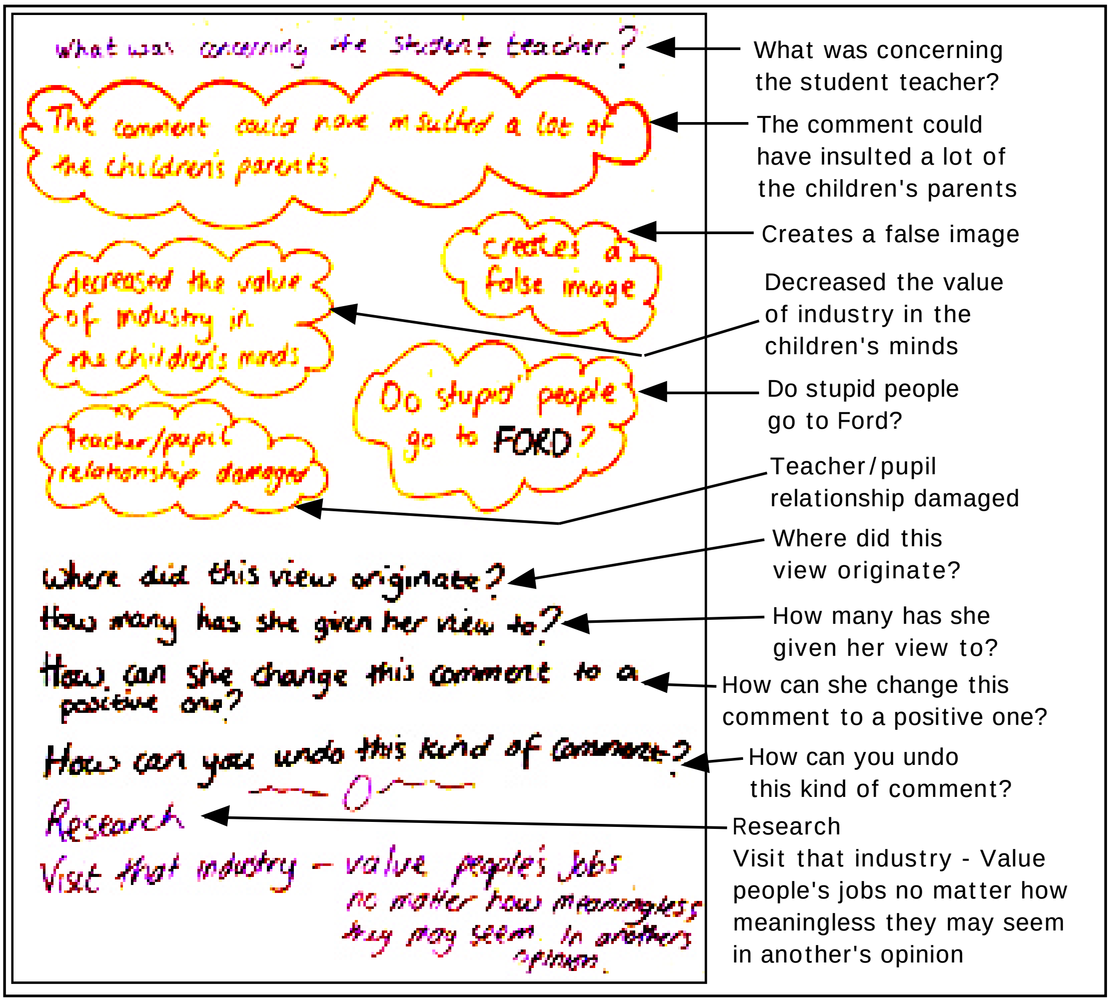


Fig. 8.13 - What was concerning a student licensed teacher – consensed views of student teacher sub-group

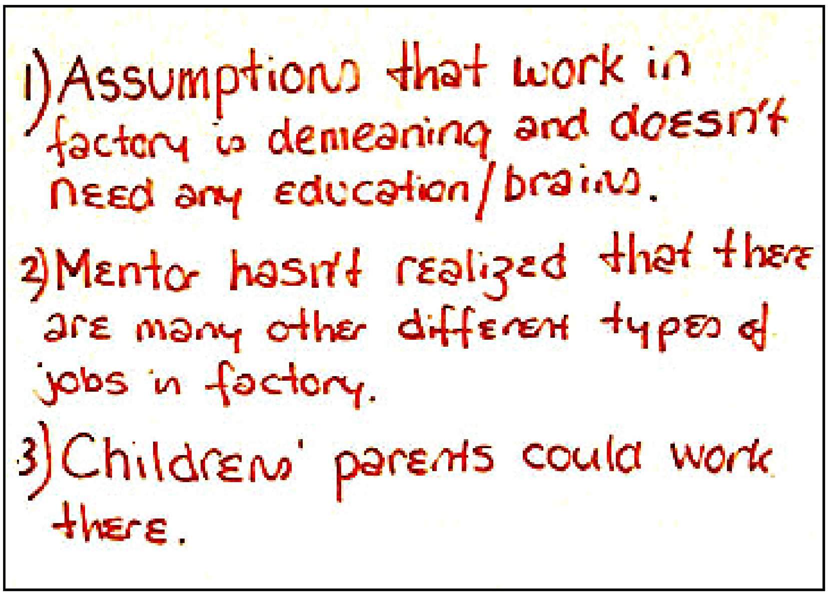
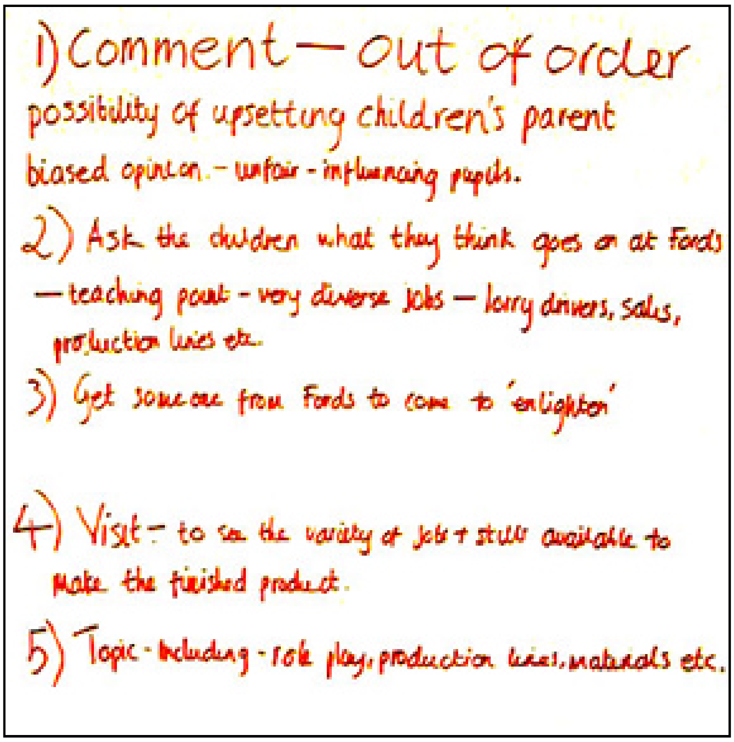


Fig. 8.14 - What was concerning a student licensed teacher – consensed views of student teacher sub-group



1) Comment — out of order
possibility of upsetting children's parent
biased opinion - unfair - influencing pupils.

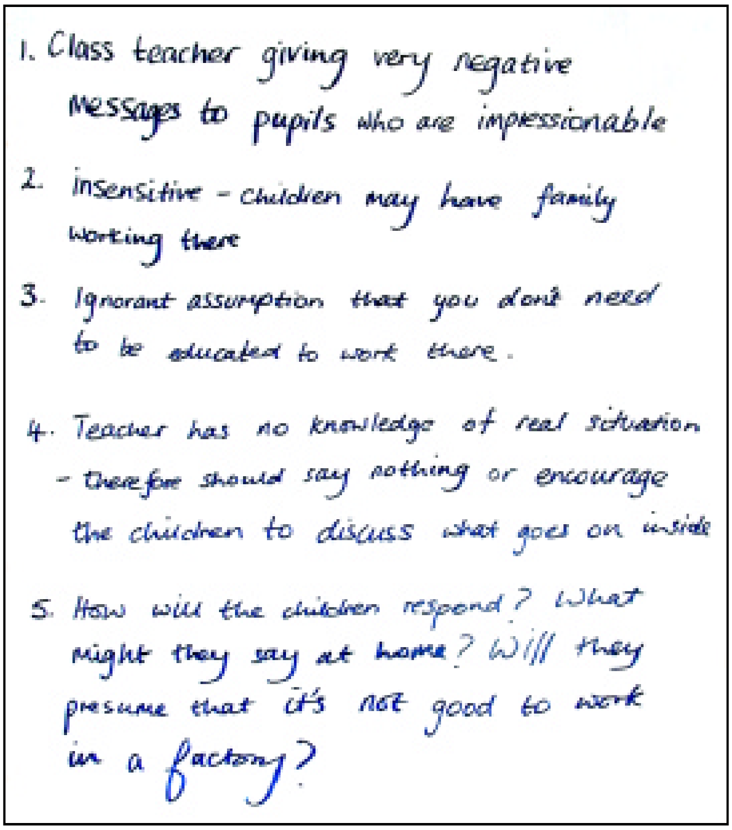
2) Ask the children what they think goes on at Fords
— teaching point - very diverse jobs - lorry drivers, sales, production lines etc.

3) Get someone from Fords to come to 'enlighten'

4) Visit — to see the variety of jobs and skills available to make the finished product.

5) Topic – including - role play, production lines, materials etc.

Fig. 8.15 - What was concerning a student licensed teacher – consensed views of student teacher sub-group



1. Class teacher giving very negative message to pupils who are impressionable

2. insensitive – children may have family working there

3. Ignorant assumption that you don't need to be educated to work there.

4. Teacher has no knowledge of real situation
– therefore should say nothing or encourage the children to discuss what goes on inside

5. How will the children respond? What might they say at home? Will they presume that it's not good to work in a factory?

Fig. 8.16 - What was concerning a student licensed teacher – consensed views of student teacher sub-group

By inspection of Figures 8.13 to 8.16, it may be inferred that the student teachers were seriously concerned about:

- the extreme lack of sensitivity on the part of the Mentor,
- the Mentor's considerable ignorance of industry,
- the cultural damage inflicted by the Mentor,
- and how that damage could be rectified.

In reality, these are just some of the problems that confront and threaten the economic fabric of our society.

In the next section 08.06, the perception of technology will be analysed statistically from a data base containing feed-back from more than 3,100 A-level students.

08.06 Results from 6th Form survey

The main body of the statistical results appears in Appendix 7, and provide the basis for the summaries drawn here with a wider perspective. These summaries reflect the necessity for economic and industrial understanding as elements crucial in the process of underpinning our productivity and capability through our use of tools and technologies as tools, in order to sustain our quality of life as a society.

Note on presentaion of statistical data: In terms of 'elementary' statistical theory, 'the median and the mode have considerable claims to use as measures of location', since they are easily interpreted—Kendall (1963:40). 'The median is the middle value and the mode is the most popular value', but the median is 'less dependent on the form of the frequency-distribution than the mean—Kendall (*ibid*). The author has adopted the 'median' as the measure of central tendency, an approach confirmed by two professional statisticians as appropriate for the nature of the data collected.

08.06.01 Summary of statistical inferences

Design & Technology

Although technology is the generic creative system of humankind that has brought us from the Stone Age to the way we live now, and we are surrounded by the benefits and artefacts of technology, we have to be taught to appreciate and understand technology. In reality, the A-level students who kindly completed the questionnaires were on a learning curve continuum; these results indicate the state of their understanding at the time.

Interest in D&T was shown to be gender-specific, with a median of 4 for girls and 7 for boys—Fig. A7.01 in Appendix 7. When analysed on the basis of pupils taking D&T, and compared with pupils not taking the subject, the medians were 8 and 2 respectively—see Fig. A7.02. Given that without exception we are all consumers and users of technology, these trends are a cause for concern.

The difficulty with D&T was seen to be only moderate with a median of 5 for both girls and boys—Fig. A7.03. A similar result was obtained when analysed on the basis of pupils taking D&T, and compared with pupils not taking the subject; the medians were 5—see Fig. A7.04. This is an interesting result as will be later demonstrated by the analysis for Maths and Science.

The importance of D&T when seeking a job yielded median values of 4 and 5 for girls and boys respectively—Fig. A7.05. However, when the analysis was based on pupils taking D&T, and compared with pupils not taking the subject, the median values were 6 and 3 respectively—Fig. A7.06. Since without exception we all use tools and technology, and technology is at the functional core of the way we live in every dimension, and of every type of industrial and business activity, these results are a serious cause for concern.

The importance of D&T in the context of Economic and Industrial Understanding yielded slightly better results with medians of 6 and 7 for girls and boys respectively—Fig. A7.07. When analysed on the basis of pupils taking D&T, and compared with students not taking D&T, the medians were 7 and 5 respectively—Fig. A7.08. These were disappointing results.

The influence of D&T on the way we live now was rated at a median value of 7 by both genders—Fig. A7.09. Analysis of pupils taking D&T, in comparison with pupils not taking the subject, gave median values of 8 and 6 respectively—Fig. A7.10. While these results indicate a fair level of understanding, there was room for improvement.

In response to the question 'How creative does the curriculum allow you to be in D&T', girls and boys scored median values of 7—Fig. A7.11. Comparison between pupils taking and those not taking D&T produced median values of 8 and 7 respectively—Fig. A7.12.

'As a modern society, how dependent do you think we are on D&T', the genders scored the same median value of 7—Fig. A7.13. For pupils taking D&T the median was 7, while for those not taking D&T the median was 6—Fig. A7.14. Although all the median values were above the halfway mark of 5, a better level of understanding would have produced higher values.

As yet, this summary is incomplete since technology is totally cross-curricular. Further inferences will be drawn when similar analyses have been completed for English, Maths, Science, and Art; the weight of inference will gradually increase as stated in Appendix 7.

<u>English in education and industry as perceived by A-level students</u>

The interest in English was gender specific with a median of 5 for girls and 3 for boys—Fig. A7.15. From Fig. A7.16, the analysis of interest in English on the basis of students taking the subject by comparison with pupils not taking the subject produced medians of 8 and 3 respectively.

When Figures A7.01 and A7.02 are compared with Figures A7.15 and A7.16, it may be inferred that boys were more interested in D&T, but they were the least interested in writing on the subject. And girls who were the least interested in D&T would be more interested in writing on the subject.

The difficulties with English were exhibited in Figures A7.17 and A7.18; all comparisons gave median values of 5. Similar results were obtained in the comparable analyses for D&T; all the medians were 5—Figures A7.03 and A7.04. What was clearly not seen was that the products of the imagination such as new concepts, new ideas, new methods, new techniques, and new materials comprise the foundation of technology, and in a multi-skilled society, all these depend on communication to become effective. So language is all-important in technology, and pivotal in the foundation of knowledge building on knowledge; this holds true for any society, whether hunter/gatherer or industrialised.

However, the value of English when seeking a job was well understood by girls and boys with medians of 8 and 7 respectively—Fig. A7.19. Similarly, the analysis for pupils studying English by comparison with those not taking the subject also provided medians of 8 and 7 respectively—Fig. A7.20. So the importance of communication when seeking a job was clearly understood, even by pupils who rated their interest in English at a median of 3—Fig. A7.16. This raises questions about the way English is taught.

For the importance of English in the context of EIU, the results were disappointing; the girls attributed a median level of 6, and for boys it was 5—Fig. A7.21. The analysis between pupils studying English, and not taking the subject gave common medians of 6—Fig. A7.22. Hence the pivotal role of English as the language through which ideas and concepts are conveyed to do with sustaining ourselves as a society was not fully comprehended, although the importance when seeking a job was evident. Once again, this raises questions about the way English is taught.

With regard to the influence of English on the way we live now, girls scored a median value of 7 and boys 6—Fig. A7.23. Similar ratings were obtained for pupils studying English by comparison with those not taking the subject; the median values were 7 and 6 respectively —Fig. A7.24.

The response to the question 'How creative does the curriculum allow you to be in English', was rated at a median value of 7 by girls, and 6 by boys—Fig. A7.25. The perceived creativity for students studying English, by comparison with pupils who were not, yielded similar medians at 7 and 6 respectively—Fig. A7.26.

As a modern society, the extent to which we are dependent on English was rated 7 by girls and 6 by boys—Fig. A7.27. When the dependence parameter was analysed on the basis of pupils studying English, and compared with students not taking the subject, the median ratings were 7 and 6 respectively—Fig. A7.28.

In overall summary for English, and with respect to the parameters of analysis, the girls in this group were:

- more 'interested',
- found it more 'important when seeking a job',
- found it more 'important in the context of EIU',
- found it more 'influential on the way we live now',
- perceived greater creativity within the curriculum was possible with English, and
- as a modern society, rated more highly our dependency on English.

The inference is that boys take insufficient interest in the need for communication. In any society, the mother-tongue is the primary vehicle used to convey ideas and concepts, to build knowledge upon knowledge, and much more in every field of human experience, endeavour and enterprise; so this result is a cause for serious concern. This raises questions about the curriculum and the way English is taught.

<u>Maths in education and industry as perceived by A-level students</u>

The analysis of Maths in education and industry was similar to D&T and English; the graphs in Appendix 7, provide the basis for the analytical inferences drawn here.

Analysis by gender shows that boys were more interested in Maths than girls, and by a margin of two median ratings namely 5 and 3 respectively—Fig. A7.29. The alternative analysis, comparing students taking Maths with pupils not studying the subject, produced median values of 7 and 2 respectively—Fig. A7.30.

Maths was perceived to be a difficult subject; analysis by gender yielded common medians of 7; some 29.6% of girls rated the level of difficulty at a scale maximum of 9—Fig. A7.31. In the context of difficulty, common median values of 7 were also obtained when comparing students studying the subject with pupils who did not take Maths—Fig. A7.32.

Although the level of interest in Maths was not highly rated, and it was perceived to be a difficult subject, the importance of Maths when it comes to getting a job was clearly understood. The median values were common at 8 whether analysed by gender, or by comparing pupils who were studying Maths with students who were not—Figures A7.33 and A7.34 respectively.

Maths was also relatively highly rated in the context of EIU. Median ratings were common at 7 in the analysis by gender, and by subject studied. Although the importance of Maths in the context of getting a job was highly rated with common median values of 8, the application of mathematical skills in EIU was perceived a little less important with medians at 7—Figures A7.35 and A7.36.

The question concerning the influence of Maths on the way we live now produced common median values of 6 for the analysis by gender, and by subject studied—Figures A7.37 and A7.38. Although above the middle ranking of 5, this result does not adequately represent the influence of Maths on the way we live now. For example, consider the understanding of maths required as part of the resolution of the problem of longitude, as discussed in this thesis on pages 71-72.

In response to the question 'How creative does the curriculum allow you to be in Maths?', girls and boys produced common median values of 3. For pupils studying Maths the median was 3, and for students not taking the subject the median was 2—Figures A7.39 and A7.40. Creativity in Maths is often at the leading edge of discovery in Technology and Science, and the absence of such awareness is a serious cause for concern, and have raised questions about the way Maths is taught.

Testing for our dependency on Maths as a society, this question produced common median values of 7 in the analysis by gender, and in the analysis by subject studied—Figures A7.41 and A7.42. So the importance of Maths in our society was fairly well understood.

Science in education and industry as perceived by A-level students

Science, but not social science, in education and industry was analysed on a basis similar to that used for D&T, English and Maths; the detailed graphs appear in Appendix 7.

The interest in Science shown by boys equated to a median of 5, and for girls it was 3—Fig. A7.43. However, the separation of the medians was far greater when the comparison was made on the basis of students taking Science with pupils not taking the subject; the median values were 8 and 3 respectively—Fig. A7.44. This is a serious cause for concern since Science is a key component of Technology, and without exception we are all beneficiaries and users of Technology in every field of human experience.

Science was perceived to be a difficult subject by girls and boys; both groups recorded median values of 7—Fig. A7.45. The comparison between groups taking Science with those not taking the subject, also produced common median values of 7—Fig. A7.46.

In the context of getting a job, boys attributed a greater degree of importance to Science than did girls; the median values were 7 and 6 respectively—Fig. A7.47. Pupils studying Science, attributed more importance to the subject than students not taking the subject; again, the median values were 7 and 6 respectively—Fig. A7.48. In these two graphs, all the median values were above the mid-point of 5, so even those students showing a low level of interest in Science had some understanding of its value in the context of getting a job.

Understanding the role of Science in the context of EIU was fair; comparison by gender, or by subject studied, yielded median values of 7—Figures A7.49 and A7.50. These results mirror those of Maths where median values of 7 were also obtained for the two methods of analysis—Figures A7.35 and A7.36. However, there is cause for concern. Maths and Science are components of Technology; the comparable analyses for D&T produced medians of 6 and 7 for girls and boys respectively, and 7 and 5 for pupils taking and not taking D&T—Figures A7.07 and A7.08. So the same level of awareness does not yet exist in D&T. In reality, all the median values should have been at least 8.

The influence of Science on the way we live now was well understood. The analysis by gender, and the analysis comparing students taking the subject with pupils not studying Science, all produced high median values of 8—Figures A7.51 and A7.52.

However, although the influence of Science on the way we live now was well understood, the level of creativity perceived in the curriculum equated to medians of 4 by both methods of analysis—Figures A7.53 and A7.54. Whereas for Science all these results were less than the median mid-point of 5, the comparable questions for D&T gave higher results. Both girls and boys rated the creativity at a median value of 7, while pupils studying D&T gave a median rating of 8, and students not taking the subject recorded 6. As yet the role of Science in D&T is not understood.

As a modern society, our dependence on Science was apparent. The analysis by gender recorded common medians of 8, and the analysis comparing pupils taking Science with students not studying the subject, also produced common median values of 8—Figures A7.55 and A7.56. From this result, it may be inferred that Science is seen as a subject set apart from Technology. However, in reality, the products of Science are normally delivered through Technology, eg drugs for medicinal use in tablet or liquid form, and there are an infinite number of other examples.

<u>Art in education and industry as perceived by A-level students</u>

The parameters of analysis for Art were:

- In the context of EIU, how important do you consider the subject of Art?
- In our society, how much do you think the way we live now has been influenced by Art?
- In your opinion, how creative does the curriculum allow you to be in Art?
- As a modern society, how dependent do you think we are on Art?

Only four parameters of analysis were used to avoid a four-page questionnaire, perceived as a deterrent for teachers contemplating participation in this research. Although the analysis of Art was restricted to four parameters instead of seven as used for D&T, English, Maths and Science, there were a number of significant results.

Art has a low rating for importance in the context of Economic and Industrial Understanding (EIU); analysis by gender produced common medians of 3 for girls and boys—Fig. A7.57. The alternative analysis produced a median of 4 for pupils taking Art, and 3 for students not taking Art—Fig. A7.58.

These poor results are curious since young people exercise 'appearance choice' every day, in their buying habits and other activities. What is a serious cause for concern is the absence of any link with EIU, and yet industry devotes significant skill and financial resources to the determination of product 'appearance' and 'style' for both home and export markets.

Product appearance and style are crucial elements within any product development process. The first requirement in good design is to make a product that is visually pleasing so as to build 'showroom-traffic' (motor industry jargon for encouraging potential buyers into the showrooms), and young people show a great deal of interest in cars.

Responses to the question 'How much do you think the way we live now has been influenced by Art?' yielded a median value of 5 for girls and boys—Fig. A7.59. Analysis by subject studied, showed that students taking Art rated the subject influence more highly at a median value of 7, and pupils not taking Art rated the influence at a median level of 5— Fig. A7.60. These responses are inconsistent with the answers for EIU.

The question 'How creative does the curriculum allow you to be in Art?' produced results that were unusually high in this research. The analysis by gender gave common median values of 8—Fig. A7.61. Students taking Art scored a median maximum of 9, and pupils not taking Art recorded a median of 8—Fig. A7.62. From Fig. 8.17 below, it may be seen that 53.7% of the students taking Art rated the level of creativity on the scale maximum of 9, thus satisfying the definition of 'median'; but these exceptional ratings were backed up with a median of 8 for students not taking Art.

Rating scale	1	2	3	4	5	6	7	8	9	*	Totals
Not taking Art	57	32	85	64	189	154	439	409	1095	3	2527
Not taking Art %	2.26	1.27	3.36	2.53	7.48	6.09	17.4	16.2	43.3	0.12	100
Taking Art	10	3	11	13	23	26	84	91	304	1	566
Taking Art %	1.77	0.53	1.94	2.3	4.06	4.59	14.8	16.1	53.7	0.18	100
Total numbers	67	35	96	77	212	180	523	500	1399	4	3093
Total as %	2.17	1.13	3.1	2.49	6.85	5.82	16.9	16.2	45.2	0.13	100

Fig. 8.17 - Comparison between pupils taking and not taking Art in response to the question: 'How creative does the curriculum allow you to be in Art?'

A comparison of the median responses on creativity by subject appears in Fig. 8.18, and was reproduced from Fig. A7.66, Appendix 7.

	Medians by gender - Girls/Boys	Medians by subject - Taking/Not taking
Art	8/8	9/8
D&T	7/7	8/6
English	7/6	7/6
Maths	3/3	3/3
Science	4/4	4/4

Fig. 8.18 - Comparison of median values in response to the question: 'How creative does the curriculum allow you to be in the following subjects?' by the two methods of statistical analysis used in this research

Fig. 8.18 presents an alarming picture, and provides evidence of the most damning kind that the original creativity in Technology, and subsequently in Science and Maths as components of Technology, which has brought humankind from the Stone Age to the way we live now is not perceived nor understood. With this stark inference, how can the good intent that was behind the Education Reform Act of 1988, as summarised in Appendix 6, ever be realised?

Although creativity in Art within the curriculum was so highly rated, our dependency on Art was not; in the gender analysis girls scored a median value of 4 and boys 3—Fig. A7.64. The alternative analysis, comparing students taking Art with pupils not taking the subject, produced medians of 5 and 3 respectively—Fig. A7.65. Here is confirmation of the absence of any link with EIU.

This collection of results, implies that creativity is perceived more in products than in processes. But it was innovative, imaginatively conceived, and visualised products in conjunction with innovative, imaginatively conceived, and visualised processes that yielded the tools and/or technologies by which humankind progressed from the Stone Age.

Similarly, it is innovative, imaginatively conceived products and processes that sustains the dynamic in any competitive world-class performance by UK companies, particularly technological companies, and which the government seeks to promote. A more modern definition of the imaginative core that resides jointly within the product design-development process, and the product development manufacturing process is known as 'simultaneous engineering'—see page 80.

<u>Summarising the educational provision for cross-curricular themes</u>

The Fig. 8.19 below provides a tabular summary of cross-curricular educational provision as perceived by this A-level student population.

Themes	A	A	B	B	C	C	D	D	E	E
Gender	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Yes %	90.9	85.7	10.9	11.7	22.6	27.6	29.8	27.5	73.1	59.9
Not sure %	5.7	8.7	37.0	36.3	36.7	34.0	35.1	33.2	17.8	22.7
No %	3.5	5.5	52.0	52.0	40.7	38.3	35.1	39.1	9.1	17.3
Total	100	100	100	100	100	100	100	100	100	100

Fig. 8.19 - Summary of cross-curricular educational provision

The cross-curricular legend for Fig. 8.19 was as follows:

- 'A' - Careers Education & Guidance,
- 'B' - Education for Citizenship,
- 'C' - Education for Economic & Industrial Understanding,
- 'D' - Environmental Education,
- 'E' - Health Education.

The main points were:

- More than 90% of girls and 85% of boys had teachers for Careers Education & Guidance—see Fig. A7.67.
- Some 11% of the pupils had teachers for Education for Citizenship; about 36% were not sure, and 52% did not—see Fig. A7.68.
- 22% of girls and 27% of boys had teachers for EIU; the rest were either 'not sure', or were certain that they 'did not'—see Fig. A7.69.
- 30% of girls and 27.5% of boys had teachers for Environmental Education; more than 30% were 'not sure', while more than 35% were certain that they 'did not'—Fig. A7.70.
- Some 73% of girls and 60% of boys had teachers for Health Education; the rest were either 'not sure', or knew that they 'did not'—see Fig. A7.71.

A number of aspects of these results present causes for concern. While there was huge support for Careers Education & Guidance, as citizens we are without exception part of the economic fabric of society. However, in employment, do we become consumers or creators of wealth? In such a context, the results for EIU presents cause for serious concern.

As first implemented, the 1988 National Curriculum was overloaded. This was confirmed by the Secretary of State for Education when he ordered an enquiry 'to look into the scope for slimming'—Dearing (1993:1). The statistics in Fig. 8.19, present a picture of the provision, after the introduction of the revised National Curriculum. But what do A-level students think about these cross-curricular themes? Do they think the cross-curricular themes should be part of the National Curriculum? The data gathering instrument offered students the opportunity to respond to these questions; their answers are presented in the next sub-section.

Summarising whether Cross-curricular themes should be in the National Curriculum

Cross-curricular legend for Fig. 8.20 is as follows:

- 'A' - Careers Education & Guidance,
- 'B' - Education for Citizenship,
- 'C' - Education for Economic & Industrial Understanding,
- 'D' - Environmental Education,
- 'E' - Health Education.

Figures A7.73 to A7.77 in Appendix 7, are summarised in Fig. 8.20 below, and offers more direct comparison.

Themes	A	A	B	B	C	C	D	D	E	E
Gender	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Yes %	89.5	84.7	29.0	28.1	49.8	54.4	73.0	59.5	92.8	81.8
Not sure %	6.2	8.5	50.2	41.0	37.1	31.5	20.2	25.8	5.8	11.8
No %	4.3	6.8	20.8	30.8	13.1	14.1	6.8	14.6	1.5	6.3
Totals %	100	100	100	100	100	100	100	100	100	100

Fig. 8.20 - Summary of responses by A-level students to the question: Do you think the Cross-curricular themes should have a place in the National Curriculum?

By reference to Fig. 8.20, and the theme legend A to E shown above, more than 89% of girls and 84% of boys thought that Careers Education & Guidance should be in the National Curriculum. There was less enthusiasm for Education for Citizenship, girls recording 29% and boys 28.1%. In the context of Education for Economic & Industrial Understanding, 49.8% of girls and 54.4% of boys considered it should be in the National Curriculum. With regard to Environmental Education, 73% of girls, and 59.5% of boys thought it should be in the National Curriculum. For Health Education, 92.8% of girls and 81.8% of boys considered it should be part of the National Curriculum.

With the exception of Education for Citizenship, the cross-curricular themes were favoured by this cohort of A-level students.

Summarising for perceived dependence on economic activity

The data gathering instrument offered the opportunity to ascertain perceived dependence on Commerce, Finance and Industry—the results appear in Appendix 7. Given that only 22% of girls and 27% of boys claimed to have had teachers for EIU, the results in Figures A7.79 (Commerce), A7.80 (Finance), and A7.81 (Industry) with medians of 7, 8, and 8 respectively, were quite remarkable. However, 49.8% of girls and 54.4% of boys thought that EIU should have a place in the National Curriculum, so one-in-two students exhibited some economic and industrial understanding.

08.07 Analysis of transcriptions

The detailed analysis and method appears in Appendix 8, and provides the basis for the inferences drawn here.

Since as discussed in earlier chapters, technology plays such a pivotal role in the function of every society that few recognise, the purpose in this section will be to comment on what various groups of people understood by both the word technology and the pivotal place it holds in our society; the groups included:

- D&T teachers
- Humanities teachers
- Parents in technology jobs
- Parents in non-technology jobs
- Technology student teachers
- Humanities student teachers
- Technology A-level students
- Humanities A-level students

The opinions and views of these groups were expressed during individual recorded interviews in response to a one-page schedule—see page 14. An explanation for the make-up of these groups appears on page 16, and in Appendix 8.

There were eight data gathering questions to do with technology on the schedule, as shown on page 14. A summary of the words spoken in response to each of the data gathering questions appears in Fig. 8.21 below.

Word counts for Q2 to Q9 Question No.	T D&T teach-ers	H Human -ities teach-ers	T Par-ents in tech jobs	H Par-ents in non tech jobs	T Tech-nology student teach-ers	H Human -ities student teach-ers	T Tech-nology A-level stud-ents	H Human -ities A-level stud-ents	Word count totals
2	389	243	356	183	272	181	149	165	1938
3	542	356	265	182	264	370	452	270	2701
4	883	444	407	91	386	223	203	218	2855
5	651	1324	433	107	435	260	280	265	3755
6	488	528	264	224	242	186	205	250	2387
7	655	290	238	223	593	251	305	316	2871
8	501	363	497	208	425	270	298	393	2955
9	989	401	173	234	313	113	254	256	2733
Sub-totals	5098	3949	2633	1452	2930	1854	2146	2133	22195
No. of people	8	7	7	8	8	8	8	8	62

Fig. 8.21 - Summary of words transcribed in response to questions on technology (From Fig. A8.01)

From Fig. 8.21 above, it may be seen that the 62 transcriptions produced more than 22 000 words in response to the eight data-gathering questions. There was great variation in the total transcribed word count for each group, ranging from 1452 words by the parents in non-technical jobs, to 5098 words for the Design & Technology teachers; all the transcriptions appear in Appendix 9.

For the analysis, a combination of 'key-word-in-context' (KWIC), and 'themes' were used, as explained in Appendix 8.

Question 2: Can you describe briefly what is meant by Technology?

Although by no means exhaustive, there was a total of 214 key-words for question 2; the key-word total was inflated by consideration for word derivatives—see Appendix 10. Summarising the main findings:

- Across all eight groups, KWIC were used on 448 occasions, including many repetitions; the word 'capability' was not used—see Fig. A8.03,
- All eight groups used key-words to explain their understanding,
- D&T teachers used 87 KWIC—the highest number among the eight groups,
- Technology A-level students used KWIC on 33 occasions—the lowest number,
- Two parents in technological jobs expressed some uncertainty about the meaning of technology,
- All groups used derivatives of 'technology', and 61 KWIC was the highest number—see Appendix 10,
- The second highest number was in 'computer' related words—30 KWIC—Appendix 10,
- Across all groups some 40 KWIC were used describing 'creative' activity—Fig. A8.04,
- In the 'creative word' sub-set, 'imagine', 'intellectual', and 'invent' were not used—Fig. A8.04,
- Understanding was expressed in many different ways, including:
    - ◊ words denoting change such as 'advances/improvements/progress'—34 KWIC—see Fig. A8.06,
    - ◊ the universal nature of technology 'anything/everything'—29 KWIC—see Fig. A8.07,
- The link between technology and the national economy was poor; across all groups there were only 11 KWIC; of these, parents in technological jobs used 6 KWIC—Fig. A8.08,
- The reality of technology was clearly evident. Across all groups there were 85 KWIC; 'computer' was used on 30 occasions, but not by D&T teachers, nor Technology A-level students—Fig. A8.09,
- The result for technology in the context of 'human and social needs' was poor; the search on 9 KWIC disclosed 18 uses across all groups; eight of these were by humanities teachers—Fig. A8.11

Question 3: Here is a list of cross-curricular themes. Have you heard of them? Which do you think should be in the national curriculum?

A summary of the responses appears in Fig. 8.22 below; during recording, the interviewees were each shown a list of cross-curricular themes; their responses to the two questions appeared side-by-side as bar-charts in Appendix 8 for each group—see Figures A8.12 to A8.19. Fig. 8.22 presents the bar-chart data as percentage values to the first of these two questions.

Sub-groups	Responses	Careers Education & Guidance %	Education for Citizenship %	Education for EIU %	Environ-mental Education %	Health Education %	Totals %
		The cross-curricular themes					
Technology teachers	Yes	87.5	87.5	75.0	87.5	87.5	85.0
	Not sure	0.0	0.0	0.0	0.0	0.0	0.0
	No	12.5	12.5	25.0	12.5	12.5	15.0
Humanities teachers	Yes	100.0	100.0	85.7	100.0	100.0	94.3
	Not sure	0.0	0.0	0.0	0.0	0.0	0.0
	No	0.0	0.0	14.3	0.0	14.3	5.7
Parents in technology jobs	Yes	71.4	0.0	0.0	28.6	57.1	31.4
	Not sure	0.0	0.0	0.0	0.0	0.0	0.0
	No	28.6	100.0	100.0	71.4	42.9	68.6
Parents in non-tech jobs	Yes	87.5	50.0	37.5	50.0	62.5	57.5
	Not sure	12.5	12.5	12.5	12.5	12.5	12.5
	No	0.0	37.5	50.0	37.5	25.0	30.0
Technology student teachers	Yes	62.5	12.5	37.5	87.5	87.5	57.5
	Not sure	12.5	12.5	12.5	12.5	12.5	12.5
	No	25.0	75.0	50.0	0.0	0.0	30.0
Humanities student teachers	Yes	62.5	50.0	12.5	75.0	100.0	60.0
	Not sure	0.0	0.0	0.0	0.0	0.0	0.0
	No	37.5	50.0	87.5	25.0	0.0	40.0
Technology A-level students	Yes	75.0	25.0	25.0	62.5	75.0	52.5
	Not sure	0.0	12.5	0.0	0.0	0.0	2.5
	No	25.0	62.5	75.0	37.5	25.0	45.0
Humanities A-level students	Yes	100.0	12.5	12.5	75.0	87.5	57.5
	Not sure	0.0	12.5	12.5	0.0	0.0	5.0
	No	0.0	75.0	75.0	25.0	12.5	37.5
Totals %	Yes	80.8	42.2	35.7	70.8	80.4	62.0
	Not sure	3.1	6.2	4.7	3.1	3.1	4.1
	No	16.1	51.6	59.6	26.1	16.5	34.0

Fig. 8.22 - Summary of responses to the question 'Have you heard of the cross-curricular themes?'

Before commenting on Fig. 8.22, we should recall that the two parental groups had children in A-level classes. Looking at the 'totals' column on the right-hand-side of Fig. 8.22, the 'Humanities teachers' were the best informed about cross-curricular themes with 94.3%; the 'parents in technological jobs' at 31.4% were the least well informed about cross-curricular themes. These parents were qualified electronic engineers; by training and instinct they were keenly aware of the importance of their profession within society, but they did not know about Education for Economic and Industrial Understanding (EIU).

Some 37.5% of Technology student teachers, and 12.5% of Humanities student teachers knew about EIU, but the overall awareness of cross-curricular themes was 57.5% versus 60.0% respectively.

Comparing A-level Technology and Humanities students in this group shows that the overall awareness of cross-curricular themes equated to 52.5% and 57.5% respectively.

Examination of the totals at the foot of Fig. 8.22, offered an assessment for each of the cross-curricular themes across all groups; the results present serious causes for concern:

- only 80.8% were aware of Careers Education and Guidance; hence two in ten people were not,
- only 42.2% were aware of Education for Citizenship; so six in ten were not,
- across all groups, some 35.7% knew about Education for Economic and Industrial Understanding; so more than six in ten people did not,
- some 70.8% were aware of Environmental Education representing seven in ten people; hence three in ten were not aware,
- some 80.4% were aware of Health Education; so one in ten was not.

When these results were summed across all groups for all themes, the 'awareness' was 62%, the 'not sure' was 4.1%, and did not know was 34.0%.

The second part of question 3 offered participants the opportunity to say whether the cross-curricular themes should be included; specifically 'Which do you think should be in the curriculum?'—the results appear in Fig. 8.23 below.

Comparisons between the totals columns in Figures 8.22 and 8.23, shows that the greatest change was with the 'parents in technological jobs' from 31.4% to 85.7% in the 'Yes' row.

A comparison of the totals at the foot of Figures 8.22 and 8.23, show that there were some significant changes in 'awareness of' to 'support for' cross-curricular themes across all groups, particularly:

- Education for Citizenship—from 42.2% to 62.1%,
- Economic and Industrial Understanding—from 35.7% to 65.2%,
- Environmental Education—from 70.8% to 79.2%.

Sub-groups	Responses	Careers Education & Guidance %	Education for Citizenship %	Education for EIU %	Environ-mental Education %	Health Education %	Totals %
		The cross-curricular themes					
Technology teachers	Yes	87.5	87.5	75.0	87.5	87.5	85.0
	Not sure	12.5	12.5	12.5	12.5	12.5	12.5
	No	0.0	0.0	12.5	0.0	0.0	2.5
Humanities teachers	Yes	85.7	85.7	85.7	85.7	85.7	85.7
	Not sure	0.0	0.0	0.0	0.0	0.0	0.0
	No	14.3	14.3	14.3	14.3	14.3	14.3
Parents in technology jobs	Yes	85.7	85.7	85.7	85.7	85.7	85.7
	Not sure	14.3	14.3	14.3	14.3	14.3	14.3
	No	0.0	0.0	0.0	0.0	0.0	0.0
Parents in non-tech jobs	Yes	87.5	25.0	25.0	50.0	50.0	47.5
	Not sure	12.5	25.0	25.0	12.5	12.5	17.5
	No	0.0	50.0	50.0	37.5	37.5	35.0
Technology student teachers	Yes	62.5	75.0	75.0	87.5	75.0	75.0
	Not sure	25.0	12.5	12.5	12.5	12.5	15.0
	No	12.5	12.5	12.5	0.0	12.5	10.0
Humanities student teachers	Yes	75.0	62.5	62.5	100.0	100.0	80.0
	Not sure	12.5	25.0	25.0	0.0	0.0	12.5
	No	12.5	12.5	12.5	0.0	0.0	7.5
Technology A-level students	Yes	75.0	25.0	50.0	75.0	100.0	65.0
	Not sure	0.0	0.0	12.5	0.0	0.0	2.5
	No	25.0	75.0	37.5	25.0	0.0	32.5
Humanities A-level students	Yes	87.5	50.0	62.5	62.5	87.5	70.0
	Not sure	0.0	12.5	12.5	12.5	12.5	10.0
	No	12.5	37.5	25.0	25.0	0.0	20.0
Totals %	Yes	80.8	62.1	65.2	79.2	83.9	74.2
	Not sure	9.6	12.7	14.3	8.0	8.0	10.5
	No	9.6	25.2	20.5	12.7	8.0	15.2

Fig. 8.23 - Summary of responses to the question 'Should the cross-curricular themes be in the National Curriculum?'

Lastly, a comparison between the bottom right-hand-corners of Figures 8.22 and 8.23, shows the overall movement for all cross-curricular themes across all groups. From Fig. 8.23, 74.2% supported the inclusion of all cross-curricular themes in the national curriculum; this compares with an 'awareness of' cross-curricular themes of 62.3%.

Question 4 asked: What do you think is meant by Economic and Industrial Understanding (EIU)?

The purpose of this question was to ascertain the extent to which the concept of 'earning our keep'—Graffy (1988:8) as a society, was understood. As adults we know the importance of an income to set-up home—Owers (1999:5), but this raises questions about how effectively that model was transferred to the national situation among these groups.

Society has four basic aims: 'survival', 'progress', 'caring and sharing', and the 'luxuries of life'—Graffy (1988:2). How well these aims are supported is dependent on the level of prosperity that prevails in society—Graffy (*ibid*). For some groups the word 'luxuries' may be problematic. However, the perceived luxuries of one generation become the necessities of the next generation—Graffy (1988:5), and the car provides a good example—page 37.

Many of the responses to question 4 indicated some understanding, but fell short of the crucial role of industry as a source of wealth-creation and jobs integrated within a local community. From Fig. A8.21, it may be seen that the overall grasp of the importance of sustaining ourselves as a society was poor, with only 20 uses of 31 keywords. Keywords shown in the table in place of numbers, illustrate examples where the word was not used in a context that indicated clear understanding of the concept of wealth-creation such as:

> 'The industrial understanding would be about how the technology perhaps is used to manufacture and create the goods in that economy.'

The next two examples demonstrated clearer understanding:

> 'I think it is an understanding of how countries actually earn their living, how they generate sufficient income to pay the wages of all the people in the service and other sectors. It's knowing how products are designed and made, and valued added, and how its accrued, how you actually take a raw material and actually in a social context generate value added to pay for all the other services that society needs.'

> 'Let's take them in turn. Industrial understanding - one thinks of manufacturing products for export. Economic in that you don't manufacture products merely for sale, it's all for the purposes of economy, earning profit not only to maintain the wages we all work for, but to provide jobs within a town or a city, but also the profits which bring wealth into the country.'

The role of industry in society was clearly understood in these two examples above, but was missing in the following:

> 'Economic will obviously be living, day-to-day living, and industrial understanding is basically the work environment.'

Fig. A8.23 indicates that the D&T teachers had the best grasp of the role of industry in society, with a score of 9. In ranking order, parents in technological jobs were second with a score of 4.

Question 5: Here is a list of national curriculum subjects. Do you think EIU has relevance in any of these subjects, and if so which ones?

The list contained the following eight subjects from the 1988 Education Reform Act:

1.	Art	Foundation subject
2.	Design & Technology	Foundation subject
3.	English	Core subject
4.	Geography	Foundation subject
5.	History	Foundation subject
6.	Maths	Core subject
7.	Modern foreign languages	Foundation subject
8.	Science	Core subject

Note: Music and Physical Education omitted.

The responses to this question were also recorded; the transcriptions appear in Appendix 9, and the analysis in Appendix 8. The bar-charts in Figures A8.24 to A8.27 (Appendix 8), capture the perceived relevance of these eight subjects in the context of 'Education for Economic and Industrial Understanding'. The perceptions for each pair of groups was as follows:

The perceptions of teachers:

Although there were only 7 Humanities teachers, they made a total of 49 curriculum subject selections as having relevance to Economic and Industrial Understanding. In contrast, the 8 D&T teachers made a total of 44 curriculum subject selections.

By inspection of Fig. A8.24, it may be seen that the D&T teachers perceived more relevance in D&T, Maths and Science than the Humanities teachers, but the Humanities teachers perceived more relevance in all the other five subjects in the context of Industrial and Economic Understanding. Both outcomes are causes for concern.

Given that D&T has always been completely cross-curricular, there are further causes for concern. The first of these concerns relates to 'Art' in which D&T teachers scored 3 and Humanities teachers scored 6. The influence of Art on product design has been significant for many decades, and manufacturers commit significant resources to product appearance.

Since good communication is a fundamental requirement in all walks of life, the poor showing for 'English' is another cause for concern; D&T teachers scored 4 while Humanities teachers scored 5. D&T teachers also scored 4 for modern foreign languages or 50%, and Humanities teachers scored 6 or 85%.

The perceptions of parents:

Before discussion, it should be recalled that there were only 7 recordings for parents in technological jobs, nevertheless there were some significant results. From Fig. A8.25, it may be seen that none of the parents in technological jobs perceived any relevance for EIU in Art. So there was no connection with product styling, which is particularly important in the motor and domestic appliance industries.

Parents in technological jobs attributed more relevance in Geography and History than parents in non-technological jobs. The outcome for Maths was disappointing; parents in non-technological jobs scored 7, and attributed more relevance to education for economic and industrial understanding than parents in technological jobs, who scored 4.

The perceptions of student teachers:

Continuing the analysis of whether the curriculum subjects have relevance in EIU, Fig. A8.26 provides a comparison between technology student teachers, and humanities student teachers. By inspection, it may be seen that with the exception of Geography and History, the technology student teachers attributed greater relevance in curriculum subjects to EIU than the humanities student teachers.

With regard to 'Art' in Fig. A8.26, technology student teachers scored 4, while humanities student teachers scored 2, and as an outcome, was the antithesis of previous results. The technology student teachers also rated communication more highly as shown by the results for English and Modern Foreign Languages; the scores were 5 and 3, and 6 and 2 respectively.

The perceptions of A-level students:

Fig. A8.27 records the collective perceptions of technology and humanities A-level students, and shows that technology A-level students attributed more relevance than humanities A-level students in the subjects of Art, D&T, English, Geography, and Science, but overall the results were disappointing.

The perceived relevance of EIU for all groups by curriculum subject:

Fig. A8.28 captures the aggregate perceived relevance of education for economic and industrial understanding for all groups by subject. D&T had the highest score at 87%, and this is to be expected. In ranking order, the remaining results were as follows: Science 79%, Geography and Maths 68%, History 55%, Modern Foreign Languages 42%, English 39%, and Art 32%. In reality, all the results for all subjects should have been 100%.

The aggregate perceived relevance of EIU in curriculum subjects by groups:

Fig. A8.29 captures the overall perception by each group for all subjects, and since the 'Humanities teachers', and 'Parents in technology jobs' groups were only seven instead of eight people, the results were converted to percentages for easier comparison.

From Fig. A8.29, it may be seen that Humanities teachers (A2) perceived the greatest collective relevance for EIU in the eight curriculum subjects at 88%. D&T student teachers (C1) achieved 73%, D&T teachers (A1) 69%, Humanities student teachers (C2) 56%, Parents in technological jobs (B1) 53%, Humanities A-level students (D2) 41%, and Parents in non-technological jobs (D2) 39%.

Many of these results present significant causes for concern.

Question 6: Can you see much evidence of technology around you?

The themes used for the purpose of this analysis appear at the bottom of Fig. A8.30; they were devised to recognise that people use their own 'word' descriptive methods.

The idea that 'technology is everywhere' (theme 1) was well understood, since there were some 85 references. Theme 2 represented the concept of 'technology as tools, artefacts, products or systems to use', and there were 101 appropriate references, indicating a high level of awareness.

'Progress or change through technology' (theme 3) was referred to 31 times. Theme 4, the concept of 'people making technology' only appeared 4 times; so technology as a by-product of human activity was not easily identified.

For question 6, there was only a single reference to 'pollution because of technology' (theme 5). The issue of pollution will be seen to be more of a concern in response to question 8.

Theme 6, 'Difficulty visualising technology' was expressed on 8 occasions. Theme 7 'Could visualise technology' had the greatest showing across all groups with an aggregate of 137. 'Dependence on technology', theme 10, was identified 15 times.

Question 7: Do you think there are ways in which you personally have benefited from technology?

For the analysis of responses to question 7, only five categories were required, as shown in Fig. A8.31. The D&T teachers and D&T student teachers commented most freely with 655 and 593 words respectively; the aggregate for all eight groups was 2,871 words.

The D&T teachers and D&T student teachers also visualised greater personal benefit from technology than any other group with 30 and 32 instances respectively; these groups also offered the highest number of examples at 22 and 27. In reality, all groups have benefited significantly from technology, but this was simply not perceived.

There were three negative replies; one of the humanities teachers responded 'Yes and no' to question 7. They were concerned about costs, and pollution and considered technology was 'a mixed blessing'. One of the parents in a non-technical job, and one of the A-level Humanities students replied 'No', both without any equivocation. All these people have benefited from technology, but the question of pollution does have to be addressed.

<u>Question 8</u>: Do you think our society has benefited from technology?

From Fig. A8.32, it may be seen that the responses to question 8 from all groups amounted to some 2955 words; the highest sub-totals were for D&T teachers and 'parents in technological jobs' with 501 and 497 words respectively. The lowest sub-total was 208 words for parents in non-technology jobs.

Across all sub-groups, there were some 109 responses supporting the idea that our society had benefited from technology, and some 58 examples were given.

These sub-groups also produced some 13 negative or 'No' responses. The negative responses were supported by some 75 expressions of concern about technology—see Fig. A8.32. Grouping the concerns, they included:

- computers and technology adding to unemployment,
- compulsion to use computers,
- difficulties for people not versed in computer technology,
- pollution and the environment,
- misuse of drugs, television and videos,
- technology and educational issues,
- obsession with computers,
- decline in social relationships,
- causes laziness,
- too dependent on technology
- technological benefits taken for granted,
- the consequences of power failures [on computers],
- people prefer to sit in front of a computer than read a book,
- computers reduce the incentive to learn to write.

Referring again to Fig. A8.32, it may be seen that 'moral or ethical issues' were also a cause for concern, particularly among the more established sub-groups. Such concerns were raised by the D&T teachers, Humanities teachers, and parents in technological jobs on 11 occasions; there was a single reference by a technology student teacher, so making the total of 12. The concerns were expressed as follows:

- misuse of technology for example in war, drugs, and videos,
- profiteering—'people who sell airwaves for money',
- 'technology being made to help to produce profit',
- 'Bill Gates worth more than Iraq',
- 'I don't think society is any happier',
- 'pollution or our misuse of technology which is often driven by money and profit',
- concerns about biology.

Question 9: Do you think our society is dependent on technology? Where on a scale of 1 to 9 would you place any dependency?

Fig. A8.33 shows the level of societal dependency on technology as perceived by the eight sub-groups. The results have been expressed in percentage terms to reflect the differences in sub-group numbers. The highest level of dependency on technology was perceived by parents in technological jobs at 91%, and the lowest by parents in non-technological jobs at nearly 71%.

08.08 In summary

The purpose in this chapter has been to examine the perceptions of technology in our society. Before presenting the evidence, it was necessary to recapitulate the pivotal place of technology in our lives, a role essentially not understood by the critical mass of influential opinion leaders.

Humankind evolved because of its tool-making skills; humankind has always used tools, and much more recently technologies, as extensions of itself. The underlying purpose has always been sustainment, and this applies with every type of nation whether hunter/gatherer or industrialised. Tools and technological evolution have been constant companions to the evolution of humankind.

However, the value judgments implicit in our culture with regard to industry, technology, business and trade, have represented ongoing sources of disparagement that seriously threaten our ability to sustain ourselves as a society, even today. Technology occupies a central role in our lives; as we become more productive and capable, so we become more dependent on technology. This thesis also reflects on the opposition created by our value judgments towards enhancing the productivity and capability that underpins the standard of living for our society. So it was important to examine one of the earliest organised manifestations of cultural prejudice, namely the popular book trade between 1760 and 1790.

This was followed by evidence from three research exercises: (1) economic and industrial understanding with teachers and student teachers, (2) a survey of A-level students, and (3) evidence from transcribed recordings in response to questions on the meaning and influence of technology.

08.08.01 Technology is as old as humankind

Technology, as the generic creative system that has brought humankind from the Stone Age to the way we live now in an industrialised society, began with the imaginative visualisation by humankind of tools that could be made from available materials—page 21.

Humankind discovered that tools could be used as extensions of itself—page 27. Hence tool-making has been and continues to be at the core of all technological evolutionary and developmental activity up to the present day. Technologies are also tools, and humankind has always created tools to enhance productivity and/or capability—page 25.

The tools of the early Stone Age tool-making were elementary, but their practices and knowledge provided the imaginative foundation for the creative system of humankind now known as technology. The technologies upon which industrialised societies today depend, are the outcome of knowledge building on knowledge over thousands of years, and made possible in human societies because of their life span—Usher (1954:67).

Developments in tools and technologies emerge because of the inner compulsion that exists among people with the knowledge and aptitude to make tools and/or technological change happen. And technological change happens as an outcome of a new convergent synthesis of knowledge as discussed on pages 30-31 in this thesis.

Such cumulative acquisition is a social cultural achievement, the enormity of which was long overlooked—Usher (1954:68). The conceptual model of cumulative synthesis in Fig. 4.02, page 31 (after Usher (1954:69)), was reproduced in this chapter on page 147 as Fig. 8.02.

Implicit within that model of cumulative synthesis for technology, there resides a law of prior dependency as shown in Fig. 8.24 overleaf. Each of the steps in Fig. 8.24 was made possible by the preceding event in the path of technological continuity and progression ever since the Stone Age. And in the earliest steps, softer materials including wood were used as hammers to make stone flakes as tools—Schick and Toth (1995:263).

The story of human evolution, and our separation from all other animal species, continues to be inextricably linked with the development of our tool-making capability from which modern technology derives—Schick and Toth (1995:16). In this context, Fig. 8.24 illustrates:

- the social phenomenon of cumulative acquisition of knowledge building on knowledge, and
- 'the law of prior dependency' which has always resided in technology.

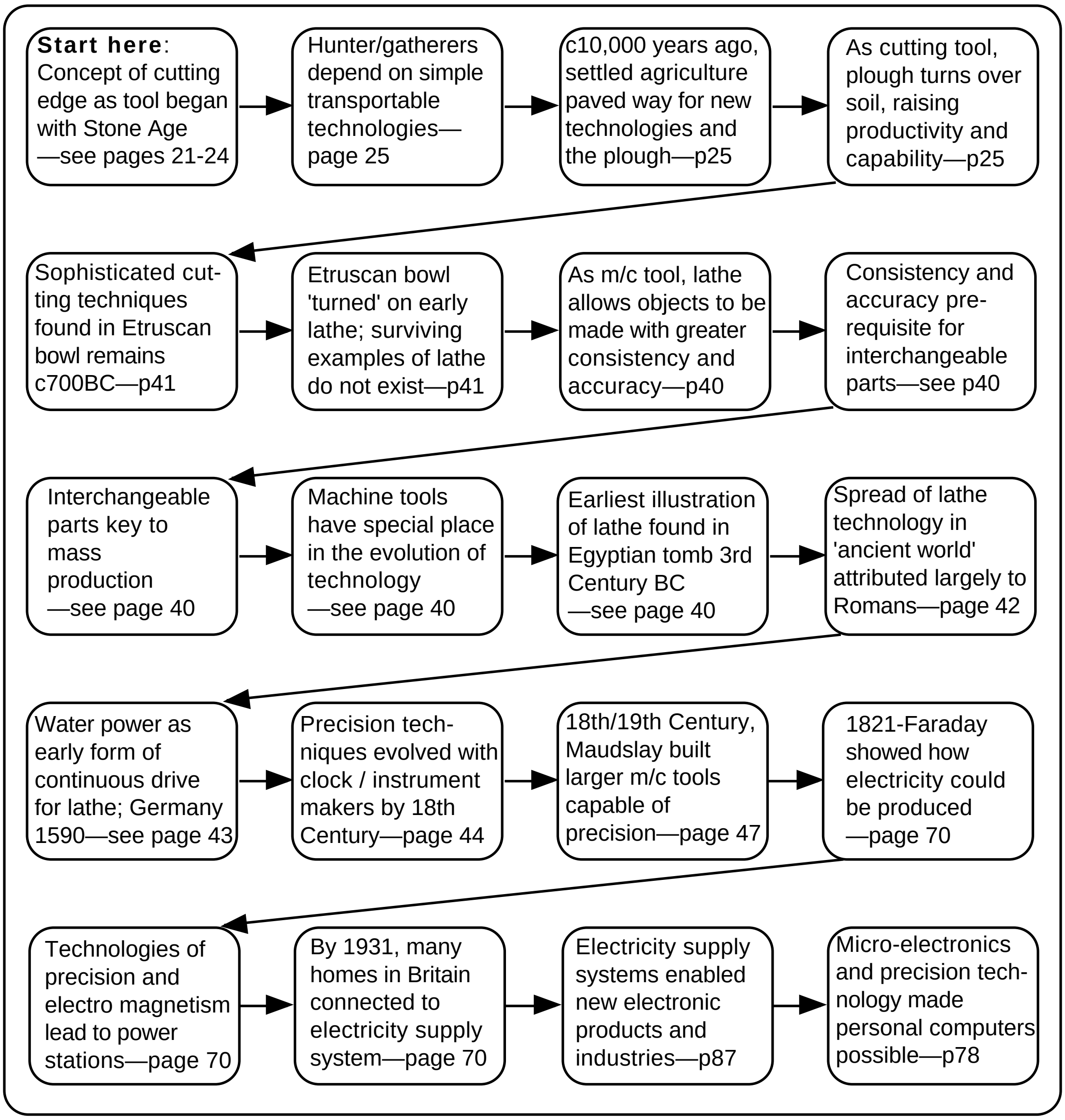


Fig. 8.24 - Model illustration of the law of prior dependency in technology

Fig. 8.24 has also been structured around the Stone Age tool concept of the 'cutting edge'. At each stage, further new knowledge has influenced and been dominant in the course of technological evolution, but the ability to cut and work new and progressively harder materials remained paramount, and particularly for the discovery of precision technology.

While Fig. 8.24 illustrates the model of prior dependency appropriate for the technological evolution that has taken place in a western industrialised society; other societies would probably have a different order and series of events, and hence a different model—eg the South American Inca peoples—see page 97. Throughout the world, societies have developed their technologies around the available materials, in order to survive in their chosen habitats—see page 37. Without exception we are all users of tools and technology. We all learn to use tools including technologies as tools, and we use them as extensions of ourselves to enhance our productivity and/or capability. Learning-to-use-tools is part of the growing-up socialising process for the younger generations—see page 108.

However, relatively few of us are tool or technology makers, and those with an aptitude for technological specialisation, have not only the basic appreciation shown in Fig. 8.01, but when they see machinery in operation, they are able to visualise the functional 'concepts'—Pirsig (1999:100). Visualisation of functional concepts happens because of the 'prepared mind'—Merrill (1968:585).

The 'prepared mind' becomes a powerful 'capability'. In the early 1970s, a group of Japanese engineers were visiting a UK assembly plant with a capacity for 1200 cars per day. The plant required 6000 correctly inflated wheel and tyre assemblies; how do you get compressed air into 375 tubeless tyre and wheel assemblies every hour? That is one every 9.6 seconds! The answer, provided by an engineer, was *not through the valve*. When the Japanese saw the machines designed and developed for this purpose they became highly excited and took many photographs. This implied that they had not yet solved the problem, but their prepared minds enabled them to understand the concepts. And Merrill (1965:585) argues:

> … evidence suggests that technological traditions are far more complex than usually realised and that they contain numerous features of the greatest significance for understanding the possibilities and processes of technological change.

The experience of the Japanese engineers makes one further point; languages may be diverse, complex and even divisive, with many variations of structure, but for those with the technological aptitudes to visualise, and understand concepts, there are no barriers. In the case of the wheel and tyre assemblies, a prepared innovative mind in one country had made reality of visualised concepts, and the reality of those concepts had been understood across time and distance without the need for intervention by language.

In recent decades, as each new generation comes along, it witnesses a greater pace of technological change as an outcome of enhancing the productivity and capability that underpins the standard of living for our society.

By today's standards, the first tools were rather elementary, but we could not have progressed as tool-makers and eventually 'graduated' as technologists without them, and the way we live now would not have been realised. Time had to elapse for the knowledge of humankind to build on knowledge, and provide the tools and technologies as tools that have brought us to the way we live now.

The discovery of precision technology in combination with the discoveries by Faraday, led to the designing and making of electrical power generation equipment and supply systems. As a national system, electrical power supply enabled the birth of many new industries and products, and the range of new products continued to grow with the advent of micro-electronics; new industries provided new jobs in local communities, so underpinning the local socio-economic infrastructure.

Personal computers are a synthesis of modern imaginative technologies in plastic, metallic and silicon materials, in combination with micro-electronic components, but newer and more sophisticated precision technological methods were at the core of the design and manufacturing processes. So although Stone Age concepts remain with us, the complex modern representations are hard to visualise, particularly by the critical mass who are technically illiterate. While without exception we are all users of tools and technologies, few are tool or technology makers.

'Precision' components 'are designed to achieve' a technological 'idea'; those who are unable to visualise the idea 'see parts', while those who do understand see the technological 'concepts' that gave rise to the design and manufacture of the product—Pirsig (1999:100). And advances are achieved by and through the prepared mind.

The growth of technological concepts, realised as tools and artifacts, confirms the creativity, productivity and capability that underpins the national standard of living enjoyed by our society. But the integration and purpose of that process within our society was never seen by influential opinion leaders; indeed there was widespread disparagement as demonstrated by the anti-industry and anti-business sentiments that prevails in UK society.

08.08.02 Anti-business and anti-industry sentiments

Before 1760, there was no concerted hostility towards business and industry, but that changed in the period up to 1790. Although this change was driven by forces outside education, the cultural context and associated value judgments have relevance here.

'The businessman was made a scapegoat for a wide range of alleged social and economic ills and became a target of abuse as a means of illustrating, preserving and extending specific class values during a period of marked social upheaval and readjustment'—Raven (1985:137); the cause was the Industrial Revolution.

Taking samples of the popular literature at five-year intervals between 1760 and 1790, a clear picture in the growth of anti-business sentiment emerged—Raven (1985:139). During this time, an 'escalating sharpness and vindictiveness' in the attacks 'upon traders, nabobs', and subsequently 'manufacturers', may be discerned—Raven (*ibid*). The successful entrepreneurs were targeted because' of their 'vulgar display' of 'newly acquired wealth', and their 'social ambitions'—Raven (1985:140).

'By 1790 the subjects' backgrounds' were exemplified with liberal 'detail', and specific 'reference to the outlandish social ambitions of the parvenu'—Raven (1985:140). The popular literature of the 1790 season, by comparison with 1770 and 1780, 'displayed intense concern with the origins of the self-made and trading families and of the morals and activities of their dependents'—Raven (1985:141).

In 1785 and 1790, the popular fiction 'produced far more dramatic fates' for the 'fictional' transgressors than in '1775 or 1780', and there were 'more evil characters to receive them' —Raven (1985:147). The 'instructional utility of the novel' was enriched when those who transgressed the norms of 'correct behaviour' received a 'ghoulish' end—Raven (1985:149).

However, there was a sharp contrast between 'popular' literature, and the 'growing intellectual appreciation of the consumer boom'—Raven (1985:157). 'Economic works' found 'progressive levels of spending … a stimulus to economic growth', differing sharply with the 'letters to editors and the verdicts' on 'novels and tales'—Raven (1985:158).

The 'consumption of manufactured goods', although 'intellectually' acceptable, 'was regarded with splenetic hostility by the [popular] fiction … industry'—Raven (*ibid*). The fiction industry could draw upon 'a vast stock of characters and storylines' to show 'the evils of luxurious conspicuous consumption'—Raven (*ibid*).

First-generation traders and industrialists were cognisant of the attitudes of 'polite society'. The second-generation sons who inherited the businesses sought to become more acceptable in society. They exhibited 'gentlemanly values' and 'country seat' aspirations, and 'modern Britain … lost out on the technological revolution'—Raven (1985:4).

08.08.03 Anecdotal evidence

The anecdotal evidence of the anti-industry and anti-business culture that prevails in UK society, as shown in Appendix 5, comes from a wide spectrum. This prejudice undermines our technological productivity and capability, and threatens our standard of living as a society. The anecdotes fall into the following categories:

- comparisons between the social standing of entrepreneurs in Britain and other industrialised countries,
- social prejudice against engineers and people who work in industry and trade,
- official recognition by Ministers and MPs of the cultural prejudice that threatens our competitive economic survival,
- the need to make a cultural adjustment embracing every aspect of society,
- many instances of the cultural prejudice learnt by teachers and academics in the absence of positive instruction about the role of technology and industry in our society,
- consistent educational institutional prejudice about the levels of intellectual capability demanded by technology and industry,
- this catastrophic failure to understand the levels of intellectual capability demanded by technology, caused one head teacher in 1999, to appoint as head of technology, an English teacher with no technological training—see anecdote 35 Appendix 5.

The demonstrated prejudice within the institution of education, including academia, may be likened to a 'hidden curriculum' that 'transmits important messages' about 'appropriate attitudes'—Boronski (1988:47), and here specifically towards technology, industry and trade.

But for much more than a Century there has been statutory sanction for this culture and prejudice, as discussed in Chapter 7; the anecdotal evidence shows that the prejudice still thrives.

However, writing about Class, culture and the Curriculum, Lawton (1975:6) states:

> '… the school curriculum (in the wider sense) is essentially a selection from the culture of a society. Certain aspects of our way of life, certain kinds of knowledge, certain attitudes and values are regarded as so important that their transmission to the next generation is not left to chance in our society but is entrusted to specially-trained professionals (teachers) in elaborate and expensive institutions (schools).'

Since 'culture is everywhere all the time, we generally take it for granted; for most practical purposes, it is invisible to the untrained eye'—Flinders (1991:88). But 'getting people to change their behaviour is relatively easy compared with changing their attitudes'—Handy (1987a:145).

Thus our cultural paradigms, as sanctioned by definition by the majority in our society, have caused us, unknowingly, to choose the path to ultimate national poverty—Owers (1997:5).

<u>08.08.04 Impressions of industry among teachers and student teachers</u>

The anecdotal evidence presented and discussed earlier in this chapter, and summarised in the previous section, includes examples of the hidden curriculum developed within the sub-cultures of education and academia. Separate exercises in Economic and Industrial Understanding with groups of teachers and student teachers confirmed the prejudice, and disclosed a serious lack of knowledge about the socio-economic infrastructure of our society.

The comments of these groups were essentially negative, often drawn as pictures showing factory chimneys discharging smoke, although with the decline in manufacturing and the technological changes in industry, there are far fewer chimney stacks on any horizon.

One of the pictures, representing the consensed impressions of a group of student teachers, showed a production line—which is a source of concern for many. What was missing from their knowledge bank was that production lines were introduced to *simplify* the process—Forty (1992:30). By the mid-18th Century, Wedgwood had already found it necessary to reduce the process of pot manufacture to its elemental parts for consistency of appearance and quality, and lower cost—page 77. By so doing, Wedgwood raised the productivity and capability in the socio-economic areas in which his factories were situated; he raised the demand for his products, raised the number of job opportunities, and through their wages, put more money into the local socio-economic community.

The anecdotal evidence summarised in the previous section, and the pictures portraying negative impressions, are unfortunately 'traditional' in much of UK society. However, when student teachers have the opportunity to study 'The Contribution of Industry to the School Curriculum', their perceptions change, and they also become extremely concerned about the insensitivity exhibited through their sub-cultural prejudice—pages 162-165.

08.08.05 Questionnaire survey and transcription analysis

The Education Reform Act of 1988 was an attempt to make significant cultural change, as demonstrated by the inclusion of Technology for the first time. As action research exercises, the questionnaire survey, the recorded interviews in 1996-97, and the intro-ductory exercises in Economic and Industrial Understanding for student teachers happened after the attempted change of cultural direction that was introduced by the 1988 Act.

The inclusion of technology in the National Curriculum with the Education Reform Act of 1988, was long overdue. Here was the opportunity to introduce the significance of technology in our lives, and in this context extracts from various curriculum orders have been summarised in Appendix 6—they have a cross-curricular context that shows the influence of technology in our lives, and makes essential reading.

However, since technology has such a long tradition that few recognise, some difficulty with its introduction as a curriculum subject was inevitable. The Orders for D&T published June 1989 contained no glossary of terms. The Orders published December 1992 did contain a 'Glossary of technical terms' in Appendix E, but there was no definition for the word 'technology'. So defining 'technology' was also problematic for Education. Indeed, the 1992 Orders for Technology state:

> Overall, there was considerable variation in respondents' views on the nature of D&T …
> —DfE (1992:4).

Nevertheless, technology has been defined. For example the archaeologists Schick and Toth (1995:49) state:

> To have a technology *per se*, there should be some agreed upon ways of doing things in a social group—that is, should be some learned, *cultural* aspect to the tool use or artifact manufacture.

For a definition with a more recent setting, Cross *et al* (1989:27) state:

> Technology is the application of scientific and other organised knowledge to practical tasks by hierarchically ordered systems that involve people and machines.

Also, in the business world in the past fifteen years, there had been a noticeable increase in the use of the word 'technology'—Malpas (1999:4). The Science and Engineering Research Council established a committee to 'address the subject of engineering research'; their report 'Review of Engineering' published in 1992, 'was well received'—Malpas (1999:3).

From the beginnings of their 'deliberations', the committee had 'great difficulty with the lexicon'—Malpas (1999:3). The committee comprised 'eminent scientists and engineers from academia and industry', and they all interpreted the words 'science, engineering and technology' differently, 'with enormous overlaps of meaning'—Malpas (*ibid*).

So this research has taken place during a period of significant attempted cultural change, and against a general background of difficulty with regard to both understanding and defining technology, adding further dimensions of interest.

Although a huge cultural step was taken with the introduction of Technology in the National Curriculum, do we yet know how important it is in the context of sustaining ourselves as a society? And do we yet look upon humankind (ourselves) as the 'tool/technology user' without equal in the cause of sustaining ourselves as a society?

The detailed analysis from the questionnaire survey was presented in Appendix 7, and reviewed earlier in this chapter by curriculum subject; there were many causes for serious concern; they are briefly reviewed here:

- low interest in D&T, Maths and Science was exhibited by girls and those not taking these subjects, but without exception we are tool/technology users and beneficiaries of the technologies that underpins the productivity and capability of our society, and hence our standard of living.
- the difficulty with D&T was rated at medians of 5 by gender and subject studied; Maths and Science were rated at medians of 7 by gender and subject studied. Given that Maths and Science are components of D&T, these results present serious causes for concern.
- in the context of 'getting a job', English, Maths and Science were more highly rated than D&T, and by both methods of analysis. Thus the crucial role of technology in our lives was not evident. Nevertheless, with English, Maths and Science there was a critical level of understanding that has to be encouraged in other subjects, including Art and D&T.
- in the context of EIU, D&T, English, Maths and Science were all more highly rated than Art. Thus there was no perception of the crucial role of Art in product appearance, and hence no appreciation of the design process to achieve acceptable product appearance.
- in the context of 'the way we live now', D&T and Science received good ratings; Maths was rated 6 by all forms of analysis, and should have been higher; also the ratings for English should have been higher.
- for 'creativity within the curriculum' Art received the highest ratings by gender 8/8, and subject studied 9/8. D&T, English, Science and Maths followed in descending order. The low ratings for Maths and Science raises serious concerns:
  - ◊ there was no perception that Maths and Science were components of Technology,
  - ◊ that they were intrinsic parts of the progression and continuity of the technology which has evolved alongside humankind; this was substantiated by the low rating of 3 for those studying Maths, and 4 for those studying Science.

  Note: The importance of creativity is a theme that has run through this thesis. For example, 'The creative innovative process is arguably dominated by visual non-verbal images—Basalla (1993:67), Ferguson (1977:827)—see page 29. But the thought processes, as they engage in visual non-verbal images, require acts of intuitive insight to achieve innovation—Usher (1954:64-66)'—see page 29. And Technology is the generic creative system by which we live, by which we survive, and by which we advance our capability and productivity on every front of human experience; also Maths and Science are components of technology—page 56.

◊ This raises questions about the way Maths, Science and Technology are taught.

- for 'societal dependency' Science received the highest ratings, followed by Maths, D&T and English. Art received the lowest ratings, and confirmed no link with EIU. This raises questions about the way Art, Science and Technology are taught, when the products of scientific discovery can only be delivered through technology.
- some of the five cross-curricular themes had a seriously uncertain status within education, as confirmed by the results:
  - ◊ more than 90% of girls and 85% of boys had teachers for Careers Education & Guidance—Fig. A7.67,
  - ◊ some 11% of the pupils had teachers for Education for Citizenship; about 36% were not sure, and 52% did not—Fig. A7.68,
  - ◊ 22.6% of girls and 27.6% of boys had teachers for EIU; the rest were 'not sure', or certain that they 'did not'—Fig. A7.69,
  - ◊ 30% of girls and 27.5% of boys had teachers for Environmental Education; more than 30% of pupils were 'not sure', and more than 35% were certain that they 'did not'—Fig. A7.70,
  - ◊ some 73% of girls and 60% of boys had teachers for Health Education; the rest were either 'not sure', or knew that they 'did not'—Fig. A7.71.

The introduction of technology in the National Curriculum with the Education Reform Act of 1988 must be regarded as a cause for celebration, and progress has been made. Analysis of the data collected from the 3100 A-level students, has produced graphs representing perceptions at a point in time. The status of technology in education was not representative of its crucial role and contribution at the core of our society. But it is reasonable to expect that the students' sense of expectation of technology, and what it might offer to them, will change and they will become increasingly critical.

Appendix 7 provides the analytical detail for this summary.

08.08.06 Analysis of transcriptions

A schedule was used to ascertain what various groups of people understood by both the word 'technology' and the pivotal place it holds in our society; 62 recorded interviews were made and the groups included:

- D&T teachers
- Humanities teachers
- Technology student teachers
- Humanities student teachers

- Parents in technology jobs
- Parents in non-technology jobs
- Technology A-level students
- Humanities A-level students

Appendix 8 contains the main body of analysis with an explanation of the method; Appendices 9 and 10 present further data. A summary of the findings appears here with respect to each of the questions asked:

Question 2: Can you describe briefly what is meant by technology?

Summary of findings:

- All eight groups used key-words to explain their understanding of the meaning of technology.
- When describing what was meant by technology, it may be seen from Fig. A8.03 that D&T teachers collectively headed the list and used some 87 words from the key-word-in-context list (KWIC) list.
- In ranking order, parents in technology jobs (professional electronic engineers), were second in their collective KWIC usage with 74 words, although there was some uncertainty about the meaning of technology.
- Humanities teachers were the third highest KWIC usage at 69 words.
- Technology student teachers used 67 KWIC.
- Humanities student teachers used 41 KWIC.
- Parents in non-technology jobs and Humanities A-level students used 39 KWIC.
- Technology A-level students used 33 KWIC.
- For the 'creative word' sub-set shown in Fig. A8.04, the overall usage was poor with a total of 40 KWIC; of these:
  - ◊ Technology student teachers used 12 KWIC,
  - ◊ Parents in technology jobs used 7 KWIC, and
  - ◊ D&T teachers used 6 KWIC.
- The keyword most commonly used was 'design' with twenty instances; every group used this word with the exception of the humanities A-level students.
- Only the Design & Technology teachers and professional electronic engineers used the word 'create', with 2 and 1 instances respectively.
- In the 'creative word' sub-set, 'imagine', 'intellectual', and 'invent' were not used—see Fig. A8.04.
- Words from the sub-set expressing the 'universal influence of technology' yielded 29 KWIC. Of these, D&T teachers, and Technology student teachers, each used 9 KWIC —Fig. A8.07.
- The link between technology and the national economy was poor; across all groups there were only 11 KWIC; of these, parents in technological jobs used 6 KWIC—Fig. A8.08.
- The reality of technology was clearly evident. Across all groups there were 85 KWIC; 'computer' was used on 30 occasions, but not by D&T teachers, nor Technology A-level students—Fig. A8.09.
- For the sub-set denoting technology as a problem solving discipline 15 KWIC were used;

the keywords were 'problem' and 'solve'; D&T teachers used 7 KWIC, Humanities teachers used 6 KWIC, and Technology student teachers used 2 KWIC— Fig. A8.10. Nevertheless, professional technologists do use the words 'problem' and 'solve' within their daily work routine—Byron (1999:5).

Question 3: *Here is a list of cross-curricular themes. Have you heard of them? Which do you think should be in the national curriculum?*

Fig. 8.25 below, derived from Appendix 8 Figures A8.20 and A8.21, summarises the responses to questions 3a and 3b, and across all groups.

		The cross-curricular themes					
Questions ↓	Responses ↓	Careers Education & Guidance %	Education for Citizenship %	Education for EIU %	Environ-mental Education %	Health Education %	Totals %
Teachers for cross-curricular themes?	Yes	80.8	42.2	35.7	70.8	80.4	62.0
	Not sure	3.1	6.2	4.7	3.1	3.1	4.1
	No	16.1	51.6	59.6	26.1	16.5	34.0
Should themes be in National Curriculum?	Yes	80.8	62.1	65.2	79.2	83.9	74.2
	Not sure	9.6	12.7	14.3	8.0	8.0	10.5
	No	9.6	25.2	20.5	12.7	8.0	15.2

Fig. 8.25 - Comparison of responses to the two questions:
3a. Did you have teachers for cross-curricular themes in the National Curriculum?
3b. Do you think cross-curricular themes should have a place in the National Curriculum?

In response to 3a, there was a 62% awareness of cross-curricular themes across all eight groups. In response to 3b, 74.2% thought that cross-curricular themes should be in the National Curriculum.

The greatest change occurred with the theme 'Education for Economic and Industrial Understanding', namely from 35.7% to 65.2%.

Question 4: *What do you think is meant by Economic and Industrial Understanding (EIU)?*

Many of the responses to question 4 indicated some understanding, but fell short of the crucial role of industry as a source of wealth-creation integral within a local community. From Fig. A8.23, it may be seen that the overall grasp of the importance of sustaining ourselves as a society was poor, with only 20 uses of 31 keywords across all eight groups. The D&T teachers had the best grasp of the role of industry in society, with a score of 9. In ranking order, parents in technological jobs were second with a score of 4.

<u>Question 5</u>: Here is a list of national curriculum subjects. Do you think Economic and Industrial Understanding has relevance in any of these subjects, and if so which ones?

The detailed analysis was summarised in two ways: (1) by curriculum subject for all groups, and (2) by group for all curriculum subjects:

The aggregate perceived relevance of education for EIU by subject for all groups showed that D&T had the highest score at 87%, and this was to be expected. The remaining results in ranking order were as follows: Science 79%, Geography and Maths 68%, History 55%, Modern Foreign Languages 42%, English 39%, and Art 32%—Fig. A8.28.

Analysis by group for all curriculum subjects showed that Humanities teachers perceived the greatest collective relevance for EIU in the eight curriculum subjects at 88%. Technology student teachers achieved 73%, Technology teachers 69%, Humanities student teachers 56%, Parents in technological jobs 53%, Humanities A-level students 41%, and Parents in non-technological jobs 39%—Fig. A8.29.

The results obtained from both forms of analysis present significant causes for concern.

<u>Question 6</u>: Can you see much evidence of technology around you?

The responses contained in the transcriptions were analysed according to twelve themes which appear together with the results in Fig. A8.30. Collectively, these themes clearly show the influence of technology in our lives; summarising the results:

- Theme 1 - the idea that 'technology is everywhere' was well understood; there were some 85 references.
- Theme 2 - the concept of 'technology as tools, artefacts, products or systems to use'; there were 101 references.
- Theme 3 - 'progress or change through technology' was referred to 31 times.
- Theme 4 - the concept of 'people making technology' only appeared 4 times; so technology as the creative process of human activity was not easily identified.
- Theme 5 - 'pollution because of technology' had a single reference, but see responses to question 8 later.
- Theme 6 - 'difficulty visualising technology' was expressed on 8 occasions.
- Theme 7 - 'could visualise technology' had the greatest showing across all groups with an aggregate of 137.
- Theme 8 - 'technology governs people' had a single reference.
- Theme 9 - 'technology in consumer goods' used 3 times.
- Theme 10 - 'dependence on technology' was identified 15 times.
- Theme 11 - 'hidden benefits of technology' had a single reference.
- Theme 12 - 'issues to do with defining technology' referred to 3 times.

<u>Question 7</u>: Do you think there are ways in which you personally have benefited from technology?

- D&T teachers and Technology student teachers visualised greater personal benefit from technology than any other group, with 30 and 32 instances respectively. These groups offered the highest number of examples at 22 and 27. In reality, all groups have benefited significantly from technology, but this was not perceived—Fig. A8.31.
- There were 3 negative replies; one of the humanities teachers responded 'Yes and no'. Concerns included costs, pollution and that technology was 'a mixed blessing'. One of the parents in a non-technical job, and one of the A-level Humanities students replied 'No', both without any equivocation. All these people have benefited from technology, but the question of pollution does have to be addressed.

<u>Question 8</u>: Do you think our society has benefited from technology?

Fig. A8.32 summarises the responses to question 8.

- Across all sub-groups, there were some 109 responses supporting the idea that our society had benefited from technology; there were 58 examples—Fig. A8.32.
- These sub-groups also produced some 13 negative or 'No' responses, supported by some 75 expressions of real concern about technology—page 360 Appendix 8.

<u>Question 9</u>: Do you think our society is dependent on technology? Where on a scale of 1 to 9 would you place any dependency?

Fig. A8.33 summarises the results expressed as percentage values for each of the eight groups; in perceived descending order of dependency they were:

- 91.3% - parents in technological jobs,
- 88.2% - technology teachers,
- 86.8% - humanities student teachers,
- 86.1% - technology student teachers,
- 84.9% - humanities teachers,
- 79.2% - humanities A-level students,
- 75.7% - technology A-level students,
- 70.8% - parents in non-technological jobs.

The 20% disparity between the top and bottom of this list has more to do with lack of opportunity to learn about the crucial role of technology in our lives, and hence the language and understanding to respond.

Since humankind in an industrialised society is utterly tool/technology dependent in every field of experience, all the results should have been above 90%.

08.08.07 Process and product

The content analysis reveals a concern for which separate mention becomes necessary. In the context of illustrating comprehension of technology, question 2 asked 'Can you describe briefly what is meant by technology?' Respondents were thus provided with the opportunity to separate 'process' from 'product'.

The keyword list used for analysis of the responses to question 2, was structured around eight themes (see Appendix 8, page 334), including:

- creative imaginative activities such as design,
- the practical reality of technology.

Fig. A8.04 Appendix 8 shows that a total of 40 KWIC were used from the 'creative' word sub-set, and these are directly related to 'process' rather than 'product'. The most commonly used word was 'design' with 20 references, and 'develop' came next with 8 references. 'Imagine', 'intellectual' and 'invent' were not used, and 'create' was only used 3 times.

The analysis for 'product' was achieved by considering keywords representing the 'reality' of technology, as shown by Fig. A8.09 Appendix 8. Here, it may be seen that there was a total of 85 KWIC; 'computers' were ranked the highest with 30 mentions, followed by 'materials' with 10 mentions.

So in their responses to question 2, the 85 KWIC showed that 'product' was far more easily identified than the 'process' for which only 40 KWIC were used. However, without the 'creative product development process', which includes 'design', there can be no products —see pp 78-83. 'Creativity, 'innovation' and 'invention', are fundamentally essential elements of the product development process, and this should be taught in the National Curriculum since they are also vital in the context of sustaining ourselves as a society; that is to pay for all the services we expect and demand from the state.

08.08.08 Closing discussion

Many schools of argument may be found in the field of educational philosophy, and examples will be discussed in Chapter 9. This thesis however, has been concerned with the debate about sustaining ourselves as a society, a cultural minefield in education. As early as 1868, the polarised nature of the debate was neatly captured in expressions of parental concern:

> '… though classics may be excellent [an indicator of the prevailing cultural pressure], yet, mathematics, modern languages, chemistry, and the rudiments of physical science are essential, and we do not find time enough for all'—Taunton (1868:18).

The same year, a Select Committee was appointed 'to inquire into the provisions for giving instruction in theoretical and applied Science to the Industrial Classes'—Parliamentary Papers 24th March 1868. Note the prejudicial link between Science and the 'Industrial Classes'.

There have been many attempts to change the culture of education, and one was summarised like this:

> The Education Act of 1944 is considered by many to be one of the most critical events in the history of English education. For the first time in England, secondary education became free for all students. It sought to provide grammar schools for the academically inclined, secondary schools for the less able, and technical schools for those with manual skills—Henry (1991:5).

The author contends that the 1944 Act was just another huge manifestation of the deeply rooted cultural problems that have beset and undermined the productivity and capability of our society. Those responsible for the 1944 Act were not only elitist, to the detriment of our society they were arguably also culturally blind, evidencing technological and economic illiteracy.

In a 'A Comparison of the Statistics of Engineering Education - Japan and the United Kingdom' (1988:3), published by The Engineering Council, the following was quoted:

> In 1960, the Japanese Economic Council of the Economic Planning Agency, which drafted the National Income Doubling [5 year] Plan, underlined the importance placed on education when it stated 'economic competition among nations is a technical competition, and technical competition has become an educational competition …'

As already stated, the Education Reform Act of 1988, was an attempt at real change. Given the historical development of education, including the decades of tension over so many issues (see Chapter 7) and the deep cultural prejudice, the Education Reform Act of 1988 was in itself a sign of real progress. For the first time technology became part of the national curriculum, and Economic and Industrial Understanding was introduced as a cross-curricular theme.

Since we earn our way in the world by also producing products that people want to buy, the introduction of a curriculum in 1988 that recognised both technology, and Economic and Industrial Understanding was vital for the UK to have a chance of recovering its competitiveness.

The rationale for this research coincided neatly with a period of significant attempted change of cultural direction. Indeed there was a national movement for change that encompassed the Education Reform Act of 1988. Beginning in 1995, the assumption and hypothesis for this research was that the educational system of:

'the UK has consistently failed to respond appropriately to 'technology' (hence our economic decline), and to test the hypothesis that *'this failure has contributed to the problems associated with the place and perception of 'technology' in the National Curriculum'.*

The evidence produced in this chapter shows that significant progress has been made, but as may be expected, there are still many serious causes for concern; they include:

- the cultural prejudice still thrives—see the anecdotes in Appendix 5,
- Economic and Industrial Understanding has a seriously uncertain status within the school having been abolished at the statutory level,
- the roles of industry and technology in our lives have yet to be understood in the depth required to sustain ourselves as a society.

For competitive world-class companies, the product development process yields successions of significant inventions as products, bringing together many specific features of novelty, and many familiar methods—Usher (1954:68). As a society, we find it easier to identify the products of technology rather than the process. But invention remains a social and cultural process—Basalla (1993:103), impacting on both the product manufacturing process and the product development process, as knowledge builds on knowledge.

There is now growing recognition of the need for further significant change as shown by two reports:

- *All Our Futures: Creativity, culture and Education*—Robinson *et al* (1999), and
- *Opening Minds: Education for the 21st Century*—Bayliss *et al* (1999).

Both reports grapple with the polarised debate that has strangled our society:

> … What has this got to do with helping young people get jobs? We live in a fast moving world… . Many businesses are paying for courses to promote creative abilities, to teach the skills and attitudes that are now essential for economic success but which our education system is not designed to promote—Robinson *et al* (1999:14).

> … Throughout the industrial world, education systems face unprecedented challenge. On the economic front, the battle of ideas has largely been won. What was a gradual and is now a massive invasion of industry and commerce by new technologies is already taking us beyond the information society into the knowledge world—one in which the countries with the strongest educational base and the highest levels of skill will win the economic prizes—Bayliss *et al* (1999:2).

The 'knowledge world' highlighted in the last of these two statements has now been identified as crucial, but the basis of technological continuity and progression, from the Stone Age to the way we live now, has always been knowledge-based. Because of the huge cultural problems in our society, the critical mass never had the opportunity to understand our dependence on knowledge building on knowledge as the foundation of all technology.

But more than that, if we are not taught to value technology as the generic **creative** system of humankind that has brought us from the Stone Age to the way we live now, how can we hope to husband the material resources of the world as more and more countries clamour to become industrialised in order to raise their standards of living?

How will young people manage the conflicts between pollution, the quality of their living standards and the quality of environmental life, in a world with a population that continues to grow?

As the most powerful animal on earth, achieved through our tools and technologies, how is humankind going to protect all other animal species? If we do not, we threaten ourselves.

Lastly, how will young people acquire the necessary knowledge base to make some very difficult decisions before the end of the 21st Century?

Chapter 9

Summary and discussion

A nation's wealth is in its people
Halsey et al—(1968:38)

09.01 Introduction

The purpose in this chapter is to reflect on the argument presented in the thesis as a whole, and to demonstrate both the historical and cultural continuity and progression inherent in technology.

From the outset, through imaginative creative activity, humankind has pushed the frontiers of technology because humankind has always been pulled by an inner compulsion to make change happen. Specifically, humankind has made change happen first with its tools and subsequently with its technologies-as-tools, to enhance productivity and/or capability, and in every field of human experience; technologies are tools. However, although without exception we are all tool-users, relatively few are tool or technology makers—the makers of change.

At first, the discussion in this chapter will trace the thread of technological continuity and progression from the Stone Age to more recent times. Subsequently, all the research will be reviewed, including the outcomes of exercises designed to test for technological understanding in the context of sustaining ourselves as a society.

Early in this research, it became evident that it was important to try to understand why humankind had separated from all other animal species; this became the subject of Chapter 3—The origins of technology.

09.02 The origins of technology

Technology evolved as the means by which humankind developed a degree of freedom not shared by other animals. Other animals evolved specialised physiques to survive in their surroundings, and were thus restricted in their habitats—page 21-24.

Humankind used its imagination, learned from experience and invented tools. Humankind used its imaginative hand/eye coordination skills on the available stone materials, and learned about the properties of the materials by which it was surrounded—page 21-24.

Because Stone Age humankind learned to make and use tools as extensions of itself, the human species was not constrained by its habitat. Humankind could pick up and put down its tools as it chose, and was free to wander—page 24.

Today, the tools we pick up to use for some purpose, come from an astonishing inventory of sophisticated aids that enhance our productivity and/or capability, and in ways that we soon learn to take for granted. When we have finished with those tools, we can put them down, or turn them off, until next required.

Culture, as collected and learned preferable forms of behaviour, was explicit in the evolutionary technological processes of humankind. Settled agriculture created the platform from which humankind could use its imaginative gifts to further explore the properties of available materials, and to discover how those properties could be utilised in ways to enhance creativity, productivity, and capability—page 25.

Humankind extended its capability and productivity by inventing settled agriculture and herding. Thus farming communities could produce beyond their immediate needs. What they did not need, the 'extra produce', was used to barter for artifacts produced by artisans. By 7000 BC, artisans were producing pottery for storage and cooking—page 26.

So economic infrastructure was first established on farming communities; artisans made artifacts to trade for some of the 'extra produce'. Trading became part of the culture. An interdependency was established between those with the skills and resources to produce more than was required for their immediate needs, and those with useful artifacts to meet perceived needs—page 27.

The artisans were also producing beyond their own needs, and survived because of their imaginative ideas in combination with their hand/eye coordinated skills. Barter as the basis of trade was eventually replaced by a system of coinage, but not before 640 BC—page 27.

Within their socio-economic communities, the inhabitants learned to develop the skills for which they had the greatest aptitude and knowledge of the necessary resources. By bartering their produce, both farmers and artisans were competing and surviving through their knowledge and skills, and technology was at the core—page 28.

09.03 The evolution of technology

Technology evolved through the imaginative gifts of humankind—Bronowski (1979:20). Humankind has an aptitude for formulating and structuring ideas—Oakley (1972:3). From the earliest times, humans learned about the materials by which they were surrounded; their acquired knowledge was used to make tools to enhance survival—page 51.

Ideas as visual images were slow to emerge during the Stone Age. As the creation of new ideas and knowledge gathered pace, it was shared. The learning spread, and so more ideas and discoveries emerged that further enhanced the capability and productivity of humankind. Thought and action were inherent in pre-literate societies—Usher (1954:59)—page 51.

The inventive process as social cumulation has only comparatively recently been understood —Usher (1954:68). When innovation occurs, it does so as a convergent synthesis—Usher (*ibid*). The creative inventive process is arguably dominated by visual non-verbal images that require acts of intuitive insight to achieve innovation—Ferguson (1977:827)—page 51.

Technology and tools are inseparable. Technology was pivotal in the evolution of humankind; it represented the product of imaginative activity. As humankind evolved, technology was significant in the development of the mind—Usher (1954:2)—page 51.

Primitive societies were totally dependent on their technologies. Equally, the evolution of technology in western industrialised societies has produced a state of total dependency, but this is is not widely understood. Historians and sociologists acknowledge the powerful influence of technology, but they have not considered the role of machine tools—Woodbury (1972a:Preface)—page 52.

There were many pioneers in the field of machine tool development. As tool-makers, their achievements appeared in the workshop, to be admired only by engineers—Rolt (1965:11). The machine-tool-makers were the 'backroom boys' of the Industrial Revolution—Rolt (1970:128)—page 52.

The earliest machine tool was probably the lathe. Turned artifacts date from as early as 700 BC—Woodbury (1972d:20/21). The evolution of the lathe supports the theory of multi-linear convergent synthesis. Early lathes were cord-driven—Bronowski (1979:78). A more rigid lathe construction did not appear before the 14th Century—Woodbury (1972d:44). Rigidity of construction was essential for precision turning and precision engineering—p52.

The skills and techniques of precision evolved first with clock and instrument makers—Rolt (1965:23). The precision instrument makers had a profound effect on technology—Rolt (1965:38). They provided scientists with instruments capable of accurate measurements to an extent previously unknown—Rolt (*ibid*). Scientists were able to 'formulate theories' that engineers could use in place of empirical methods—Rolt (*ibid*).

By the middle of the 18th Century, the move from theoretical to applied science was in its infancy, so the impact of 'scientific discovery on practical technology' was insignificant—Rolt (1965:38)—page 53. During this period, machine-tool precision was feasible only on a miniature scale; it could not be scaled up for heavier industrial uses—Rolt (*ibid*)—page 53.

The industrial lathe came of age by the middle of the 19th Century—Woodbury (1972d:96), with a significant list of design criteria as social cumulation. By this time, a range of special-purpose machine tools had also evolved. The lathe and these machine tools evolved because of imaginative creative activity continually at the forefront of mechanical methodological knowledge, and importantly, further new materials technology—page 53.

At the simplest level, a characteristic format of technology has prevailed spanning the evolution of humankind from the Stone Age to the Space Age. Humans enhanced their creativity, capability and productivity by making tools from the materials they found around them—page 54. But the knowledge of humankind built on knowledge as cumulative acquisition, and was manifest as social cultural achievement in their tools; progressively their tools became more sophisticated. Eventually humans learned to work with precision, the key to interchangeable parts and mass-production. And the technological imagination that enabled mass-production has brought us to the way we live now—page 54.

All the modern technologies upon which we now depend have a matrix of multi-linear components that were the products of imagination at some time in the past. In new strategic inventions, multi-linear components have a mutual dependency, and precision makes possible all the technologies required by any modern industrial society—page 55.

Prior to the second half of the 19th Century, the influence of science in industry was less significant. The knowledge of humankind has built continuously on knowledge, thus providing the impetus for the technological continuity that has brought us to the way we live now. The process of invention as social cultural achievement evolved in mechanical knowledge, and before humankind had learned to organise and acquire new knowledge on a scientific basis—page 56.

Science became increasingly influential, but as an additional source of organised knowledge. As a further source of knowledge, science offered new understanding and explanations for methods that had become traditional or empirical, and were based on imaginative practical technology. The contributions made by science would not have been possible without practical technology, nor without the resolution of precision technology—page 53.

Technology is the generic creative system by which we live, by which we survive, and by which we advance our creativity, capability and productivity on every front of human experience. The driving force for technological change, now aided by science and mathematics, has always been a human inner compulsion to create further enhancements in capability and productivity. Here in summary is the essential place of technology in a western industrialised society—page 56, but how widely is this understood?

09.04 Technology, Industry and Wealth Creation

The relationship between industry and technology is vital in the culture of any society, particularly in an industrialised western society—page 57.

The greatest part of human existence has been supported by technology based on mechanical principles 'without much … theoretical understanding'—Cotterell (1990:11). Only recently has science become dominant in the creation of new technology—Cotterell (*ibid*). But technology with a scientific basis depends on practical mechanical technology, and typically through the imaginative mastery of precision to achieve utility—page 59.

As the generic creative system of humankind, technology has undergone a structural change as knowledge continues to build on knowledge through the ages. The ever-changing nature of technology was evident with the examples in chapter 5. They showed how humankind used technology to support local economic infrastructures—page 86.

By 1831, Faraday had found the relationship between electrical and magnetic effects—Bowers (1990:4); the basis of the new technology was scientific. Electricity generation and supply were not feasible without the technologies of precision engineering as introduced by Maudslay in the late 18th Century—Chapter 4, page 47.

Electricity was yet another example of a new convergent synthesis, and like all technology it was the product of the creative visual imagination of humankind. As a new technology, electricity generation and supply systems gave birth to a growing range of electrical and electronic products and industries—Byers (1988:90-96)—thesis p86-87, that is ongoing.

Since technology is as old as humankind so is the design process, but that is not the usual perception. In business and industry, design is perceived as a phenomenon of 'the eighties' —Gorb (1990:15), and considered *now* to be 'an inescapable concern of every company'—Oakley (1990:3). Furthermore, good design is perceived to be essential for manufacturing industry, and important for competitiveness—Roy (1990:49)—page 87.

Design has always been an intrinsic part of technology. The place of design in our lives would be better served had technology been perceived as the generic creative system that has brought us from the Stone Age to the way we live now. But such perceptions required the introduction of technology as a National Curriculum subject long, long before the Education Reform Act of 1988—page 87.

For industry, design is a complex process of making choices and decisions about product appearance, product functionality, product manufacturing methods, and a suitable functional organisational structure. Appearance has long been perceived as the essential outcome of the design process—Forty (1992:6), an entirely erroneous assumption—page 87.

The expectations of consumers have become increasingly significant in product design. In the 18th Century, Wedgwood found it necessary to prepare instructions for every stage of manufacture to achieve 'absolute consistency'—Forty (1992:34)—page 87. Providing the consumer with cheaper products of a uniformly high standard required different workforce skills. Separating the stages of manufacture paved the way for greater use of machines and further reductions in production costs. But in the mid-19th Century, machine manufacture was considered to have corrupted extant craftsmanship, and it was widely held that 'machines led to inferior design'—Forty (1992:42)—page 87; another erroneous assumption.

In 1801, the population of England and Wales was nine million; $2^{1/2}$ million of these lived in towns. By 1851, the comparisons were eighteen and ten million, due in part to the change from an agrarian to an industrial [technological] economy—Rolt (1988:138)—page 88.

Definitions of technology make reference to social groups, or people and machines. The material culture of humankind is sophisticated and complex—Cotterell (1990:1), and has been reflected in the social structures through the ages—page 88.

Complex products require intricate organisations to manage the development process. The type of product influences the organisation, and dictates the range of intellectually driven specialisations and skills that are required. As technology moves on, so do organisational structures—page 88.

Organisational modes of behaviour or 'cultures' can arise that threaten competitiveness. To overcome such problems, when there are many technical responsibilities and functional inputs, 'matrix' organisational designs are recommended—Farish (1995:33). The matrix structure retains strong departmental functional identity, with cross-linking—Wilson (1990:131). Currently, it offers 'better' management of the 'turbulent environments' of the complex [technological] innovative processes—Wilson (1990:130)—page 88.

The government is concerned about the performance of British industry. However, this research shows that industry is disparaged in the UK, and the role of industry as wealth creator for society and the state is a function that is not widely understood—page 89.

09.05 Technology and Culture

Technology is a system intrinsic in every human society; every society uses tools. As a response to 'biological drives', every society develops its own 'solutions'; these 'alternative solutions' are known as 'cultures'—Argyle (1976:78). Technology is inherent within the survival solutions of every society, and hence in culture—page 108.

By the 1830s, the technical changes that had transformed the methods of manufacturing production were described as *Industrialism*—Williams (1990:xiii). But the changes due to *Industrialism* also changed society as a whole, hence *Industrial Revolution*—Williams (1990:xiv)—page 108.

The new technologies of the *Industrial Revolution* enabled cheaper products. Through entrepreneurial drive, these products were sold in new markets in greater quantities, so creating more employment, wealth and prosperity for the UK—the dynamics of societal change—page 108. The word culture acquired extra meaning as a response to the 'changes in social, economic and political life' that had influenced the words *industry*, *democracy*, *class* and *art*—Williams (1990:xvii). Since technology had influenced the nature of industry, it similarly influenced the development of meaning in the words *industry*, *democracy*, *class* and *art*—page 108.

Humankind has been dependent on tools since the Stone Age. The tools inventory of humankind has expanded significantly by all the new technologies. Every generation was born into a level of technology that was taken for granted through socialisation, but these processes and our dependency on tools and technology were never understood—page 108.

Since the Stone Age, the knowledge of humankind has built on knowledge as social cultural achievement, and yielded an inventory of tools and technologies-as-tools that is astonishing in its variety, and in its breadth and depth. Technology has evolved alongside humankind as a primary intelligible system, but this also is not widely understood—page 108.

Culture is present 'all the time'—Flinders (1991:88), pervading and determining the whole of human behaviour—Rosaldo (1989:26), but without training it is not easily perceived—Flinders (*ibid*). Culture is the basic structure through which life is experienced—Flinders (1991:88). Equally, for a western industrialised society, technology is present all the time, pervading and influencing the whole of human behaviour, and provides a basic structure through which life is experienced; without appropriate education and training this is also not easily understood—page 108.

Culture is used in reference to 'intellectual' and 'artistic activity'—Williams (1988:90). For humankind, the eloquence of imaginative expression appears not only in music, literature, painting and sculpture, but also in the tools and technologies of humankind which have brought us from the Stone Age to the way we live now—page 108; this too, is not understood.

Mechanical knowledge was identified and applied throughout most of the life-span of humankind, with little 'theoretical' grasp—Cotterell and Kamminga (1990:11). The Greeks exalted the pure and theoretical sciences while disparaging mechanical research or 'practical application'—Landels (1997:187)—page 108.

But it was practical application, driven by the creative imagination of humankind, that has brought us to the way we live now, and in every field of human experience. In early 17th Century Britain, 'mechanical' was used regularly to refer to 'routine, unthinking activity', an example of 'social prejudice'—Williams (1988:201)—page 108.

09.06 Technology in Education - statutory considerations

Our educational system was designed around the needs of the upper classes; since they were wealthy the economic demands of the nation came second. By design, the economic needs of the nation became the burden of the industrial classes. The social gap between the upper classes and their educational systems, by comparison with the industrial classes and the education specified for them, ensured that there was no esteem attached to working in industry; this huge cultural prejudice still exists—page 140, and remains deep in our psyche.

Attempts to change the curriculum to reflect the economic needs of the nation have been on-going for more than a century. There has been a great deal of legislation and debate of the issues, but in reality not much has happened in the context of changing the education system (or the culture) so that sustaining ourselves as a society became a matter of priority—p140.

The material studies were seen as important, but only for the industrial classes. There was no grasp of the relationship between the images visualised through the imagination, and the realisation of those images by skilled hand/eye coordination into the tools and technologies upon which we are now so dependent—page 140. The most sophisticated technologies cannot be realised as products without visualisation, without precision technology to the fore, and the application of imaginative hand/eye coordination.

From the earliest days 'practical subjects' have had 'low status' in the 'academic hierarchy' —Penfold (1988:20). For more than a century, there has been 'official obeisance to the educational value of practical subjects' in the curriculum—Penfold (1988:20), which our opinion leaders have perpetually undermined—page 140.

There is a cultural obsession with the practical aspects of technology, and a failure to see the intrinsic intellectual creative content as a necessary precursor of the practical content—page 140. Opinion leaders disparaged and under-rated the intellectual challenge of technical education. The evidence suggests that they also failed to understand that the skills pyramid of competitive companies require a foundation in the imaginative creative hand/eye coordination skills, progressing to intellectual technological knowledge together with leadership skills at the apex.

For the best part of two centuries, the developmental process of the system of education has been one of seeking change every few years. This change process was usually authorised by parliament or government departments; their terminology attributed value to curriculum subjects such as the classics, science and maths. Equally, it was their terminology that attributed a lack of value to industry. 'Textual materials that survive over long periods often reflect an elite bias'—Weber (1990:11)—page 140.

When prominent opinion leaders apply value judgments, they disclose their cultural preferences, and establish standards for others to follow. When defining the direction to be taken by education, these opinion leaders employed terminology that provided 'statutory sanction' for disparagement. Such values have cascaded through the sub-culture of education and on into society; unfortunately for our society, these lessons have been learned all too well—page 141.

Thus in our society, no social esteem is attached to working in industry, even though the products and services of industry are the life-blood of society. Without exception we are all tool-users and consumers of technology, and furthermore we are totally dependent on technology, and the products and services of industry—page 141.

Critically, since our society is 'technically illiterate'—Sharon (1989:55), our dependency on technology and industry is not understood. But, significantly, little social stigma attaches to being 'technologically illiterate', and therefore 'only partly educated'—Penfold (1988:21).

From this state of being only partially educated, it maybe argued that sustaining ourselves as a society has never been a matter of sufficient 'learning' priority within the culture of our opinion leaders, nor their preferred educational systems—page 141.

09.07 The perception of technology

09.07.01 Anti-business sentiments

Before 1760 there was no prolonged and concerted hostility towards business and industry in the UK, but that changed in the period up to 1790. This change was driven by forces outside education, but the cultural context and associated value judgments persist, and are relevant here—page 148.

'The businessman was made a scapegoat for a wide range of alleged social and economic ills becoming a target of abuse as a means of illustrating, preserving and extending specific class values during a period of marked social upheaval and readjustment'—Raven (1985:137), caused by the Industrial Revolution—page 149.

The popular literature between 1760 and 1790 provided a clear picture of the growth 'of anti-business sentiment'—Raven (1985:139). The successful entrepreneurs were targeted because' of their 'vulgar display' of 'newly acquired wealth', and their 'social ambitions'—Raven (1985:140)—page 149.

Between 1760 and 1780, 'popular … literature' provided an ongoing 'fictional milieu of country gentlemen and provincial nobility' that contrasted sharply with 'the representation of the men of trade'—Raven (1985:140)—page 149.

The literature of the 1790s, displayed 'much fiercer' malediction of 'trading families'; heroine figures were portrayed 'struggling … against arranged marriages with men of recently acquired' wealth—Raven (1985:141)—page 149.

First-generation traders and industrialists were cognizant of the attitudes of 'polite society'. The second-generation sons who inherited the businesses sought to become more acceptable in society. They exhibited 'gentlemanly values' and 'country seat' aspirations, and 'modern Britain … lost out on the technological revolution'—Raven (1985:4)—page 151.

09.07.02 Anecdotal evidence

There are some 65 anecdotes in Appendix 5; they are presented not as criticism, but as examples of what was learned in the absence of positive instruction about the role of technology, industry and business—page 151. What was learned, was almost entirely negative, and poured widespread scorn with statutory sanction on both the creative intellectual and practical hand/eye coordination skills associated directly with enhancing our productivity and capability as a society—page 151.

In isolation, many of the anecdotes are not remarkable; this helps to shroud the prejudice endemic in our society. When these anecdotes are considered collectively, a picture of societal prejudice and ignorance towards industry, trade, business, profit, wealth creation, and engineering, emerges from almost every walk of life, particularly education. The author contends that it is this societal prejudice that undermines our technological creativity, productivity and capability, and threatens our standard of living as a society—page 152**.**

<u>09.07.03 Attempted cultural change through curriculum</u>

In addition to Technology, the 1988 Education Reform Act made a concerted effort to recognise the need for Economic and Industrial Understanding (EIU); it was introduced as a cross-curricular theme, and teacher training was similarly influenced—page 155.

Although the majority of opinion perceived no compulsion about the delivery of EIU in the curriculum, Craft (1995:159) argued:

> Thus, within parts of the statutory curriculum (and despite Dearing's proposals to slim the curriculum and its assessment) relevance to work and the economy is now something to which all pupils from 5 years upward are entitled by law … .

Dearing made no direct reference to cross-curricular themes, but he concluded (1993:27):

> The challenge facing the world of business and industry is as obvious as it is severe. To survive, let alone prosper, it is necessary, day in and day out, to aim for and achieve standards previously thought unobtainable … .

In the context of EIU, the introductory exercises with teachers and student teachers showed the extent of their cultural prejudice—pages 155-160. This should cause no surprise; the positive benefits of industry have never been taught, neither as part of the curriculum nor in teacher training. Indeed, disparagement of industry by statutory sanction has filled the void in the absence of positive instruction about the role of industry and technology in society—page 160.

However, when student teachers had the opportunity to learn not only about industry in the community, but to reflect on the prejudice of their own sub-culture, they were horrified at the lack of sensitivity, the ignorance about industry, and the cultural damage inflicted—pages 160-165.

09.07.04 Statistical survey

The 3-page questionnaire that yielded the raw data for statistical analysis, was designed around the philosophy contained in the quote at the beginning of this chapter namely: *A nation's wealth is in its people*—Halsey *et al* (1968:38). This approach considered the cross-curricular nature of technology, and its importance to industry as our society attempts to sustain itself. The extracts from the National Curriculum summarised in Appendix 6, exemplify this philosophy. In short it has to do with 'earning our keep'—Graffy (1988:8). As adults we know the importance of an income to set-up home—Owers (1999:5), but how effectively do we transfer that model to the national situation?

Society has four basic aims: 'survival', 'progress', 'caring and sharing', and the 'luxuries of life'—Graffy (1988:2). How well these aims are supported is dependent on the level of societal prosperity—Graffy (*ibid*), a point also well made by Robinson *et al* (1999:5):

> It is emphasised the urgent need to unlock the potential of every young person and argued that Britain's economic prosperity and social cohesion depend on this.

So in the context of 'prosperity' for any society the creation of wealth, and its distribution is of paramount importance both at the regional and national level; Fig. 9.01 below provides a good illustration.

Fig. 9.01 illustrates the socio-economic impact of a group of food manufacturers, showing the contribution made in so many ways through money flowing into the local community, the national economy, and the sources of employment. The corporation tax contributed to the Gross Domestic Product, the source of the general fund used by government to pay for all the services society expects and demands from the state—Owers (1999:5).

Given that technology as a curriculum subject only received full statutory sanction with the 1988 Education Reform Act, great strides have been made. However, the detailed analysis contained in Appendix 7, and the summary in pages 165-174, show that there are many causes for serious concern. Among those concerns is the status of cross-curricular themes which in some cases can only be described as ambivalent. Treating the mechanism of sustaining ourselves as a society (EIU) in an equivocal way, does not make sense given the demands and expectations of our society on all the public services, including education.

But a change in educational philosophy is emerging; at long last education is seen as an investment in 'human capital', and vital for the 21st Century—Robinson *et al* (1999:5). Furthermore, it is argued, preparation for the 21st Century will require more than simply improving 'literacy and numeracy skills', and '… Britain's economic prosperity and social cohesion depend on this'—Robinson *et al* (*ibid*).

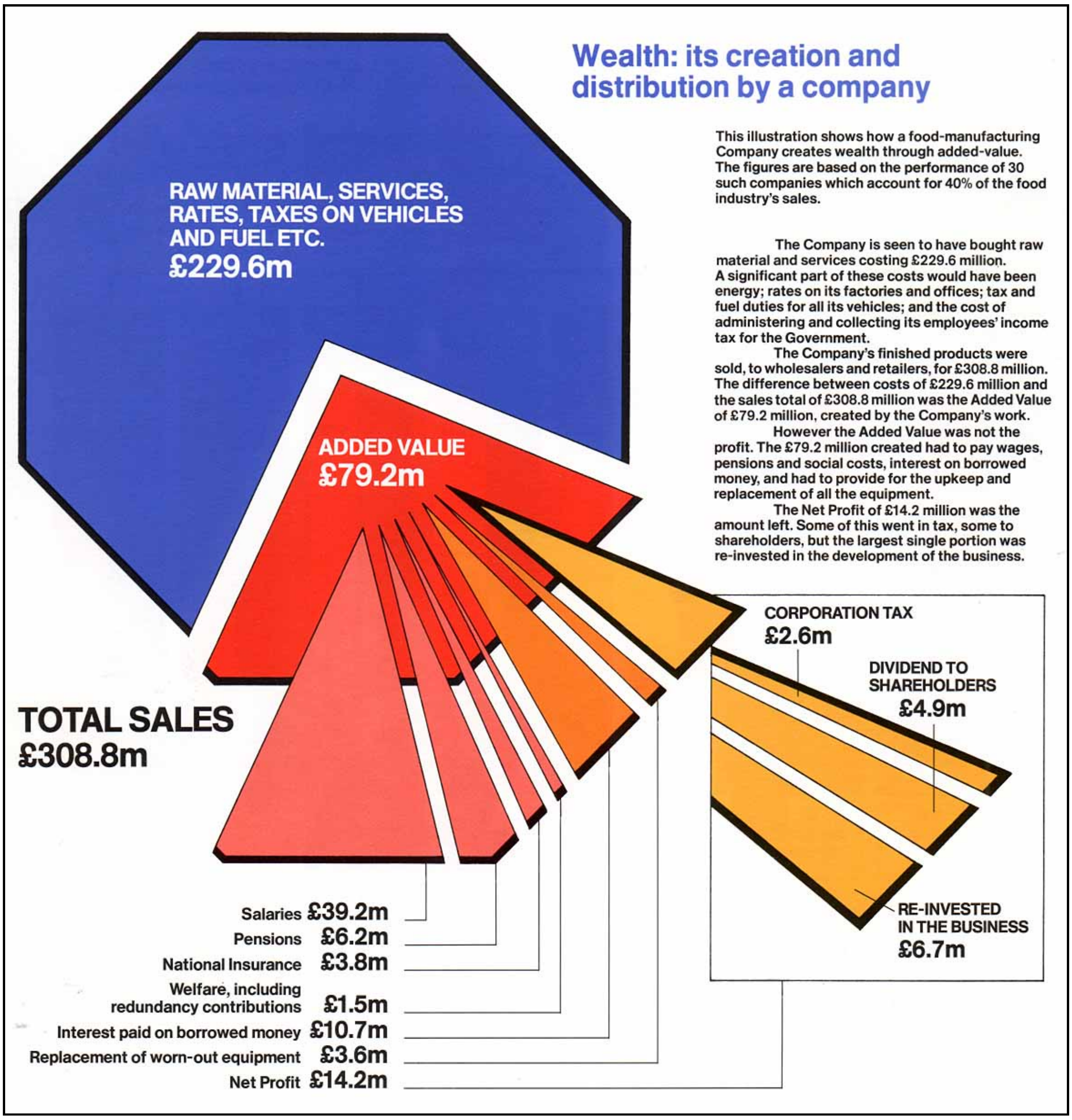


Fig. 9.01 - Example of wealth creation by a group of food-manufacturing companies see Graffy (1988:7)

The challenges now faced by education are 'without precedent'—Robinson *et al* (1999:5); the statistical analysis, and many other parts of this thesis, shows clearly the nature and enormity of those challenges. But with the value judgments dominant in our culture, how can we hope to meet those challenges?

<u>09.07.05 Transcriptions content analysis</u>

The transcriptions came from eight groups of people as follows:

- D&T teachers
- Humanities teachers
- Parents in technology jobs
- Parents in non-technology jobs
- Technology student teachers
- Humanities student teachers
- Technology A-level students
- Humanities A-level students

A one-page schedule was used for the recorded interviews, and 62 transcriptions were produced; the analysis was presented in Appendix 8, and summarised in pages 174-184. The purpose of the schedule was to ascertain what was known and understood about technology, but also to test for economic and industrial understanding.

All eight groups were able to express what they thought was meant by technology, but for one group 'parents in non-technology jobs', one individual 'did not know'. Also, two parents in technological jobs expressed some uncertainty about the meaning of technology, and this result shows the problems with the lexicon as experienced by Malpas (1999:3).

In the 'creative word' sub-set, 'imagine', 'intellectual', and 'invent' were not used by members of any group—Fig. A8.04.

The link between technology and the national economy was poor; across all groups there were only 11 KWIC; of these, parents in technological jobs used 6 KWIC—Fig. A8.08.

The status of cross-curricular themes, particularly EIU, was again found to be ambivalent, and a seriously disappointing outcome given the importance of these themes for our society.

In the context of what was meant by Economic and Industrial Understanding (EIU), many responses indicated some understanding, but fell short of the crucial role of industry as a source of wealth-creation and jobs integrated within a local community. The overall grasp of the importance of sustaining ourselves as a society was very poor—Fig. A8.21.

Also in the context of what was meant by EIU, technology teachers perceived more relevance in D&T, Maths and Science than the humanities teachers, but the humanities teachers perceived more relevance in Art, English, Geography, History and Foreign Languages. Both outcomes present causes for serious concern since technology is completely cross-curricular—Fig. A8.24.

None of the parents in technological jobs perceived any relevance for EIU in the subject of Art, but this is general and a serious cause for concern—Fig. A8.25.

By inspection of Fig. A8.26, it maybe seen that with the exception of Geography and History, the technology student teachers attributed greater relevance in curriculum subjects to EIU than the humanities student teachers.

The idea that 'technology is everywhere' was well understood; the concept of 'technology as tools, artifacts, products or systems to use' was also well understood. Technology as the by-product of human activity was not easily identified—Fig. A8.30.

The D&T teachers and Technology student teachers visualised greater personal benefit from technology than any other groups—Fig. A8.31. In reality, all groups have benefited from technology to a significant extent, but this was simply not perceived.

Across all sub-groups, there were some 109 responses supporting the idea that our society had benefited from technology, and some 58 examples were given; but there were some 75 expressions of concern about technology—Fig. A8.32.

The level of societal dependency on technology as perceived by the eight sub-groups was as shown in Fig. 9.02 below:

Parents in technological jobs -	91%
Technology teachers -	88%
Humanities student teachers -	87%
Technology student teachers -	86%
Humanities teachers -	85%
Humanities A-level students -	79%
Technology A-level students -	76%
Parents in non-technological jobs -	71%
Note: See Fig. A8.33.	

Fig. 9.02 - Level of societal dependency on technology as perceived by eight selected sub-groups

Although each sub-group was small in number, there remain causes for serious concern with these results, and particularly with the younger age groups. Without exception humankind is a tool-using animal, and we use tools and technologies as extensions of ourselves in every field of experience. Humankind is able to pick up and put down its tools whenever it pleases, but we remain totally dependent on tools and technologies in every field of human activity. As we adopt each new level of technological productivity and capability, we contemplate reverting to earlier levels less and less. Humankind has also become the most powerful tool-user on planet earth, but has humankind yet recognised the enormity and nature of this responsibility?

09.07.06 Summarising the perception of technology

In addition to technology as a National Curriculum subject, the 1988 Education Reform Act introduced Economic and Industrial Understanding (EIU) as one of five cross-curricular themes. The introduction of EIU was long overdue, and an essential step in the process of correcting a culture in which the critical mass of opinion leaders consistently disparaged industry and technical education, but without realising the impact of their philosophy. The evidence includes:

1 A study of *English Popular Literature and The Image of Business 1760–1790*, by Raven (1985), demonstrating the origins of hostility towards business in modern Britain. Two aspects were considered: (1) 'the commercial growth of the book trade and the social

impact of popular literature', and (2) the 'attitudes' and 'prejudices' in the literature 'promoted' by the 'writers' and 'booksellers'—Raven (1985:1)—p148. And 'modern Britain … lost out on the technological revolution'—Raven (1985:4)—page 151.

2 Our educational system was designed around the criteria of the upper classes, and since they were wealthy the economic demands of the nation came second. By design, the economic needs of the nation were left in the hands of the industrial classes. The social gap between the upper classes and their educational systems, by comparison with the industrial classes and the education specified for them, ensured that there was no esteem attached to working in industry, or receiving a technological education—page 139. These prejudices are still firmly implanted in the value judgments of our society; they threaten the collective productivity and capability of our society, and hence our standard of living.

3 Anecdotal evidence - Appendix 5 contains some 65 examples of the prejudice endemic in our society, but the bulk of the population would not be able to spot these damaging sentiments. Indeed, they would see nothing wrong with such sentiments when they were pointed out to them. In isolation, many of the anecdotes are not remarkable, but collectively, a picture of societal prejudice and ignorance towards industry, business, trade, profit, wealth creation and engineering, emerges from almost every walk of life. **It is this societal prejudice that may lead us along the path to ultimate national poverty.**

4 Curriculum change - In the context of EIU, the introductory exercises with teachers and student teachers showed the extent of the cultural prejudice—page154-159. This should cause no surprise; the disparagement of industry and technical education by statutory sanction has been a peculiarity of our culture, and long filled the void in the absence of positive instruction about the roles of industry and technology in society—page159. But when positive instruction had been received, student teachers were horrified by the prejudices of their culture—pages161-164.

5 Statistical survey - the detailed analysis in Appendix 7, and the summary on pages 164-173, show that there were many causes for serious concern. Among those concerns is the status of cross-curricular themes which in some cases can only be described as ambivalent. Treating the mechanism of sustaining ourselves as a society (EIU) in an equivocal way, does not make sense given the demands and expectations of our society on all the public services, including education. As adults we know the importance of an income to set-up home, but the critical mass are unable to transfer that model to the national situation; they have never been taught how.

6 Transcriptions content analysis:

+ in the 'creative word' sub-set, 'imagine', 'intellectual', and 'invent' were not used by members of any group—Fig. A8.04,
+ the link between technology and the national economy was poor—Fig. A8.08,
+ the status of cross-curricular themes was again found to be ambivalent,

+ the overall grasp of the importance of sustaining ourselves as a society was poor —Fig. A8.21,
+ technology as the by-product of human activity was not easily identified—Fig. A8.30.

Many initiatives have been promoted by minority groups to address the perceived short-comings of the curriculum; a selection of these will be discussed in the next section.

09.08 Independent curriculum related initiatives

The anecdotal evidence in Appendix 5, summarised on page 211, also showed the direction in which change was needed. The RSA[6] were at the centre of a … campaign 'to transform attitudes which were perceived to be a root cause of Britain's long relative economic decline' —Chandler (1998:38). In particular, 'a change of attitudes towards those activities which provide the nation's wealth would be required'—Chandler (*ibid*).

After two years in the planning, Industry Year *1986* was launched as a national initiative with targets in 'three broad categories':

- 'to increase awareness of industry's role in national life,
- to extend initiatives linking education and industry,
- to encourage action within industry itself'—Chandler (1998:39).

Of these three, education was deemed 'the most important … where long term change … could be achieved … and increasingly took centre stage'—Chandler (*ibid*).

Before Industry Year *1986*, there were few initiatives dedicated to schools/industry link activities. There were some such as Understanding British Industry (UBI), Geography Schools Industry Project (GSIP) or Schools Curriculum Industry Partnership (SCIP).

From 1986, there was a significant growth in the field of schools/industry link initiatives. Education Business Partnerships were also introduced and run by LEA's; they provided central coordination of the services designed to encourage schools/industry link activities, because it was economically important for society, both regionally and nationally.

Government support for these initiatives was verified by the Foreword in a Directory of School/Industry link initiatives, signed by no fewer than three Secretaries of State, and published by HMSO. The foreword shows clearly that Government were trying to make education more relevant in the context of sustaining ourselves as a society—Appendix 11.

A summary of some 35 initiatives appears in Appendix 11, and this list is by no means exhaustive. Collectively, the aims of these groups maybe summarised as follows:

[6] The Royal Society for the encouragement of Arts, Manufactures and Commerce

- to increase understanding of the necessary place of industry and commerce in the creation of the nation's wealth, and the need for a positive and open-minded attitude to industry and commerce,
- to encourage links locally,
- to encourage the integration into the curriculum of provision for Economic and Industrial Understanding,
- to popularise science, stimulate discussion about science and technology,
- promote developments in schools to enhance young people's understanding of science, engineering, industry and technology, and the related social consequences,
- to bring about closer understanding between schools at all levels of education and industry,
- to increase public awareness of the role of engineering in society, and demonstrate the direct and beneficial impact good engineering has on everyday life,
- promotion of staff development within teacher training so that issues relating to enterprise, economic and industrial awareness were incorporated in all courses for trainee teachers,
- provide opportunities for young people to spend six months in industry or commerce between leaving the sixth form and going into higher education,
- to help teachers to influence school curricula and examinations, bringing the lessons taught in school more into line with the needs of adult life.

As Industry Year *1986* came to a close, the momentum was taken-up by Industry Matters which ran to the end of 1989—Chandler (1998:40). Both 'success and failure' were claimed; success because the initiative 'had made its mark'—Chandler (1998:41). Failure 'because the momentum … eventually foundered on institutional jealousy, political ambition and apathy' —Chandler (*ibid*).

Success was also claimed because 'never again would education and industry regard each other with the same degree of ignorance and hostility'—Chandler (1998:41), an inference hardly supported by this research. In reality, how could any of these laudable initiatives succeed fully when they were not only bolt-on, but the value judgment issues within the hidden curriculum were almost certainly never addressed? Surely much more would have been achieved if the prejudice endemic in our society, and the motivation for the initiatives, had been put in context together with the need for technology?

In the next section, before discussing knowledge and educational philosophy, the recent growth in technological activity will be considered.

09.09 The growth of technological knowledge and activity

On 7th March 2000, the Department of Trade and Industry hosted the '"Knowledge 2000" - Conference on the Knowledge Driven Economy'—DTi website[7]. The importance attached to this conference maybe gauged by the list of people making speeches—Appendix 12. The first four speakers and their topics were:

[7] http://www.dti.gov.uk/knowledge2000/guterres.htm

- Stephen Byers, Secretary of State for Trade and Industry, 'The importance of the Knowledge Economy',
- David Blunkett, Secretary of State for Education and Employment, 'The development of skills through education',
- Tony Blair, The Prime Minister, 'The Knowledge Economy - Access for all',
- Antonio Guterres, The Portuguese Prime Minister, the 'European perspective'.

Extracts from their presentations include:

- Stephen Byers — 'The new economy - the knowledge driven economy - has as its cornerstones learning, skills, innovation and enterprise.'
- David Blunkett — 'The knowledge economy is clearly a reality and not a slogan, but it doesn't yet impinge on the consciousness of the millions of people who are interested in whether they have got a job, whether their kids are getting a decent education, ….'
- Tony Blair — I strongly believe that the knowledge economy is our best route for success and prosperity.… The new knowledge economy is here, and it is now.'
- Antonio Guterres — 'Innovation and knowledge are increasingly becoming the decisive source of wealth and also the main source of difference between nations, ….'

These four short extracts make use of a number of keywords such as *learning*, *skills*, *innovation*, *economy*, and *enterprise*, as well as *knowledge*. But in these brief extracts, there were also two messages expressing genuine social concern: (1) '*doesn't yet impinge on the consciousness …*'. and (2) '*increasingly becoming the decisive source of wealth and also the main source of difference between nations, ….*'

However, since the Stone Age, human societies have always been innovation- and knowledge-driven as demonstrated by their technologies, through the Bronze Age, the Iron Age, on into the technologies and enterprise of the Industrial Revolution, to the present day.

For the UK, there were significant economic and social benefits due to the Industrial Revolution, but this is not widely understood. The pace of technological change now makes technology more visible, particularly since precision technology made feasible electricity generation and supply systems, and the subsequent spawning of so many new industries and products. These new industries play significant roles in the socio-economic fabric of the UK, both locally and nationally.

An examination of the foundation dates of learned societies provides an indication of the recent growth of technological knowledge and activity from the early 19th Century, and indirectly illustrates the pace of change. Fig. 9.03 below provides a summary of these societies by their establishment dates.

Established	Name	Royal Charter
1818	The Institution of Civil Engineers	1828
1847	The Institution of Mechanical Engineers	1930
1860	The Royal Institution of Naval Architects	
1863	The Institution of Gas Engineers	1929
1866	The Royal Aeronautical Society	1949
1869	The Institute of Materials	1899 & 1975
1871	The Institution of Electrical Engineers	1921
1874	Institute of Physics	1970
1889	The Institute of Marine Engineers	1933
1892	The Institution of Mining and Metallurgy	1915
1895	The Chartered Institution of Water and Environmental Management	1995
1897	The Chartered Institution of Building Services Engineers	1976
1904	The Institute of British Foundrymen	1921
1906	The Institute of Plumbing	
1908	The Institution of Structural Engineers	1934
1912	The Institution of Railway Signal Engineers	
1918	The Institution of Fire Engineers	
1922	The Institution of Chemical Engineers	1957
1923	The Institution of Lighting Engineers	1924
1923	The Welding Institute	
1929	The Institute of Energy	1946
1938	The Institution of Agricultural Engineers	
1943	The Institute of Healthcare Engineering and Estate Management	
1944	The Institute of Measurement and Control	1975
1945	The Institution of Engineering Designers	
1945	The Institute of Road Transport Engineers	
1946	The Institution of Plant Engineers	
1954	The British Institute of Non-Destructive Testing	
1957	The British Computer Society	1984
1959	The Institution of Nuclear Engineers	
1961	The Association of Cost Engineers	
1981	The Engineering Council	1981 & 1996
1995	Institute of Physics and Engineering In Medicine	

Fig. 9.03 - Summary of learned institutions and societies, and their technological fields

Although not exhaustive, Fig. 9.03 lists some 33 learned societies concerned with particular technological disciplines. They organised their dedicated disciplines to share knowledge, and promote further learning on a scientific basis and to gain further knowledge.

In the middle of the 18th Century, the move from theoretical to applied science was in its infancy, so the impact of 'scientific discovery on practical technology' was insignificant—Rolt (1965:38)—page 45, and this is reflected in Fig. 9.03.

Between 1801 and 1851, the population of England and Wales grew from 9 to 18 millions; the ratio living in towns changed from 2 1/2 to 10 millions, or from 28% to 55%, due to the shift from an agrarian to an industrial [technological] economy—page 87. The 'dark satanic mills' is one of the abiding and negative images of the Industrial Revolution, but the growth in national prosperity in the space of fifty years supported the doubling of the population, and in spite of all the negative perceptions, it was still a remarkable entrepreneurial and social achievement. In this context Brian Redhead (1986) narrates for the RSA:

> Although industry gave us an Empire and made Britain for a while the most powerful nation on earth, we took the rewards while disparaging the means—see Appendix 4.

The growth in knowledge of the technological disciplines began to accelerate from the early 19th Century, as shown by Fig. 9.03. The Civil Engineering technologies were the first to become established, followed by the Mechanical, Aeronautical and Electrical Engineering technological disciplines, and their dedicated institutions or societies. One of the more recent was The British Computer Society established in 1957.

Important branches of knowledge not shown in Fig. 9.03, includes the medicinal, surgical, dental and drug technologies, as well as all the food-related technologies; huge advances have been made in all of them. Those advances were only possible through the products and services and technologies of industry, and precision technology played a key role in all of them; that is neither understood nor appreciated, but it is taken for granted by our society.

The Engineering Council should be mentioned since it has a special role. Established in 1981, its aims include 'to enhance the standing and contribution of the UK engineering profession in the national interest', and to work 'in partnership with the Institutions' 'to set standards of academic achievement'—Engineering Council (2000:50).

A primary philosophical concern for all these societies and learned institutions would be to promote continuity and progression in their technological disciplines, through knowledge building on knowledge, in order to enhance the intrinsic productivity and capability for the benefit of society. Between them, these institutions hold much of the technological knowledge that underpins the way we live now, and particularly our standard of living.

As technology becomes more sophisticated, it also becomes more difficult for the technically illiterate to understand. Some of the older technologies are easier to comprehend. For example, the hot air balloon becomes airborne because the warm air trapped by the balloon envelope is lighter than the unheated air outside the balloon fabric. But the dynamics of a modern passenger aircraft are altogether more complex—Owers (1999:2). Indeed '… evidence suggests that technological traditions are far more complex than usually realised'—Merrill (1968:585).

However, when trying to come to terms with the relevance of technology, education has always been up against its own value judgments. These value judgments have always presented obstacles to the acceptance of technological education on equal scholarly merit, obstacles that prevent an in-depth understanding, and therefore an ability to see the need for change in education. The late introduction of technology in the National Curriculum, as part of the Education Reform Act of 1988, was symptomatic of those powerful obstacles.

As shown in section 09.08, the perceived need for change in education was the rationale for many independent initiatives outside education. Their primary aim was to help education to achieve change. However, for education to confront the value-judgments implicit within its own sub-culture would be extremely difficult. The diverse nature of those issues, and their impact on the knowledge required to sustain ourselves as a society will be considered next.

09.10 Knowledge and educational philosophy

In the 'Final Report', Dearing started his introduction as follows:

> '*"Upon the education of the people of this country, the future of this country depends."*
>
> 3.1 If this was true when Disraeli spoke these words in 1874 when Britain was at the height of its economic power, it is even more so today. In a highly competitive world there is nowhere to hide'—Dearing (1993:16).

As discussed on page 199, the Education Reform Act of 1988, introduced a period of significant attempted change of cultural direction, but how many noticed? And how many understood what was being attempted, or indeed why?

The acquisition of knowledge for the purpose of sustaining ourselves as a society should be highly regarded, but in the UK that was not the case; the reasons were never as straight-forward as a polarised argument. Within education philosophy there were always many tensions, and many different schools of argument (see Chapter 7), without the complication of sustaining ourselves as a society. One of the biggest obstacles has always been that 'cultures "see" what they are predisposed to see, and ignore the rest'—Hampden-Turner and Trompenaars (1995:60).

09.10.01 - Economic power and recent relative indicators

Why was Britain at the height of its economic power in 1874, and was it significant? The Industrial Revolution was first experienced in Britain; it began about the middle of the 18th Century, and by 1850 Britain was the workshop of the world—Rubinstein (1994:1).

The Industrial Revolution began in the UK because of a new convergent synthesis; some 'ingredients' could be found in other parts of the world, but the 'British combination was unique'—Ackrill (1987:4). These issues are discussed in greater detail in Appendix 13.

One indicator of the health of manufacturing industry for any country is export performance, but for society as a whole, there are other important economic indicators. An analysis of a number of factors appears in Appendix 13, and they are summarised as follows:

- in 1899, the UK had a 33.2% worldwide share of exported manufactured goods that fell to 6% by 1993—Fig. A13.01,

- in 1955, the UK's share was 19.9%, Germany (D) had 15.4%, the USA had 24.4% and Japan had 5.1%—Fig. A13.01,
- by 1989, the shares for the UK, Germany, USA, and Japan were 8.2%, 20.4%, 15.8% and 17.6% respectively—Fig. A13.01,
- exports of manufactured goods – between 1955 and 1989, total world-wide trade rose from $33.99 to $1521.1 billions; the UK share declined substantially from 19.9% to 8.2%; only the UK experienced such a loss—Fig. A13.01—see also 2nd para p227.
- patent applications by leading industrial nations between 1990 and 1999 – both Japan and Germany experienced decline, but they recovered; the UK was the only country with a continuing downward trend—Figs. A13.02/03.
- comparative growth in Gross Domestic Product of five leading industrialised countries between 1988 and 1997 – the UK had the lowest rate of growth—Figs. A13.04/05.
- comparisons of R&D expenditure in the business enterprise sectors of five leading industrialised countries between 1988 and 1997 – the UK had the lowest rate of expenditure—see Fig. A13.07.

In each of these four economic parameters, the UK had the worst performance, an inference that presents extremely serious causes for concern as we seek to sustain ourselves as a society. Two extracts from the 'Knowledge 2000 Conference' (see pages 218 and 219) capture those concerns:

> David Blunkett — 'The knowledge economy is clearly a reality and not a slogan, but it doesn't yet impinge on the consciousness of the millions of people who are interested in whether they have got a job, whether their kids are getting a decent education, ….'
>
> Antonio Guterres — 'Innovation and knowledge are increasingly becoming the decisive source of wealth and also the main source of difference between nations, ….'

The 'Knowledge 2000 Conference' was yet another attempt to refocus our culture, so that sustaining ourselves as a society mattered once again, but this has become exceptionally difficult for our society, and it was always challenging for the world of education, given its philosopical and cultural foundations.

09.10.02 - Educational philosophy

The field of philosophical debate in education is truly immense. Possibly one of the most challenging strands concerns 'vocational' and 'liberal academic education', especially the 'dominance' of the latter, and the 'failure' of the former—Sanderson (1993:189). Whether parity of esteem can ever be reached between these two forms of education, is subject to influences 'deep in the past'—Sanderson (*ibid*).

'Many of the assumptions of our academic culture are deeply embedded in the institutional framework of "what everyone knows is education"'—Young (1972:11). In the context of educational concerns, the perceptions developed by individuals resides partly in their 'institutions and traditions'—Hirst (1983:8). 'Theory' may offer 'explanation' for human behaviour in areas such as 'education', involving not only the 'sciences' and 'social sciences', but also 'matters of beliefs and values'[*sic*]—Hirst (1983:4).

There were three 'traditions of liberal education' in the Victorian period, 'classics at Oxford, mathematics at Cambridge and philosophy in Scottish universities'—Sanderson (1993:189). Liberal education was for the 'free man of independent means who did not need to use it to earn a living'—Sanderson (*ibid*). Thus liberal education gained 'prestige' by 'association with high independent social status'—Sanderson (*ibid*).

'Liberal education' also cultivated the 'dignity of mystery'—Sanderson (1993:190), as observed in the 1880s:

> However, that principle [the teaching of languages] was the same in both countries, [France and England] and may be expressed in terms applicable to both. That principle was the choice of an ancient language that could be taught authoritatively by the learned in each country. They can never teach a modern language in that authoritative way, as in modern languages their degree of accomplishment must always be inferior to that of the educated native. When the teacher assumes great dignity it is essential to its maintenance that he should be secure from this crushing rivalry, and this security can be given by an ancient language alone. Besides this professional consideration there is the effect of antiquity, and of a certain mystery, on the popular mind. So long as the people can be made to believe that a lofty and peculiar wisdom, not communicable in translations, was enshrined in Latin and Greek words, the learned were supposed to be in possession of mysterious intellectual advantages—Hamerton (1889:16).

What the Victorians described as 'instrument knowledges', were considered 'inferior', and for later study 'in the Inns of Court, hospitals, bankers' parlours or the offices of the civil engineer or estate manager'—Sanderson (1993:189). Note that there was no mention of manufacturing industry, indeed:

> For those in high places industry was something to be neither seen nor heard. It was not a calling for a gentleman! Better by far to be a land owner, a member of a learned profession, an officer of the Crown, but not, pray not, in industry! We even devised an education system which chose not only to ignore industry but to steer its ablest pupils well away from it. This cultural disparagement of industry, this snobbery, is the root cause of Britain's industrial decline!—as narrated by Redhead—Appendix 4.

<u>09.10.03 - Technological dependence but cultural disdain</u>

The educational system that evolved in Britain, was intrinsically the 'product of a society' that regarded 'what happened in schools and universities as having little bearing on the wealth of the country'—Rae (1977:11). Liberal education was 'cheap', encouraging 'vested interests' —Sanderson (1993:189). Curriculum change to include 'more science' required expensive 'laboratories', placed under central university control, necessitating a 'transfer' of funds from the colleges—Sanderson (1993:190). Thus 'cheap and "useless" liberal education' was defended by the 'college fellows' to preserve their 'financial and autonomous power status'—Sanderson (*ibid*).

Until recently, and by default, the driving forces behind the design of our educational system were such that no recognition of technology, as a culturally valued subject, was possible. Furthermore, there was no perception that tool use was inherent in every human society, and therefore an intrinsic part of every culture, including our own. Yet for a sophisticated industrialised society, tool design, tool manufacture and tool use, were always at the core of the technologies that have underpinned our standard of living, including the funding of education.

Thus it may be argued that our educational system was founded on a number of flawed assumptions, including:

1. 'As all civilisation really takes its rise in human intercourse, so the most efficient instrument of education appears to be the study which most bears on that intercourse, the study of human speech'—Taunton Report on secondary education (1868:22)—page 118,
2. there was no intellectual content in the design of processes to apply practical skills, and
3. there was no imaginative or intellectual content in the application of practical skills.

While Taunton's intentions were straightforward and symptomatic of the times, they were a grossly inadequate appreciation. Humankind separated from all other animal species because of communication skills, but more particularly because humankind excelled as a tool-maker and tool-user; these skills were probably among the earliest imaginative influences in the evolution of humankind.

The law of prior dependency, intrinsic in technological continuity and progression, as discussed on page 187, shows the importance of communication as the vehicle through which knowledge was built on knowledge, with a continuous stream of ideas and concepts as social cumulation. These ideas and concepts were derived as the product of the iterative creative loop—page 143.

The substance of the knowledge was always most crucial in underpinning our technological progression to the way we now live, and this was neatly captured in two statements:

1 '… as the forerunners of man began to be nimble with their hands in making tools and clever with their brains in planning them, the nimble and the clever enjoyed a selective advantage'—Bronowki (1979:404).

2 'The new science of *electromagnetism* (the combination of electrical and magnetic phenomena) was developed further by workers in many countries. One of the best was Michael Faraday, a truly gifted experimenter with a talent for physical intuition and visualization. That talent is attested to by the fact that his collected laboratory notebooks

do not contain a single equation. In the mid-19th Century, James Clerk Maxwell put Faraday's ideas into mathematical form, introduced many new ideas of his own, and put electromagnetism on a sound theoretical basis'—Halliday *et al* (1997:538).

The new convergent synthesis perceived by Faraday, could only benefit society when joined eventually with precision technology, a further convergent synthesis attributable to practical men—see pages 86-87. In the progression and continuity of technology, mechanical knowledge was identified and applied during most of the life-span of humankind, with little 'theoretical' grasp—Cotterell and Kamminga (1990:11)—page 58.

During the Industrial Revolution, the influence and skills of the practical man were still in demand, and at times even 'preferred'—Ackrill (1987:20). The Industrial Revolution was achieved 'by hard heads and clever fingers'—Ashby (1958:50). Prosperity followed the continuous improvements in productivity and capability, but they were achieved by the 'craftsman-inventor', the 'mill-owner', and the 'iron-master', all 'self-made men'—Ashby (*ibid*).

Men like Arkwright[8], Bramah[9], Crompton[10], Darby[11], and Maudslay[12], received no 'education in science or technology'—Ashby (1958:50). Indeed, 'English universities' had little to do with the Industrial Revolution—Ashby (*ibid*), but they took the rewards.

However, to maintain the momentum of the Industrial Revolution, the transition from essentially non-theoretical empirical knowledge, to progressively greater levels of 'theoretical grasp', not as exclusive knowledge, but as additional fundamental knowledge, became essential. This point was well made by Playfair[13], 'one of the organisers of the Exhibition' in 1851—Ashby (1958:53). In his *'Lectures on the Results of the Great Exhibition of 1851'*, London 1852, Playfair stated 'Industry must in future be supported … by a competition of intellects'—Ashby (1958:54).

The assumptions in (2) and (3) above, as supported by the anecdotal evidence, and the long-standing disparagement of technical education with statutory sanction, were founded on an intellectual appreciation that was technologically illiterate, and hence 'only partially educated' —Penfold (1988:21), in the context of the real world. So Playfair's advice that 'Industry must in future be supported … by a competition of intellects', made no societal impact.

In reality, society is dependent on technology, but condemns 'it at the same time'—Pirsig (1991:51). For society generally, and education in particular, there has been a longstanding difference in the 'visions of reality'—Pirsig (1991:60). For any society, whether hunter-gatherer or industrial, a state of dependency on tools has evolved as part of the instinctive drive to survive through enhancing productivity and capability.

[8] Arkwright, Sir Richard (1732–92), invented/erected spinning-mill, 1769–DNB, 1995, Bath Press Ltd.
[9] Bramah, Joseph (1748–1814) invented Bramah lock, and hydraulic press–DNB, 1995, Bath Press Ltd.
[10] Crompton, Samuel (1753–1827), inventor of spinning-mule–DNB, 1995, Bath Press Ltd.
[11] Darby, Abraham (1711–63), first use of coke to smelt iron ore [for pig-iron]–DNB, 1995, Bath Press Ltd.
[12] Maudslay, Henry (1771–1831), employed by Bramah (1789–98)–DNB, 1995, Bath Press Ltd. [see p47].
[13] Playfair, Sir Lyon

Hunter-gatherer societies 'socialise' their young into their technologies of survival. As a society that had gained an Empire through technological industrial capability, the UKs educational system socialised the young of the opinion leaders in a different direction, and away from wealth-creating entrepreneurial activities. And so, through its educational system, the 'great trading nation … became a great administrative nation', and 'appointed itself—Head Prefect of the world'—Rae (1977:11).

The UK had protected markets in the Empire, and although they did not provide the bulk of its trade, it was sufficient 'to allow the British to get away with a failure to innovate, particularly in the field of technology'—Rae (1977:11). At a time when the technologies founded on practical knowledge required the additional knowledge and impetus of scientific discovery and explanation, the 'public schools and universities of the late 19th Century looked with "disdain"' on any thought that they might 'be of benefit'—Rae (1977:12). In reality, throughout the 19th Century, 'technical education in Britain remained woefully inadequate'—Pacey (1996:20).

At the highest levels in technology, innovative processes exhibit 'abstract concepts'—Usher (1954:56)—see page 39, and there was limitless scope to engage in 'abstract concepts' within the iterative creative loop that drives technological innovation. Had the leading educational institutions recognised the necessary aptitudes, and participated in the training of 'prepared' young minds to engage in the iterative creative loop (see pages 139-141 and 187), they could have brought the sciences to technology as additional knowledge and understanding. But even with the addition of modern subjects, the 'Imperial school curriculum' remained 'essentially non-utilitarian'—Rae (1977:15).

As stated earlier, Design & Technology was finally introduced as a National Curriculum subject with the Education Reform Act of 1988. 'Some difficulty with its introduction was inevitable since technology has such a long tradition that few recognise'—Owers (1999:4). Orders for D&T were published in 1989, 1992 and 1995, but not without concerns. For example, the 1995 orders p4, 1b refer to 'focused practical tasks …'. Here was evidence that our society continues to have a cultural obsession with the practical aspects of technology and is incapable of visualising the intellectual content as the crucial precursor to the practical content—Owers (*ibid*).

Another example: 'The report sets out a coherent and persuasive view of design and technology as an essentially practical activity …' (Letter by Kenneth Baker to Lady Margaret Parkes, Chair, referring to Interim Report on D&T, dated 23.11.1988—page 99 of the 1989 Orders). 'So our cultural problems go all the way to the top of our society'—Owers (1999:4). Given the dominance of the approved educational system among our leaders, this is to be expected, but it adds to the obstacles to be overcome for our society, and education.

Many of the national initiatives discussed on pages 217-218, have been directed at the obstacles that reside in our society in the context of 'wealth creation' and sustaining ourselves as a society, but how can we hope to change our culture when the prejudice of our leaders remains largely untouched?

09.11 - Closing discussion

The purpose in this chapter has been to reflect on the thesis as a whole, to show that technology evolved from the tool-making skills of humankind. The foundations of technology were essentially empirical as knowledge built on knowledge, with little scientific contribution before the Industrial Revolution—Rolt (1965:38)—see page 45.

The Industrial Revolution started in Britain about the middle of the 18th Century—Rubinstein (1994:1)—see p66, and 'for a while made Britain the most powerful nation on earth'—as narrated by Redhead (1986)—Appendix 4. By the 1830s, the technical changes that had transformed the methods of manufacturing production were described as *Industrialism*—Williams (1990:xiii). But the changes due to *Industrialism* also changed society as a whole, hence *Industrial Revolution*—Williams (1990:xiv)—page 107. The Industrial Revolution in England also wrought a new society—Williams (1990:xiv).

As a burgeoning new but highly stratified society, there were many value judgments at work in the UK, as discussed in chapters 6, 7 and 8. In essence, those value judgments were expressed without understanding the concept of sustaining ourselves as a society—it had never been taught. But those value judgments were a hidden curriculum expressed in many different ways from across society, and exceptionally difficult to counter.

One of those ways that was difficult to counter, was the stance taken by influential opinion leaders in the field of education, so deferring the introduction of technology as a National Curriculum subject, but this too has been discussed. However, there is one other area of polarised debate that should be considered, and concerns whether Britain has experienced industrial decline because of an 'anti-technological culture'—Edgerton (1996:7).

09.11.01 - The 'anti-technological culture' debate

In his critique, Edgerton[14] stresses the polarised nature of the debate, listing some 140 references—(1996:73-86). Among the group who argue that an 'anti-technological culture' does exist in Britain, Edgerton cites Snow[15], Wiener[16], and Barnett[17]. Among those in the opposing school, Edgerton cites Collins and Robbins[18], and Rubinstein[19]—(*ibid*). A brief summary of their respective arguments appears in Appendix 14, but essentially:

[14] Edgerton, D, *Science, technology and the British industrial 'decline' 1870–1970*, 1996, University Press, Cambridge [CUP].
[15] Snow, C P, *The Two Cultures and the Scientific Revolution*, 1959 and later eds., CUP.
[16] Wiener, M, *English Culture and the Decline of the Industrial Spirit 1850–1980*, 1981, CUP.
[17] Barnett, C, *The Audit of War*, 1987, 1988, 1990, Macmillan Publishers Limited, London.
[18] Collins, B and Robbins, K (eds), *British Culture and Economic Decline*, 1990, Weidenfeld and Nicholson, London.
[19] Rubinstein, W D, *Capitalism, Culture, and Decline in Britain 1750–1990*, 1994, Routledge, London.

> Snow (1965:4) argued that there were two cultures: 'Literary intellectuals at one pole—at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension—sometimes (particularly among the young) hostility and dislike.'
>
> Wiener (1987:Preface) writes about 'a distinctive complex of social ideas, sentiments, and values in the "articulate" classes [of Britain], embodying an ambiguous attitude toward modern industrial society. In the world's first industrial nation, industrialism did not quite seem at home.'
>
> Barnett (1990:xi) writes about 'the education and training of the nation; the human quality of the workforce; the capability of management; the cultural values and attitudes of the governing class and the intelligentsia; even the influence of religion. For all these factors inter-reacted to determine the level of British operational efficiency as an industrial society.'

Edgerton (1996:75) considers that Collins and Robbins offers a 'devastating critique of the Barnett/Wiener thesis'. And Rubinstein offers 'a devastating critique of the cultural critique … and a study of the relations of business and public schools'—Edgerton (1996:76). However, Edgerton (1996:75) also conducted a review of the reviewers of the Barnett thesis, and found that 'most historians agreed with him on education and technology'.

One can't help but be aware of the literature referring to an 'anti-technology culture' in Britain, and, as a consequence, the linking with industrial decline. As a debate, this has been made much more difficult by the absence of a definition for technology. Certainly, the concepts and practice of 'technology' and 'science' are not easily defined—Edgerton (1996:12). And this was confirmed by the omission of a definition for 'technology' in the Orders for D&T published in 1989, in 1992, and in 1995. Furthermore, on pages 191 and 192 in this thesis, the following was written:

> The Science and Engineering Research Council established a committee to 'address the subject of engineering research'; their report 'Review of Engineering' published in 1992, 'was well received'—Malpas (1999:3).
>
> From the beginnings of their 'deliberations', the committee had 'great difficulty with the lexicon'—Malpas (1999:3). The committee comprised 'eminent scientists and engineers from academia and industry', and they all interpreted the words 'science, engineering and technology' differently, 'with enormous overlaps of meaning'—Malpas (*ibid*).

<u>09.11.02 - Defining technology</u>

Since science, engineering and technology are relatively recent concepts in the experience of humankind, what were the foundations? Science first came into the English language in the 14th Century, as a term for knowledge—Williams (1988:277). Later, 'in 1725: "the word science is usually applied to a whole body of regular or methodical propositions … concerning any subject or speculation'", and 'can be read, loosely, as a modern definition' —Williams (*ibid*).

Malpas (1999:11) provides a later definition for science, and states:

> Science is the knowledge and understanding of the character and behaviour of everything that exists, be it natural or manmade. This knowledge is obtained through observation and experiment – the scientific method. Science does not have practical use as a necessary objective – whereas engineering always does. The output of science is also frequently, technology. Scientific knowledge and the scientific method are basic elements of engineering research.

Only Malpas offers a definition for engineering:

> Engineering is the process of assembling knowledge and experience to create machines, devices, systems, and structures, processes and products to meet human needs – and to improve and extend those previously created. Engineering research seeks fundamental understanding to improve the engineering process. The ultimate output of engineering research is the development of new or improved techniques and processes for creating machines and devices etc, with better specifications and/or lower costs, and the machines and devices etc, themselves – in short, technology.

With regard to technology, Edgerton (1996:72) states:

> A confusing term which originally meant the study of technique. Now it usually means both the study of technique, and technique itself.

Williams (1988:315) on the other hand states:

> Technology was used from the 17th Century to describe a systematic study of the arts … or the terminology of a particular art. … The root is *tekhne*, Greek – an art or craft. In the early 18th Century a characteristic definition of technology was 'a description of arts, especially the Mechanical' ….

'If you can't define something you have no formal rational way of knowing that it exists. Neither can you really tell anyone else what it is'—Pirsig (1991:206). The difficulties with defining technology have certainly exacerbated understanding the crucial place it occupies in the life of every individual, and in society as a whole. The absence of a meaningful definition for technology, has added to the massive cultural difficulties faced by education, and they will not be easily overcome. So if the 'place and perception of technology in the National Curriculum' was to be understood, it became necessary to characterise technology; indeed a number of people have asked 'What is technology?

By defining technology 'as the generic creative system of humankind that has brought us from the Stone Age to the way we live now', a number of important and crucial concepts in the process have been linked:

- without exception humankind is a tool-user,
- some among humankind are tool-makers,
- humankind separated from all other animal species mainly because of tool-making skills,
- animals of all species leave indications of what they were; but the only animal that left indications of what it *created* was the human animal—Bronowski (1979:42), the by-product of its tool-culture,
- the tool-making-culture of humankind was a by-product of the imagination,
- we use tools, and technologies-as-tools, as extensions of ourselves to enhance our productivity and/or capability,
- the collective productivity and capability underpins the standard of living for any society,
- while world trade is shown in monetary terms, it seriously masks the paradigm that every society barters (trades) according to its skills, knowledge, productivity, and capability.

Since without exception we are tool-users, in reality the evidence of technology stares us in the face, but we have not been educated or trained to see it. As a society we have been blinded by longstanding cultural disdain for industry and technology as well as the related skills and knowledge; this disdain now threatens our economic viability as a society.

The final chapter will summarise the conclusions against the overall driving rationale for the research project; the closing argument will reflect on the difficulties of making real cultural change, thus providing the basis for the recommendations.

Chapter 10

Conclusions and Recommendations

That which our school-courses leave almost entirely out,
we thus find to be that which most nearly concerns the business of life.
(Herbert Spencer, 1861), see Barnett (1990:185)

10.01 Conclusions

The premise for this research was as follows:

> The general purpose is based on the viewpoint that the educational system of *the UK has consistently failed to respond appropriately to technology* (hence our economic decline), and to test the hypothesis that *this failure has contributed to the problems associated with the place and perception of technology in the National Curriculum.*

There are four elements in this premise, and arguments for each one have been developed in chapters 3 to 9. Conclusions for each of these elements appear below; my belief is that they have each been proven.

10.01.01 The place of technology

From an historical and cultural perspective, this research suggests that our tool culture has been at the core of the evolution of humankind through knowledge building on knowledge as social cumulation. Hence the place of technology in our lives may be helpfully and briefly summarised as follows:

1. Technology is the generic creative system of humankind that has brought us from the Stone Age to the way we live now.
2. Humankind has progressed from the Stone Age because of its tool-culture.
3. The sophisticated technologies we use today as tools, are the outcomes of knowledge-building-on-knowledge ever since the Stone Age.
4. Knowledge builds on knowledge as social cumulation. In reality the 'hero inventor' has the role of witness to a new convergent synthesis, which is the outcome of his/her new knowledge and ideas building on existing knowledge.
5. As knowledge builds on knowledge, technology becomes multi-layered, and is implicit in the law of prior dependency.
6. Without exception we are all tool-users.
7. Although we are all tool-users, relatively few of us are tool- or technology-makers.
8. We use tools, and technologies as tools, as extensions of ourselves in order to enhance our productivity and/or capability.
9. As a society, our collective productivity and capability underpins our standard of living relative to other countries.
10. In order to function as individuals and as a society, we are dependent on tools and

technology.

11 The evidence of our dependency stares us in the face every day; we have not been educated or trained to see this dependency, but ever since the Stone Age humankind has been socialised into using tools.

However, because of long-standing cultural disdain as identified in our value judgments, the perception of technology by the dominant influential majority never equated with its crucial place in our society or our lives; there was no comprehension of the tool-culture upon which we are so dependent. As a consequence, technology was the last subject to be introduced into the curriculum on a national basis.

The lack of a definition for technology in any of the published Orders, substantially reduced the impact of the subject when introduced with the Education Reform Act of 1988.

10.01.02 The perception of technology in the National Curriculum

This research has shown that as a cultural phenomenon, not only is the central place of technology in our lives not understood, but that there has been long-standing disparagement; chapter 8 provided an in-depth review, disclosing:

- the adverse influence of popular literature between 1760 and 1790—see page 148,
- anecdotal evidence of widespread failure to understand the importance of wealth-creation activity as the by-product of our tool-culture—see page 151 and Appendix 5,
- in the context of economic and industrial understanding, the introductory exercises with teachers and student teachers showed the extent of their cultural (value judgment) prejudice, a bias they could not help; it has been handed down to us all—page 154,
- disparagement of industry by statutory sanction filled the void in the absence of positive instruction about the role of industry and technology in society—page 159,
- as a newly introduced 'foundation' subject, D&T has to find a place among long established subjects including the higher ranked 'core' subjects of Mathematics, English and Science. From a cultural standpoint, and with statutory sanction, D&T has always been lower-ranked, but our standard of living as a society is underpinned by our tool-culture—see also Appendices 7 and 13.
- Furthermore, Maths and Science are components of technology, and any benefits from Maths or Science are usually delivered through technological application as part of the intrinsic tool-culture upon which we are utterly dependent.

When a subject is valued neither culturally nor educationally, its place in society cannot be adequately examined, defined or understood, at a level of acceptance likely to be influential. The enormity of our cultural and value judgment problems was borne out by the introduction of technology as a National Curriculum subject in 1988 rather than say in 1888, or earlier. Given our dependency on tools and technologies, both as individuals and as a society, this can only be described as an absolute disaster. We have not been taught to value our tool-culture, and as a consequence we can't even appreciate the enormity of the disaster.

10.01.03 The failure to respond appropriately to technology

The Industrial Revolution happened first in Britain because of a new synthesis of material resources, new and evolving technological skills, and entrepreneurial drive. The driving force of the Industrial Revolution was provided by hard heads exploiting new techniques as an outcome of the imagination which also developed more refined practical skills. These capabilities not only enabled Britain to trade with other parts of the world, but helped with the foundations for the acquisition of an Empire; Britain became the workshop of the world.

Britain became wealthy on the proceeds of the Industrial Revolution, but the popular literature of the latter half of the 18th Century was strong in its condemnation of the vulgar display of newly acquired wealth, and an anti-business and an anti-trade culture became established. More than 200 hundred years later, these value judgments may still be found in our society—see anecdotes in Appendix 5.

In the 19th and 20th Centuries, during the formative years of education, the most influential opinion leaders in society seriously and grossly underrated the intellectual demands of technical education, and the importance of its successful application in industry. As a consequence, the influential majority in education disparaged both education useful to industry, and industry itself.

By deprecating the processes through which wealth was created, the educational system of the UK has consistently failed to respond appropriately to 'technology', and hence our relative economic decline. The importance and role of our tool-culture was never comprehended, and indeed it is still not understood.

10.01.04 The UK's economic decline

As a trading nation, the state of absolute decline, in the sense of 'from clogs to clogs' (see anecdote 22), has clearly not yet been reached. However, the state of significant relative economic decline as a trading nation has long been evident. In 1899, the UK had a 33.2% share of all exported manufactured goods world-wide, and this fell to 6% by 1993. Among the leading world-wide exporters, no other trading nation experienced such a loss; indeed others have caught up and overtaken the UK.

Apart from export performance, data from the most recent period confirms the presence of significant factors that can only ensure the UK's continued relative economic decline; these data include:

- patent applications – between 1990 and 1999, both Japan and Germany experienced a decline, but they recovered; the UK was the only country with a continuing downward trend—see Fig. A13.04.
- Gross Domestic Product – between 1988 and 1997, the UK had the lowest rate of growth

in GDP—see Fig. A13.06.

- R&D in business enterprise sector – between 1988 and 1997, the UK had the lowest rate of expenditure—see Fig. A13.08.

Not all the variables that impact on these issues are within the influence of UK society. As other nations improved their industrial competitive performance, a certain relative decline was to be expected. However, the UK has the worst performance in all the parameters of comparison, and hence a very serious problem in terms of relative economic decline.

The achievement of change requires a critical mass of opinion leaders in the most influential institutions. As yet, the critical mass in education perceives no role for themselves in this context, but significant cultural change must take place both as a prerequisite for sustainable economic recovery, and now for a sustainable environment.

10.02 Closing arguments

10.02.01 Introduction

Problems of enormous proportions have been uncovered that almost certainly can be resolved only by a significant political initiative, and the reasons are developed here.

The 19th Century educational developments were 'crucial in establishing and consolidating the modern system of schooling'—McCulloch (1994:23). 20th Century developments, 'were also intended to *reform* the system', recognising the 'changing social and economic needs of Britain in the new century'—McCulloch (*ibid*). However, while earlier reforms have had 'some effect, the structures and cultures' were 'highly resilient to fundamental change'—McCulloch (1994:23), and so they remain as demonstrated in this thesis.

Furthermore, although the educational establishment is clearly involved in any attempt to achieve significant cultural change, there is an overwhelming argument for the technological institutions associated directly with the creation of original wealth through our tool-culture, to participate in the process of making change in the vital interests of the country's future prosperity. Above all, the educational establishment needs huge support to achieve significant cultural change.

10.02.02 Not a new problem

The dimensions of the problem are dominated by the structure and organisation of the educational establishment, as culturally determined by attitudes belonging to the 19th Century—see for example Rae (1977), Ashby (1958), Barnett (1990), and Wiener (1987). However, 'cultures "see" [only] what they are predisposed to see and ignore the rest'—Hampden-Turner, and Trompenhaars (1994:60), thus creating a problem of intractable proportions necessitating serious political intervention and leadership.

Conceptually, the discussion in this thesis has been concerned with the following:

- developing the central place that technology holds in the lives of every one of us, particularly our functional dependence as individuals, and as a society—see Chapters 3, 4, 5, 6, 7, 8 and 9,
- also, developing the central place that technology holds in the lives of every one of us, but as a cultural phenomenon, and a chosen way of living. We are surrounded by the products and artefacts of our tool-culture, but we fail to understand the dominant and intrinsic intelligible system in our culture by which those products and artefacts were created—see in particular Chapter 6,
- while at the same time exposing the restrictions on learning about and understanding technology imposed by cultural value judgment factors—see Chapters 6, 7, 8 and 9.

Education should be the last bastion of prejudice, but during the 19th Century the discriminations found a tenacious hold, when times and value judgments were very different. The problem for our society is that the discriminations of the 19th Century laid the foundations for our present system of education. This research shows that those prejudices still thrive, and further that they continue to shape the structure of our educational system—the tenacious hold has not yet relinquished its iron grip, and increasingly threatens our ability to sustain ourselves as a society. If a new direction for education is to be found, it is necessary to understand the direction from which we have come—McCulloch (1994:169), inevitably an extremely painful process.

McCulloch (1994:169) argues that 'a great deal more attention needs to be given to the historical dimension of educational problems and policies.' However, concerns about the direction pursued by our educational system and the need for educational reform have long excited very strong comment, and this chapter began with a quote by Spencer in 1861. Further quotes illustrate both the duration and the enormity of those ongoing concerns. T H Huxley provides an early example when conversing with Bernard Samuelson as Chairman of the Select Committee on Scientific Instruction in 1868—Ashby (1958:35). Ashby records the whole of the conversation, but only an extract is shown here:

> But surely … , you would rather reform the system of education at the universities and add science to what is taught there? — I am afraid that my ideas on that subject are so revolutionary, that I should almost startle the Committee if I were to state them fully; but I may venture to say that my conception is that our present system of education should be turned up-side down. At present the universities make literature and grammar the basis of education; and they actually plume themselves upon their liberality when they stick a few bits of science on the outside of the fabric. Now that, in my apprehension, is not real culture, nor is it what I understand by a liberal education. The thing you really have to do is, in my opinion, to invert the whole edifice, and to make the foundation science, and literature the superstructure, and final covering—see Ashby (1958:35-37).

Roughly 100 years later:

> There is only one way out of all this: it is, of course, by rethinking our education. In this country, for the two reasons I have given [the two cultures: Literary intellectuals at one pole—at the other scientists], that is more difficult than in any other—Snow's Rede Lecture of 1959 (1965:18).

1988:

> According to Kenneth Baker, who as Education Secretary was chiefly responsible for the Education Reform Act of 1988, it was especially important at this time not to be 'baulked' by disagreements on how to tackle the problems afflicting education: 'For a variety of reasons the education system needed radical change if it was to match the needs of twenty-first century Britain. If this meant foregoing the usual snail's pace at which reform in education was conducted, then so be it.'—McCulloch (1994:2).

In 1991, the enormity of the problems facing our society were well summarised by a former Secretary of State for Trade & Industry, and a former Secretary of State for Education. Speaking on a BBC Radio 4 programme called 'Analysis - From clogs to clogs' [note the title] April 1991, Keith Joseph stated:

> I'll tell you what, the same story has got to be told to every vintage, every annual cohort of boys and girls leaving school that all their wishes for a civilised society will depend upon their generation creating the jobs and the earning power through being inter-nationally, profitably competitive. The story will never cease to be necessary. One day perhaps it will become, as it were, universally understood from the mother's womb.

Coming up to date:

> … schools as we know them are fast becoming an anachronism. … Of course schools have changed and developed considerably over the centuries, but despite the best efforts of many wonderful teachers, their very traditions and structures mean that they are educating young people for a world that no longer exists—Lucas and Greany (2000:vii).

> Our success in bringing about irreversible reform will depend on our ability to address deep-seated problems—Barber (2000:33).

> We must ask ourselves from where the energy, knowledge, imagination, skill and investment will come to meet the immense challenge of education reform over the next decade—Barber (2000:35).

> It is clear in Hong Kong and elsewhere that the business and religious sectors are strong allies. This is true in the USA. It is clear in Eastern Europe, …. Each a different combination but each fit for their purpose—Barber M (2000:35).

> Three priorities stand out. The first is to reduce the curriculum content. … . The second is to increase opportunities for learning beyond the classroom… . The third priority is to transform the nature of teaching—Bentley (2000:63).
>
> Schools are, of course, critically important gateways to the whole of adult life—Fryer (2000:67).

As stated earlier this is not a new problem, and the above selection of comments provides confirmation, but it is a problem that has been given hardly any recognition, and most probably because it is not understood.

10.02.03 Locating the problem

There has been so much written in the field of education that some difficulty may be experienced trying to focus on factors having a direct bearing. But surely, one of the most important concepts for education concerns the processes by which we sustain ourselves as a society, and how we create the necessary original wealth to do so? Writing about *Our Obsolete Attitudes*—Rae[20] (1977:15) stated:

> I believe … they were able to convince themselves and their fellow countrymen that what was wrong with the education system that had served the Empire was its social injustice, characterised by them as "elitism". By concentrating on this aspect of the education system, they were able to ignore the *real* anachronism which was the bias in the curriculum, indeed in the whole school ethos, against what might be useful to the trading and industrial society and towards what was unworldly, theoretical, and academically pure.

As shown by the anecdotes in Appendix 5, the sentiments expressed in the last sentence still prevail. John Rae's paper leads to a further cultural or value judgment dimension emphasised by C P Snow during his Rede Lecture in 1959:

> Pure scientists have by and large been dim-witted about engineers and applied science. They couldn't get interested. They wouldn't recognise that many of the problems were as intellectually exacting as pure problems, and that many of the solutions were as satisfying and beautiful. Their instinct—perhaps sharpened in this country by the passion to find a new snobbism wherever possible, and to invent one if it doesn't exist—was to take for granted that applied science was an occupation for second-rate minds. I say this more sharply because thirty years ago I took precisely that line myself—see Snow (1965:32).

So at the scientific end of the spectrum, there was a further divide. Pure science was respectable, and applied science [engineering] 'was an occupation for second-rate minds'—Snow (1965:32). The Greeks similarly exalted the pure and theoretical sciences while disparaging mechanical research or 'practical application'—Landels (1997:187)—page 108. But crucially, it is the application of technology through our tool-culture that has brought us

[20] Rae, J, Headmaster of Westminster School in London, and former headmaster of Harrow public school.

to the way we live now.

The term 'culture' is used in reference to 'intellectual' and 'artistic activity'—Williams (1988:90). For humankind, the eloquence of imaginative expression appears not only in music, literature, painting and sculpture, but also in the tools and technologies of humankind that have brought humankind from the Stone Age to the way we now live. Tools, and technologies as tools are an intrinsic part of our culture. Indeed, technology is inherent within the survival solution of every society, and hence in culture, but we have not been educated or trained to understand or value this. On the contrary, the dominant critical mass have been trained only in disparagement for the field of technological study, and hence for the multi-layered tool-culture that has brought humankind from the Stone Age to the way we live now.

In reality, our educational system has been structured around the philosophy that little intelligent activity takes place in the technological processes associated directly with wealth creation, neither at the practical level nor in the processes dictating the practical level. And yet, the continuous improvements in technological processes, as an intrinsic part of our culture, have brought humankind from the Stone Age to the way we now live because of imaginative activity realised as tools, technological tools and artefacts. Those improvements today underpin our functionality in society, in every field of human experience, and crucially, our standard of living.

10.02.04 Confronting our problems

There has been a long string of strategies designed to encourage curriculum change including the Technical and Vocational Education Initiative, the City Technical Colleges, the Teacher Placement Service and many others as discussed in Section 09.08 on page 217 of the previous chapter; their primary purpose was to help education to achieve change.

Also, 'relevance to work and the economy is now something to which all pupils from 5 years upward are entitled by law'—Craft (1995:159)—see page 211. At best, the actual status of many of these initiatives was only ever 'bolt-on'. While each initiative would claim at least some success, and no one likes to identify with anything less than success, in reality they could have achieved so much more if our cultural problems had been confronted.

'The history of education as an area of study has also been severely undermined by recent changes in the teacher training curriculum'—McCulloch (1994:169). So any reforms have to address not only the curriculum, but teacher training, as well as the culture and adverse value judgments we have unknowingly inherited with statutory sanction.

10.02.05 The imperative for cultural change

In this research, the data from the students statistical survey suggests that an urgent problem has become a crisis. For example, whether taking Maths or not taking Maths, all the students regarded the subject as important in the context of getting a job as shown by the medians of 8—see Fig. A7.34 Appendix 7. Also, both groups rated the importance of Maths in the context of Economic and Industrial Understanding at 7—see Fig. A7.36. However, what was symptomatic of the crisis were the poor levels of creativity perceived as allowable in the curriculum for the subject of Maths by students taking and not taking the subject; their medians were 3 and 2—see Fig. A7.40. But there are many other causes for serious concern that also support the 'crisis' thesis; these are covered in detail, starting on page 164.

As a society struggling to sustain itself, yet another measure of the crisis we face was the utter failure by a headteacher to understand the crucial nature of technology in our lives, as individuals or as a society, when he appointed as Head of Technology a teacher qualified in English but technically illiterate—see anecdote 35. Given our culture and the dominant value judgments, this action should cause no surprise, but it should cause a great deal of concern.

There have been so many attempts to achieve or encourage change, including the many acts of Parliament, but also the independent curriculum initiatives as discussed in Chapter 9. The Education Reform Act of 1988 provided a step in the right direction, and this too was discussed in the previous chapter.

10.03 Recommendations

10.03.01 Characterising technology

> *Learning is what happens when we realise that things are not quite as we previously thought—Kimble and Perry (2001:13).*

In order to reflect on a conceptual framework for technology, it is necessary to bring together some of the earlier discussion. Merrill (1965:585) argues:

> … evidence suggests that technological traditions are far more complex than usually realised and that they contain numerous features of the greatest significance for understanding the possibilities and processes of technological change. Even 'accident', that unpredictable source of change, is well known to depend on a prepared mind …—p186 this thesis.

And Edgerton (1996:72)—p230 this thesis, describes technology as:

> A confusing term which originally meant the study of technique. Now it usually means both the study of technique, and technique itself.

So the purpose here is to consider the nature of that complexity in an attempt to unravel some of the confusion. To do so, the author contends that we need to understand our tool culture which goes back to the Stone Age. Hence it is appropriate to repeat the perceptions of two archaeologists—p26 this thesis. Schick and Toth (1995:49) state:

> Technology is something much larger than the tool itself. It refers to the system of rules and procedures prescribing how tools are made and used … To have a technology *per se*, there should be some agreed-upon ways of doing things in a social group—that is, there should be some learned, *cultural* aspect to the tool use or artifact manufacture.

A description with a more recent setting by Cross *et al* (1989:27)—p55 this thesis, states:

> Technology is the application of scientific and other organised knowledge to practical tasks by hierarchically ordered systems that involve people and machines.

The Science and Engineering Research Council established a committee to 'address the subject of engineering research'—p191 and p230 this thesis. The committee had 'great difficulty with the lexicon'—Malpas (1999:3). 'Eminent scientists and engineers from academia and industry', all interpreted the words 'science, engineering and technology' differently, 'with enormous overlaps of meaning'—Malpas (*ibid*). As an outcome of the deliberations of the committee, Malpas (1999:11) defined all three subjects as follows:

> Science is the knowledge and understanding of the character and behaviour of everything that exists, be it natural or manmade. This knowledge is obtained through observation and experiment – the scientific method. Science does not have practical use as a necessary objective – whereas engineering always does. The output of science is also frequently, technology. Scientific knowledge and the scientific method are basic elements of engineering research.
>
> Engineering is the process of assembling knowledge and experience to create machines, devices, systems, and structures, processes and products to meet human needs – and to improve and extend those previously created. Engineering research seeks fundamental understanding to improve the engineering process. The ultimate output of engineering research is the development of new or improved techniques and processes for creating machines and devices etc, with better specifications and/or lower costs, and the machines and devices etc, themselves – in short, technology.

By addressing the concerns of the The Science and Engineering Research Council, Sir Robert Malpas (1999:2) reflected on two of his 'crusades': (1) 'getting technology into the corporate bloodstream', and (2) 'to relate more closely the national effort in science and engineering to the needs of the economy; to the need for wealth creation and improving the quality of life'. These admirable 'crusades' were derived entirely from societal concerns. However, it is also important for technology to be understood by the widest audience, to be seen to have a direct relevance to the way people live, and particularly for statements that could be included in legislative documents to do with the National Curriculum.

Black and Harrison[21] (1985:3) describe 'The essence of technology' as follows:

> Technology is the practical method which has enabled us to raise ourselves above the animals and to create not only our habitats, our food supply, our comfort and our means of health, travel and communication, but also our arts — painting, sculpture, music and literature. These are the results of human capability for action. They do not come about by mere academic study or speculation. Technology has always been called upon when practical solutions to problems have been called for. Technology is thus an essential part of human culture because it is concerned with a wide range of human purposes.

[21] Black, P, Professor and Harrison, G, Professor, *In place of confusion*, published by the Nuffield-Chelsea Curriculum Trust and the National Centre for School Technology, Trent Polytechnic (1985).

<u>The difference between technological 'product' and technological 'process'</u>

The composition of culture is 'multifaceted', and grouped into two system domains through which culture is experienced—Poyatos (1983:27)—see Fig. 6.04 p106 this thesis. These system domains are defined as 'Sensible' and 'Intelligible', and describe experiences achieved respectively through the 'senses' and through the 'mind'—Poyatos (*ibid*). The imaginative and creative technological activity of humankind was also represented; examples include vehicles, architecture, town and settlement layouts, and many others. These examples have followed the pattern whereby humankind has consistently applied inventive capability on the materials by which it was surrounded 'in order to remake its environment'—Bronowski (1979:20), but we identify with the 'products' more easily than the 'process'. Although technology is the generic creative system of humankind, and therefore a 'process', it is not listed by Poyatos (1983:27) as an 'intelligible' system.

This research confirms that the 'products' of our technology were more readily identified than the 'processes' that yielded them—see p198, and this is to be expected in a society that has failed to take technology seriously. The constituent parts of the technological processes that have brought humankind to the way humanity now lives, includes:

a. imaginative activity, ability to visualise, to plan for the future, to witness cause and effect,
b. knowledge building on knowledge as social cumulation, eventually leading to scientific understanding that continues to grow, also the 'law of prior dependency'—see p186,
c. skills and aptitudes of the highest calibre in a skills pyramid—see p209 this thesis,
d. knowledge of and about materials,
e. learning as a culturally determined form of behaviour.

The most basic level of 'process' was illustrated in Fig. 8.01—p143 this thesis, showing an iterative creative loop. At the most basic level of 'process', there have always been iterative components of thought feeding off knowledge building on knowledge, while observing cause and effect, to reach a new convergent synthesis as yet another step in technological progress.

Conceptually, if the pivotal role of technology is ever going to be properly appreciated by our society, there should be a place in the National Curriculum that enables the process of understanding, and the subject should be characterised in the following way:

1 Technology is the generic creative system* by which humankind has progressed to the way humanity now lives.
2 Humankind has progressed because of its tool-culture.
3 The sophisticated technologies used today as tools, are the outcomes of knowledge-building-on-knowledge throughout the evolution of humankind.
4 As knowledge builds on knowledge, technology becomes multi-layered.
5 Without exception we are all tool-users, but few are tool- or technology-makers.
6 Humankind uses tools, and technologies as tools, as extensions of itself to enhance productivity and/or capability.

7 The collective productivity and capability of a society underpins the standard of living relative to other countries.
8 In order to function as individuals and as a society, we are totally dependent on tools and technology.

*Note: The 'creative system' embraces the 'iterative creative loop', and all the parts of the process as described in parts 'a' to 'e' above.

10.03.02 The dilemmas for policy making

On page 6 the following was stated:

> The school curriculum is influenced by society …. Hence the National Curriculum.

The problem for our society is that the slice of our culture that the educational establishment felt authorised to pass on hardly ever rated the processes by which we sustain ourselves as a society. As adults we know the importance of an income to set-up home—Owers (1999:5), and while the transfer of that model to the national situation received suitable recognition[22], in reality the prevailing culture and value judgments were too powerful to allow significant change. Hence the real problems still exist as highlighted by Rae[23], and many others.

The 'Closing arguments' in section 10.02, page 235 to 240, illustrates the enormity of the problems that confront our educational system, and hence our society. Reference to section 10.02 shows that many authoritative, eclectic writers have expressed significant levels of concern; they included Spencer (1861), Samuelson (1868), Ashby (1958), Snow (1959), Rae (1977), Wiener (1987), Barnett (1990), Joseph (1991)—see p237 this thesis, McCulloch (1994), Lucas and Greany (2000), Barber (2000), Bentley (2000), and Fryer (2000).

There is however another important influence, namely '… a master can only teach what he himself has learnt, and he is naturally inclined to set the highest value on the studies to which his own life has been given—Clarendon (1864:12). When the 'chief interest of the master' was devoted 'to one set of studies', it was unlikely that 'true success' would be obtained with a 'different and rival set in the same school'—Taunton (1868:17). Also, many 'parents' in this 'rank' were against their sons receiving an education unsuitable for University entrance—Taunton (*ibid*). Parents required 'modern departments' to stand high in 'social' esteem, enabling university access—Taunton (*ibid*), see p119 this thesis.

There can be no doubt that the hearts and minds of Ministers have been won over to the need for change; here is a sample of some of their comments from the past eighteen months, collected by Professor Stephen Heppell as a member of the Standards in Education Task Force:

[22] See for example Taunton (1868), and Select Committee Report (1868) p120 this thesis; also Devonshire 2nd report (1872) p122 this thesis, The Samuelson Report (1882-4) p123 this thesis, and many others.
[23] *Our obsolete attitudes*, (1977), and also Pacey (1996) p227 this thesis.

- Education, education, education …
- A world class education system …
- The challenge for policy is to develop a new culture in education.
- The 21st Century will demand that we develop the diverse talents of all pupils …
- We must modernise comprehensive education and open up access to new technologies for all …
- We believe that education has a key role to play in marking the year 2000 …
- Education is the Government's number one priority …
- … our children will be leaving school IT-literate, having been able to exploit the best that technology can offer …
- Nor should teachers be denied the tools that other professionals take for granted …

The rhetoric is encouraging; the need for change has been clearly identified among ministers. As more and more countries clamour to become industrialised, the case for substantial educational cultural and curriculum change in the UK is overwhelming, and requires a series of significant political initiatives in primary, secondary, and higher education.

The need for educational change has also been identified in other countries. Following a six-year study in co-operation with 13 OECD[24] countries, Black and Atkin[25] (1996:1) stated:

> Many countries are anxious about their education. … Almost all conditions of society are in rapid change, and schools must reflect these changes in new ways of preparing their students for the future.
>
> Science, mathematics and technology are areas of special concern. Science and technology are themselves two of the main forces driving social changes. We all agree that we must provide enough future specialists in all three areas, and educate all our future citizens about them.

Crucially, the curriculum needs to reflect the influential role of technology on the way we live. There is indeed a 'challenge for policy' not only to identify the areas of change required, but to design the processes that will lead at long last to successful change. If successful change is going to be achieved, the educational fraternity must feel ownership of the process, and while prescription here is not possible since it was not part of the research remit, it is appropriate to highlight areas for consideration as outcomes of this research:

- The curriculum — There are currently three 'core' subjects of Mathematics, English and Science. Since Mathematics and Science are 'knowledge' components of Technology, and our productivity and capability are determined by our technology, ***Technology: the creative system of humankind*** should become a fourth core subject.
- In the classroom — Our 'tool culture' is the foundation of Technology. The processes by which we are socialised into using tools and technologies as tools from the earliest years. The importance of technology in the context of the local socio-economic community. Our total dependency on tools and technology—almost every field of human experience is touched by our tool and technology culture.

[24] Organisation for Economic Co-operation and Development.
[25] Black, P and Myron Atkin, J, *Changing the Subjec*t, 1996, Routledge in association with OECD.

- Higher education — In 1993, Howard Davies Director-General of the CBI, described British Industry as 'hot on invention, but cold on product development'—see p433 and 434 Appendix 13. How can these desperately important issues be addressed?
- Higher education teacher training — Our functional dependence on tools and technology as individuals and as a society.

As minimum areas for change, these suggestions will not be easily accepted because we continue to be challenged by a past that resides in the present. What has to be borne in mind is that our educational philosophy never equated with our status as a trading nation, and Chapter 7 provides an in depth study—'by any standard it is an atrocious story. For UK (Technology) Limited it has been an absolute disaster'—p139. But also:

> The authority of those who teach is very often a hindrance to those who wish to learn—Cicero [106–43BC]—see Meighan (1994:54).

And the authority of those who direct the educational establishment has very often been a hindrance to real cultural change, so preventing teachers from learning what they should teach in order to sustain ourselves as a society.

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