

COMPARATIVE INDUSTRIAL RELATIONS  
CIR/88/179

THE DEVELOPMENT OF ELECTRONICS ENGINEERS

A JAPANESE/UK COMPARISON

A PRELIMINARY REPORT

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**THE ISSUES**

**1. Improving the Skill Formation Process as an Answer to Shortages of IT and Electronics Engineering staff**

The performance of enterprises in the electronics industry are more and more dependent on the motivation and talents of their technical staff. As the micro-electronics 'revolution' spreads throughout manufacturing industry, commerce and the service sectors, so the same dependence develops. One immediate result is the growth of shortages - or alleged shortages - of engineering and technician staff. In most countries, manpower planners have argued that there is a fundamental shortfall in the supply of trained engineers with electronics specialisation.

In the UK, the situation is complicated by the importance, post-second World War, of government defence contracts for major manufacturers and the collapse of the UK consumer products manufacturers before the superior competitive strength of American, European and Japanese manufacturers. This has led to the establishment of a large number of foreign manufacturing plants in the UK and their sales organisations. Although the computer industry was developed in the UK from the 1940s onwards, an increasing proportion of the hardware available has been also produced by imports and from foreign owned local plants. Software development has also been very important, particularly by specialist firms. All this means that there are a number of independent factors affecting the demand for graduate, technician and experienced electronics engineers and information technology staff which has made planning the supply very difficult. A recent report estimates that there is an immediate shortage of IT specialists of the order of 19,000;



(2)

a further 35,000 will be needed in the next two years and 51,000 within five years (1). Shortages have eased over the last two years, because of the fall in the growth rate of the electronics and computing industry. However, shortages in the South East continue and in a survey of a 143 companies it appears that recruitment of experienced staff still continue to predominate over the training and retraining of existing staff (2).

Returning to the supply side, the Engineering Council Report on the 'Comparison of the Statistics of Engineering Education; Japan and the United Kingdom' (3) shows the difficulties in defining the precise numbers of graduate and technician engineers coming on the labour market from vocational schools and universities and polytechnics. There are problems in the subjects included in the statistics and also in estimates of sub-university vocational training school output.

Table 1 demonstrates the size of the differences in the estimates of the number of engineers produced by schools and universities according to the Engineering Council and official government statisticians. On either basis, however, the output in Japan is very much higher than in the UK.

(3)

Table 1 - Different estimates of numbers of Engineering Students Successfully Completing courses in 1983 in Japan and UK

<u>Technician Qualifications</u>	<u>JAPAN</u>		<u>UK</u>	
	<u>Engineering Council</u>	<u>Dept. of Employment</u>	<u>Engineering Council</u>	<u>Dept. of Employment</u>
Nos. graduating (in '000's)	46.0	14.5	20.8	20.5
As % of age group	2.85	0.91	2.32	2.28
Per 1000 working population	0.81	0.25	0.89	0.88
<hr/>				
<u>University level Bachelor Degrees</u>				
Nos. graduating (in '000's)	74.0	60.0	16.8	14.4
As % of age group	4.68	3.80	1.87	1.60
Per 1000 working population	1.29	1.05	0.71	0.62
<hr/>				
<u>Post-graduate degrees</u>				
Nos. graduating (in '000's)	8.3	7.2	2.8	2.3
As % of age group	0.52	0.46	0.31	0.26
Per 1000 working population	1.45	1.26	1.20	0.98

Source: The Employment Gazette (Dec. 1987); Engineering Council Report (May 1988) (3)

Table 2 gives some details of the trends in the enrolment of students for under-graduate engineering courses in Japan and the UK since 1974. It is clear that there has been a constant and dramatic increase in the numbers of electrical/electronic students in the UK, but only a slight increase in Japan. The size of the differences in numbers studying, however, is also striking.

Table 2 - Entrants to Undergraduate Engineering Degrees:  
Japan and UK (1974-1985) (in '000's)

<u>Degree Type</u>	JAPAN				UK			
	<u>1974</u>	<u>1978</u>	<u>1983</u>	<u>1985</u>	<u>1974</u>	<u>1978</u>	<u>1983</u>	<u>1985</u>
Electrical & Electronic	20.3	21.5	22.1	21.7	2.7	3.6	4.3	5.1
Mechanical	17.0	17.0	17.4	17.0	2.0	2.8	3.1	2.9
Production	4.5	5.1	4.7	4.4	0.15	0.27	0.30	0.35
Total Eng. Degrees	79.8	82.7	80.0	77.8	11.6	15.8	16.4	18.9

Source: Engineering Council Report (May 1988) (3)

This type of data cannot by itself demonstrate the reasons for alleged shortages of professional level staff. The demand for such staff depends on the relative size of the industries using such skills within the economy and on the work organisation, job specialisation and qualifications for recruitment, taken to be necessary by personnel and line managers within companies. There is unlikely to be any consensus between Japanese and UK personnel managers over the meaning of an undergraduate degree as a qualification (especially as the type of teaching and degree of specialisation is so different).

In the UK, policy solutions for shortages have been argued largely in terms of increasing the basic supply of new graduates, but also by increasing relative rewards for engineers. A further argument has been to improve the number of technicians and the promotion routes from technician grades to professional level jobs. None of these policies seems to have met the reported shortages. The turnover of young engineers in their first jobs seems to be high and there are many reports that engineer graduates do not take technical jobs but prefer to move into commercial and financial jobs as the prospects appear to be better. In telecommunications, for example, it appears that pay levels are rising faster than for other electronics sectors and that staff turnover is high. Up to 60% of companies surveyed reported considerable recruitment and retention difficulties (4). Attitude surveys in four firms carried out at LSE in the last few years found that there was substantial evidence that young engineer graduates who did enter large manufacturing firms, particularly into the development function, were frequently dissatisfied by the experience and changed their career goals to working in small firms or as freelance professionals or consultants.

The consequences of shortages are undoubtedly severe as the process of research and development may be slowed down, production problems may remain unsolved and maintenance and customer service may be defective.

There are two opposed policy solutions from an economic view-point. The neo-classical human capital approach leads to suggestions that a more effective market solution would be to allow private vocational schools to offer individual skill qualification courses and to encourage firms to bid up the price of skills that are in short supply. Individuals would then be encouraged to invest in their own training, knowing that this would be recouped in the higher salaries which would follow the successful completion of such training. The 'human resource development' approach is entirely different. This would encourage firms to develop 'core' work-forces with privileges that would bind them to the firm for a substantial part of their career. If engineers were included in such a privileged elite, then companies would be encouraged to provide internal technical training, knowing that they would not lose the benefits of such training through labour turnover.

Both policy solutions tend to ignore the issue of the effectiveness of the skill formation process. It could be that skills are in short supply, partly because of the lack of any effective information system recording who has what skill or what type of knowledge (5). It is also possible that potential skill exists without recognition, and that under the right motivation and with greater willingness among individuals to try new jobs, then shortages could be greatly reduced.

Much of the argument in the UK about the shortages of the supply of engineers rests on the assumption made by all parties in the dispute that engineers and technicians are 'produced' by expenditure in educational institutions and then 'used' in R & D and work situations. Such assumptions are typical in manpower forecasting. It is, however, reasonable to suppose that technical knowledge and skills are, in reality, developed over time by individuals as a result of the demands made on them by work problems that they have to solve and their response to such demands. This means that technical knowledge should not be conceived of as a 'stock' which is available, but rather as a potential capacity to respond i.e. it is greatly affected by self-perceptions (confidence), perceptions of opportunities and willingness to act. Knowledge and skills are learnt through this experience of active response.

From this perspective, the 'gap' between supply and demand for trained engineers or researchers is best seen as a lack of utilisation of talents which are potentially available. What needs to be explored is the extent that individuals could actually perform at a far higher level of effectiveness, if they are working at tasks which are stimulating and in a way which is developing their knowledge and understanding, continuously and creatively. This means a focus on the nature of engineers' roles and the extent to which such roles enable technical talent to be developed.



There is a considerable amount of rather fragmented evidence that the present roles of engineers, especially young engineers, in UK manufacturing firms do not seem to the individuals concerned to be stimulating or creative. A recent report by G. Werskey (1986) (6) shows considerable conflict, for ex-Imperial College (London University) engineers, between the values of their education (creativity, etc.) and their actual experience in industry. This, of course, may be partly explained by their perceptions of their roles i.e. they may not realise the extent to which they could, if they wish, develop new projects, initiate ideas, etc. Analysis in depth of such roles in their organisational context seems required, as well as exploration of how the roles could be changed to improve performance. It also clearly means that the management of the technical work-force has to be closely examined.

A first major issue of this research, therefore, is to test the argument that a comprehensive approach to developing greater utilisation of talent could help to solve skill and knowledge shortages.



## 2. A Specific Japanese Approach to Developing High Technology?

There are many commentators in the USA and a relative few in Europe who believe that the spectacular economic success of Japan over the previous two decades is due at least partly to the size, form and type of approach adopted in large firms towards research and the development of new products. Chris Freeman, for example, argues that the use of national programmes (for example, through the role of the Ministry of International Trade and Industry) has been complemented by specific company R & D strategies backed up by coherent education and training policies (7). A recent report by the current Scientific and Technical Attache in the British Embassy in Tokyo (8) states that the:

'average annual real rate of growth in expenditure on research and development in Japan has been (over the last five years) in the range of 8-10%. Expenditure on R & D in 1986/87 was £36 billion of which nearly 80% was provided by the private sector. The total is 4 times the figure in the UK. Leading Japanese companies are now generating huge cash flows and reserves and see investment in R & D as their chief comparative advantage in world trade terms'.

Professor Daniel I Okimoto, in a recent paper, argues that the functional needs of the information industries in Japan include:

'Staying abreast of swiftly changing technology.

Sustaining high rates in investments in R & D.

Innovating in order to stay competitive, bartering for other technology and being quick to enter new product markets.

Moving down steep learning curves.

Expanding the volume of production and sales, thereby lowering per unit costs.

Recouping up-front R & D investments through rapid commercialisation of products.

Stressing process technology, product reliability and after-service.

Exporting actively and taking a global view of markets.

Meeting climbing levels of capital intensity.

Over-coming conservative, risk-averse strategies and mobilising to undertake risky and uncertain projects.

Coping with relatively brief product life-cycles' (9).

Most of these objectives required the mobilisation of large number of technical staff engineers - technicians and scientists - in research and development activities at all stages of the product development cycle. Such staff are reported to work with great intensity in project teams. The outstanding characteristic of such teams is their flexibility. Constant job rotation appears to be a normal aspect of engineering work life in Japan.

The second major issue of the project raised by this report therefore is the extent to which Japanese research and development policies in the electronics and information technology industries depend on a crucial difference of role for technical staff. In particular, the motivation for and skills used in learning behaviour seems worthy of close attention. Clearly, if the policies described by Daniel Okimoto are being carried out, then there are likely to be major implications for personal behaviour. This is particularly true for individual learning patterns and for the transmission of knowledge between individuals,

project groups and departments. It has been argued (10) that European status and occupational systems inhibit the transmission of knowledge, as well as the problem of individual competitiveness; Japanese organisational systems may be better designed for this purpose (11).

There has been much debate already about the impediments to developing innovation in West European firms compared with Japanese or the United States. A recent research study (12) from the Atlantic Institute for International Affairs discusses the capacity of European countries to compete internationally in high technology. It concludes that 'high-tech' industries are producing an impressive range of innovations, but that there are major organisational and structural problems which prevent the marketing and adaption of such innovations for users. The message is similar to that of the classical study of electronics firms in the UK produced by Tom Burns and George Stalker in the 1950's (13). They focussed on the cultural and 'political' conflict between R & D scientists and engineers, who operated in an 'academic' or loose organic style of management and the more mechanistic and hierarchical organisation style of production management and marketing and sales management. The conclusion, thirty years ago, still stands unchallenged; uncertain and dynamic marketing and customer relations demands a total company culture of organic relations in which scientific and technical expertise is married to a more entrepreneurial style.

The UK electronics industry certainly has not performed well in sales terms compared with Japanese companies in recent years. A report by McKinsey for the National Economic Development Office shows that whilst the UK electronics market grew 9.4% in real terms between 1986 and 1987, major UK indigenous companies experienced sales growth of only 2.6% per year in the same period. In contrast, Japanese electronics companies increased sales by a average 7.6% per year and US companies by 6.6% per year (14).

Part of the explanation of this result may lie in the role behaviour of engineers and technical staff in the research, development, production and customer services fields. The FAST Programme of the European Commission emphasises the need for specialists who can think in terms of 'systems integration', necessary for designing and operating systems which inter-relate factory production and office automation and can cope with, for example, the fusion of laser technologies and micro-electronics in the communications industry (15). Japanese engineers, in particular, have an extraordinary high output of patents registered. In 1987, the number of patents registered in the United States by Japanese firms exceeded those granted to British, French and West German inventors combined (16). How has this been achieved? How far do the roles of technical specialists in Japan provide greater opportunities for 'system integration' than those of similar staff in UK firms?

These are difficult questions to answer, but an obvious research strategy was to start by making a detailed comparison of individual role behaviour over a period of time.

## CONCEPTS AND FRAMEWORK FOR THE PROJECT

The focus of the project lies in locating different patterns of role behaviour of technical staff in different functional areas and in different firms in Japan and the UK. It is hoped that detailed examination of actual role behaviour - particularly emphasising learning and problem solving behaviour - in the context of work organisation and its culture, will throw light on the issues sketched above. Both the implications of different approaches to engineering work and possibilities for improving effectiveness will also be explored.

### 1. The Meaning of 'Engineer'

In the study, the term 'engineer' is used in the Japanese sense as referring to any person deemed to be qualified to work on 'technical' problems. In terms of level, we distinguish four types :

- Level A:     **Advanced Technologist**, qualified by a period of sustained formal post-graduate study in Science or Engineering. This is clearly a specialist role, although the area of specialism may have been acquired since graduation.
  
- Level B:     **Graduate Technical Staff**, normally holding a degree from a Higher Educational body and working on technical problems. In some cases, e.g. software engineering, the expertise used will have been learnt almost entirely since graduation. The degree of specialisation here is problematic.

Level C: **Technical Support Staff**, normally persons with some degree of formal technical vocational education and working on technical problems. Qualifications will vary here.

Level D: **Craft or Specialist Tradesmen**, usually designated as operatives or manual workers who have a specialised trade qualification and use this in their work.

In Japan, the distinction between Levels C and D is not always clear. Usually, normal High School graduates with additional vocational training will work at Level C. Level D is likely to be found mostly in production and maintenance. They may or may not have served an apprenticeship.

There is no assumption in Japan of being 'professionally qualified' - in the UK sense - in Levels B and A. As there is no equivalent to the concept of UK professional qualifications in Japan, it cannot be used for comparative study. We use the term **Recognised and Qualified Technologist** to refer to the situation where the individual can use a specialist qualification, recognised by the State or by the occupation, as an entitlement to a specialist job.

This study deals in the main with technical staff of levels A and B in large manufacturing firms in the electronics and information technology industries in the functions of research, product development and design manufacture and customer technical support services. Within those



firms, which are in general the market leaders, the technical staff were selected from particular product organisations or from research laboratories. The unit for analysis is therefore the individual engineer within an immediate work organisation.

## 2. Values and Beliefs

Four types of organisational sub-cultures can be distinguished.

Organisations may:

- (a) Encourage the development of a role as an **individualistic technical specialist**. This culture emphasises the need for each engineer to acquire technical expertise for their future career possibilities.
- (b) Emphasise the need for **marketing generalists**. The emphasis here is on customer service and is found in Information Technology firms.
- (c) Emphasise the role of **individual researcher**. This culture is academic, and similar to (a) sees the acquisition of knowledge as one of the pursuit of individual excellence. Knowledge may be valued for its own sake, however.
- (d) Emphasise the need for **professional research expertise** on a collective basis. This is a 'system' approach. Research is necessary to build expertise within the organisation. Who knows what is less important.

It follows that motivation for 'learning' can have many different components. It is of particular interest here to distinguish the emphasis on problem solving as an end in itself; from scientific pursuits and intellectual curiosity; from careerism as a motive; from managerial or organisational objectives or occupational objectives.



We use the term 'learning' to include both Off the Job education and training activities and OJT or On the Job spontaneous or formal training activities. It includes both skills and knowledge. The relevance of the skills and knowledge is also important. Some learning is directly relevant to specific current problems; some is only indirectly relevant. The pursuit of learning may also, of course, be primarily future directed - either for the solution of future problems or more general, as in academic research.

### 3. The Frame of Reference

The conceptual frame of reference taken for the project is in the form of a standard input-output model. Figure 1 makes the distinction between inputs, particularly historical factors which lead to ways of thinking and behaviour and organisational, product and labour market and educational system factors which have helped to shape behaviour and responses; throughout processes which refer to ongoing system behaviour and outputs, which refer to the effects of engineers' actions on themselves and on system performance and its consequences. Four levels of analyses can be distinguished:

- (1) **Organisational**; this refers to work organisation, the factors shaping it and its effects.
- (2) **Individual Orientations and behaviour**; this refers to work roles and career systems, etc. the factors shaping them and the results for the individual.

- (3) **Individual experience**; this refers to the individual and his or her experience over time i.e. including role experience previous to and outside immediate work roles. It leads to individual self appraisal of the value of that experience.
- (4) **Societal**; here we find all the contextual factors which help to shape and influence the individual engineer within the firm.

Figure 1 shows the main focus of the study at present lying with (2) and (3).

Figure 1 The Conceptual Framework for the Study

<u>Levels</u>	<u>Inputs</u>	<u>Throughput processes</u>	<u>Outputs</u>
1) Organisational	Context	Context	Context
2) Ind. orientations	Focus	Focus of study	Focus
3) Ind. experience	Focus	Focus of study	Focus
4) Societal	Context	Context	Context

The focus of the study is at the individual level and two types of data are being studied: (i) The actual career and work experience of each individual; (ii) the orientations and frame of reference for each individual and the resulting behaviour patterns and types of decision taken e.g. on careers, education, etc.

Individual behaviour is being studied in an organisational context and this means that it is important to study the factors which shape the demands placed on each engineer, their peer group relations and relations to immediate management. Organisational factors also affect the motivation of each engineer and the opportunities and constraints perceived within the firm.

Individual behaviour also reflects the influence of various factors in each society, the type of early education, the national culture of engineering and the perceptions of status within each society.

**THE SAMPLE**

As this is an exploratory study, the sample of engineers is composed of volunteers and is not a representative or random sample. The nature of the issues to be explored and the methods of research adopted in this study require the personal collaboration of each engineer over a minimum period of six months. This inevitably means that those who agreed to take part in the study are a 'self-selected' group of engineers who have strong interest in the issues at which we are looking.

In both countries, the engineers are from large firms. The restriction of the study to large firms limits overall generalisation but major career and role problems seem to occur most in such companies. The current sample (as of June 1988) is from the following companies:

<u>UK</u>	<u>JAPAN</u>
GEC Plessey Telecommunications	Mitsubishi Electric (21)
(i) Coventry Plant (19)	Toray Engineering (15)
(ii) Liverpool Plant (7)	Toshiba R & D (10)
(iii) Nottingham Plant (9)	NEC (16)
Marconi Communication Systems (6)	Hitachi Research Lab (9)
Thorn-EMI Electronics (12)	Sanyo R & D (10)
Honeywell-Bull (4)	Meidensha (10)
Total no of participants (57)	(91)

Marconi Research Laboratory has just agreed to provide 5-8 engineers for the sample. Negotiation is currently being undertaken at IBM (Havant Plant), Philips Research Laboratory and GEC Hirst Laboratory. We expect to negotiate the collaboration of another 20-25 engineers from these companies to take part in the project.

Table 3 shows the general profile of our sample in the two countries. The two samples are not yet properly comparable. The Japanese sample is older and better qualified and one-third are working in research <sup>1</sup> compared with the UK sample which is overwhelmingly in development work. (We are trying to adjust this by negotiating with one more UK research laboratory to take part.)

- 1 It should be noted that the distinction between research and development functions is not always clear in the case of Japanese companies as there are frequent job rotation and staff flow between different sections or departments. Further, the strong emphasis on task flexibility and sharing of work roles means that the distinction between research and development functions is sometimes rather blurred.

Table 3 - A General Profile of the Sample

	JAPAN		UK	
	%	No	%	No
<u>AGE</u>				
21-25 years	3	(3)	44	(22)
26-30	35	(32)	32	(16)
31-35	33	(30)	12	(6)
36-40	21	(18)	6	(3)
41-45	5	(4)	2	(1)
46-50	3	(3)	4	(2)
<u>SEX</u>				
Male	99	(90)	92	(46)
Female	1	(1)	8	(4)
<u>EDUCATION</u>				
HNC or BTEC equivalent	-	(0)	6	(3)
Bachelors degree	51	(43)	70	(35)
Masters degree	39	(33)	22	(11)
Doctorate	9	(8)	2	(1)
Other/not applicable	1	(1)	-	(0)
<u>LENGTH OF SERVICE WITH PRESENT COMPANY</u>				
Less than 3 years	11	(10)	38	(19)
4-6	25	(23)	30	(15)
7-9	29	(26)	20	(10)
10-14	27	(25)	8	(4)
15-	8	(7)	4	(2)
<u>JOB FUNCTION</u>				
Research	39	(35)	6	(3)
Development	39	(35)	44	(22)
Design	15	(14)	20	(10)
Technical Management	2	(2)	12	(6)
Other	5	(5)	18	(9)
Total (N)	100.0	(91)	100.0	(50)



Based on the background questionnaires completed by the participants, some interesting points to emerge from the comparisons of the two samples are:

(a) The Japanese engineers show a strong preference to pursuing a technical career and are interested in possibilities for research and technical advancement. Their career objectives appear to be consistent with their present technical work roles, whereas the U.K. engineers are strongly oriented towards a career in management or a more individualised career path such as self-employment, consultancy or to leave engineering completely. A high proportion of the U.K. engineers seem to reject their present technical roles as their ideal career objectives. The ultimate career goals of a high proportion of the U.K. engineers seem to be in the areas which are disconnected from their present work roles (Tables 4 and 5).

Table 4 - Reasons for Joining Present Company (Multiple Answers)

	JAPAN		UK	
	%	No.	%	No.
Location	33.0	(30)	62.0	(31)
Salary/benefits	5.5	(5)	28.0	(14)
Status position	1.1	(1)	8.0	(4)
Prestige of organisation	26.4	(24)	24.0	(12)
Opp. for managl. advancement	4.4	(4)	18.0	(9)
Opp. for R & D	24.2	(22)	2.0	(1)
Opp. for tech. advancement	60.4	(55)	62.0	(31)
Opp. to work in spec. area	82.4	(75)	42.0	(21)
Invited by company	6.6	(6)	8.0	(4)
Other	3.3	(3)	42.0	(21)
Total (N)	-	(91)	-	(50)



Table 5 - Career Goals

	JAPAN		UK	
	%	No.	%	No.
Academic career	20.9	(19)	—	(0)
Management large firm	26.4	(24)	20.9	(9)
Management small firm	1.1	(1)	18.6	(8)
Tech. career large firm	45.1	(41)	23.2	(10)
Tech. career small firm	—	-	9.3	(4)
Consultancy	2.2	(2)	9.3	(4)
Self employment	1.1	(1)	7.0	(3)
Leave engineering	—	-	4.7	(2)
Other	3.3	(3)	7.0	(3)
Total (N)	100.0	(91)	100.0	(43)

(b) Contrary to the general belief that Japanese engineers are not 'professionally oriented', our Japanese sample spend more time and have more opportunities for engaging in 'professional activities' such as reading papers at conferences than the U.K. sample (Table 6). Also roughly the same proportion of engineers in both countries said they belong to a professional association (Table 7). However, it should be noted that almost all the Japanese engineers who said so are affiliated to 'academic societies', the nature and function of which differ from the 'professional organisations' such as the Institution of Electrical Engineers in the U.K..

Table 6 - Number Of Conferences Attended During Last Year

	JAPAN		UK	
	%	No.	%	No.
None	40.6	(37)	46.0	(23)
1 - 2	24.2	(22)	36.0	(18)
3 - 5	28.6	(26)	16.0	(8)
6 -10	6.6	(6)	2.0	(1)
<b>Total</b>	<b>100.0</b>	<b>(91)</b>	<b>100.0</b>	<b>(50)</b>

Table 7 - How Many Engineers Belong To A Professional Association?

	JAPAN		UK	
	%	No.	%	No.
Yes	57.2	(52)	52.0	(26)
No	42.8	(39)	48.0	(24)
<b>Total</b>	<b>100.0</b>	<b>(91)</b>	<b>100.0</b>	<b>(50)</b>

(c) Another striking difference between the two samples is that the Japanese engineers had registered a significant number of patents. Out of 91 Japanese engineers, 79 of them had registered patents whereas only 4 U.K. engineers had registered one patent each.

(d) The Japanese engineers have received proportionately more training in all areas apart from project analysis/practical skills (Table 8). As regards the format of training, there is a far higher proportion of internal classes/seminars available to Japanese engineers, and a relatively high proportion of formal O-J-T. The U.K. engineers tend to rely more on written manuals, informal O-J-T and Off-J-T (Table 9).

**Table 8 - In What Skills Have Engineers Been Trained  
In Their Present Position? (Multiple Answers)**

	JAPAN		UK	
	%	No.	%	No.
Technical	72.2	(65)	62.0	(31)
Managerial	27.8	(25)	20.0	(10)
Marketing	20.0	(18)	12.0	(6)
Design	24.4	(22)	20.0	(10)
Development	28.9	(26)	18.0	(9)
Production	13.3	(12)	4.0	(2)
Financial	25.6	(23)	8.0	(4)
Project Analysis	4.4	(4)	14.0	(7)
General/practical	25.6	(23)	38.0	(19)
None	11.1	(10)	18.0	(9)
Other	10.0	(9)	12.0	(6)
Total (N)	-	(90)	-	(50)

**Table 9 - What Format Did The Training Take?  
(Multiple Answers)**

	JAPAN		UK	
	%	No.	%	No.
Internal classes/ seminars	80.0	(64)	58.5	(15)
Written manuals	15.0	(12)	31.7	(9)
Formal OJT	21.3	(17)	17.0	(5)
Other OJT	38.8	(31)	46.3	(15)
Off-J-T	23.8	(19)	43.9	(14)
Other	3.8	(3)	17.0	(5)
Total (N)	-	(80)	-	(41)

## RESEARCH DESIGN AND METHODS OF DATA COLLECTION

### 1. The Monthly Reports

Due to the nature of the issues which we are exploring, there needs to be a close integration of social science and technological understanding. The close collaboration of the engineers with the researchers in the process of data collection is therefore crucial. At the initial stage, each engineer was asked to fill in a background questionnaire on their education and training experiences, employment history, professional activities and career goals. This provided background information of each individual participant which is essential for the analysis and interpretation of the monthly report data and for the final stage of in-depth individual interviews.

All the U.K. engineers who had filled in a background questionnaire and about half of the Japanese engineers who had done so agreed to take part in the core of the research by the filling in a monthly report on the learning opportunities which have occurred to them, both on and off the job, over a six-month-period. The purpose was to try to negotiate the personal collaboration of the engineers and to allow the engineers to record what they thought were important critical incidents happening during the period. The monthly report sheets (see Appendix A), were designed in such a way so as to allow both factual information (such as the type of learning opportunity, the situation in which it took place and whether there was any key person who helped the individual to learn effectively) and the individual's assessment and evaluation of the learning activities to be recorded. For each learning incident

reported, the individual was asked to assess (1) the main points where he/she felt important pieces of new knowledge, important new skills, new understanding, etc. were acquired; (2) why he/she felt this new knowledge or new skills was important; (3) what type of follow-up action seemed to be necessary and (4) what type of follow-up action actually took place. (See Appendix B)

At the time when this report was written, the Japanese engineers had completed their six months of reporting while the British engineers were still mid-way through the process. The greatest problem encountered in the data collection process was how to sustain the interest of the participants and ensure that they sent in their reports once a month. Communication and constant encouragement from the researchers is crucial. The methods we used to sustain the continuing collaboration of the participants included sending them reading materials relevant to the research and organising 'feed-back' meetings (see below) in each company to discuss with them some of our interim findings. These methods proved to be useful for keeping the engineers in touch with the researchers so as to ensure that their interest in the project could be sustained right through to the final stage of the research.

## 2. The Individual In-depth Interviews

This research design is certainly unique and, to the authors' knowledge, is the first time it has ever been implemented. The successful implementation of these research methods requires time and effort on both sides - the researchers and the engineers. This inevitably means that the number of engineers involved can only be limited. The data



collected therefore is 'biased' in the sense that (1) those engineers who agreed to take part are a 'selected group' of 'volunteers' rather than a representative sample from each organisation and (2) the amount and quality of data from the participants tend to vary in accordance with the extent of the interest and enthusiasm each individual has towards the project. It is therefore essential that, at the end of the six-month-period, in-depth individual interviews are to be carried out (1) to fill in the information gaps in the monthly reports; (2) to discuss with each individual the 'meanings' and implications of the data recorded and (3) to probe for further information on the nature of the engineers' roles in the organisational context, their actual tasks and responsibilities and work group relations and the extent to which their roles affect their experiences and perceptions of learning.

The advantage of self-reporting of the real situation and work roles of a small number of engineers in a few organisational cases, on a longitudinal basis, is that a realistic assessment of actual roles and task opportunities and how these affect the scope and capacity for learning can be carried out. Interviews alone are unlikely to penetrate the complexities of engineering task situations.

### 3. 'Process Analysis': A System of 'Feedback' Meetings

Both in the middle and at the end of the data collection period, 'feedback' meetings are being organised with groups of engineers to discuss the data with them and with interested personnel staff in each organisation. This kind of 'feedback' meeting during which researchers discuss the results face-to-face with the participants is described as 'process analysis' by Fricke (17). He used it to describe work on the redesign of jobs at factory level and recently the analysis of the social objectives of engineering design teams in the introduction of new technology. In our research, we adopt the term to mean a specific form of action research in which the participants in the research project are involved in discussion of the results and of policy implications.<sup>1</sup> The 'feedback' meetings not only serve the practical function of sustaining the interest and involvement of the participants in the project but they also constitute an essential part of the data collection processes. Our experience so far suggests that researchers can often utilise the 'feedback' meetings as a forum for 'group interviews' to probe for the participants' reactions and perceptions of the research findings. Maintaining a continuous 'dialogue' between the researchers and the participants in the data collection processes is crucial for arriving at results and findings which are meaningful to both the researchers and the actors.

<sup>1</sup> For a detailed discussion of the implementation of 'process analysis' in international comparative research, see Thurley, K. (1988) Methodological Problems of Comparative Research : The 'Triangulation' approach in international cross-cultural research, STICERD, London School of Economics, August.



**PRELIMINARY ANALYSIS OF MONTHLY REPORTS**

At the time this report was written (July 1988), the monthly report data collection was still incomplete. In-depth individual interviews had not been carried out. (The Japanese engineers' interviews have been planned for the late summer of 1988 and the U.K. engineers' interviews will follow at the end of 1988 and early 1989.) Up until the present, a total of about 250 monthly reports have been received from 46 Japanese engineers over a period of six months. The British engineers were still mid-way through their monthly reports. About 30 of the British engineers had been reporting to us on a regular basis and about 100 reports had been received from them over a period of 4-5 months. The following preliminary analysis is based on the monthly reports we received from the engineers at that time.

The analysis focuses on three major variables: (1) Frequency of learning incidents reported; (2) type and range of knowledge and skills acquired and (3) methods and situations of learning. It should be noted that the interpretation of the monthly report data is highly subjective. It is, therefore, essential that these data should be cross-checked and discussed with each individual engineer at the stage of interview. Some of our preliminary findings are as follows:

**1. Frequency of Learning Incidents Reported**

(a) There are great variations between individuals within the same organisation, between different organisations and between Japan and U.K. with regard to the frequency of learning opportunities reported both on and off the job.

(b) Individual attributes such as age, sex and the educational background, as well as personality characteristics and their work roles, are important factors affecting perception and experience of learning. In a U.K. firm, one woman engineer reported 29 OJT incidents over a period of four months as compared to her male colleagues who reported an average of 2-3 OJT incidents over the same period of time. The individuals' perception of their roles in the organisation and their career orientations also appear to affect their motivation and style of learning. At present, our sample is too small to permit a correlation analysis according to individual attributes and types of work roles. This should be further investigated when we have obtained a larger sample and at the stage of the individual interviews.

(c) Differences between companies are equally striking e.g. engineers at Toshiba reported more learning opportunities than engineers at Toray. This could reflect differences in firm size (particularly relevant in the case of Japan), the academic standards achieved by the graduates recruited, job functions, management style and company policies on training. However, what is even more striking is that engineers in U.K. firms reported more OJT incidents than Japanese engineers - this appears to contradict the general belief that OJT is a

more developed feature of ability and skill development in Japanese firms; the data shows that OJT is of equal importance in the UK firms. The crucial point here, however, is not so much the frequency of OJT incidents reported, but the differences in meaning of 'OJT' in two different organisational sub-cultures — Japanese engineers reported more formal, structured and group learning situations; whereas in the UK, the majority of the OJT incidents reported are of the spontaneous individual problem solving type of learning (see below). It is necessary to investigate the extent to which organisational sub-cultures, work arrangements and work group relations affect engineers' perceptions and the patterns of learning.

Table 10 -

Number Of Learning Incidents Reported Per Individual Per Month

	<u>Toshiba</u>	<u>Mitsubishi</u>	<u>Toray</u>		<u>Japan</u>	<u>UK</u>
OJT	0.70	0.27	0.22		0.39	0.94
Off-J-T	0.83	- *	0.17		0.50	0.36

\* The analysis here does not include Mitsubishi because the sample was undergoing a one-year special training course and they all reported the same off-J-T.

## 2. Type of Knowledge/Skills acquired

(a) There are striking differences between Japanese and U.K. engineers with regard to the type and range of knowledge and skills they acquired on the job. U.K. engineers tend to acquire more technical-specific knowledge or skills (for technical problem solving) and most of these knowledge or skills acquired are for coping with immediate technical problem solving rather than for future tasks or projects. In the Japanese case, there are some variations between the three companies, but on average Japanese engineers reported learning more technically general and theoretical knowledge which is not directly related to present technical problem solving, but is useful for future tasks or projects. The Japanese engineers tend to put more emphasis on broadening their knowledge and skills and keep these as a kind of 'stock' for future career development. Also, equally important, is the emphasis by the Japanese engineers on learning non-technical and general organisational skills and knowledge (about the company situation, research activities in other project teams or departments, etc.); this is particularly striking in the Toshiba case. Engineers in Toshiba reported high frequencies of attending presentation meetings or study circles which involved engineers from other sections whereby they discussed and exchanged information.



Table 11 - Type of Knowledge/Skills Acquired (OJT)

	<u>Toshiba</u>	<u>Mitsubishi</u>	<u>Toray</u>	<u>Japan</u>	<u>UK</u>
Technical-specific (present)	13.2%	19.2%	6.6%	13.4%	53.7%
Technical-specific (future)	5.2	20.6	6.6	11.0	23.9
Technical-general (present)	2.6	17.2	40.6	14.6	4.5
Technical-general (future)	36.8	31.0	33.3	34.2	1.5
Non-technical/Org Skills	36.8	13.8	13.3	24.4	13.4
Managerial	2.6	0	0	1.2	3.0
Others	2.6	0	0	1.2	0
(N)= Total no of OJT incidents	100.0 (38)	100.0 (30)	100.0 (15)	100.0 (83)	100.0 (67)

These facts are, of course, considerably affected by the precise roles and functions carried out by those within the sample. In the final analysis, it will be necessary to relate the type of role to the type of learning behaviour and learning objectives displayed by each individual. It appears, as discussed in section 3, that there are far more researchers in the Japanese sample and this is likely to have a strong influence on the data reported in Table 11. However, it is necessary to explore the precise role by interview as the terminology of 'research', 'development', 'design', etc. is so ambiguous. This will be carried out as the next step in the field-work planned for the research.

(b) Also for off the job formal learning, Japanese engineers tend to focus more on acquiring technically general knowledge and skills for future tasks and projects. In the U.K., a relatively high proportion of the formal training opportunities are in the areas of management. This appears to be one area of training most desired by the U.K. engineers. Many young engineers in the U.K. sample complained about the lack of opportunities for management training. This reflects the strong interest exhibited by the U.K. engineers to move into managerial posts at the very early stage of their career.

Table 12 - Type Of Knowledge/Skills Acquired (Off-J-T)

	<u>Japan*</u>	<u>UK</u>
Technical-specific (present)	5.2%	8.7%
Technical-specific (future)	3.4	17.4
Technical-general (present)	5.2	0
Technical-general (future)	48.3	26.1
Non-technical/Org Skills	8.6	4.3
Managerial	24.1	39.1
Others	5.2	4.3
(N) = Total no. OFF J T incidents	100.0 (58)	100.0 (23)

\* The analysis here does not include Mitsubishi because the sample was undergoing a one-year special training course and they all reported the same Off-J-T.

### 3. Methods and Learning Situations

(a) On the job learning tends to be more formal and structured in Japan. Both for formal and informal types of on the job learning, Japanese engineers tend to learn in group situations whereas in the U.K. spontaneous individual learning is much more significant. This striking contrast between the group and individual approach to learning is very important as it affects the speed of the diffusion and transmission of knowledge and skills within the work organisation (10). The extent to which each individual's learning goals are integrated with organisational needs and objectives is also affected. In our Japanese sample, the team supervisor is often mentioned by the engineer as a key person in the learning process, whereas this is not the case in the U.K.



Table 13 - Methods/Learning Situations (OJT)

	<u>Toshiba</u>	<u>Mitsubishi</u>	<u>Toray</u>	<u>Japan</u>	<u>UK</u>
Formal OJT-Individual	0%	0%	0%	0%	0%
Formal OJT- With one other	5.4	0	0	2.5	1.5
Formal OJT-Group	46.0	45.0	7.2	38.8	3.0
Spontaneous-Individual	10.8	34.4	21.4	21.2	79.1
Spontaneous-With one other	10.8	17.2	21.4	15.0	8.9
Spontaneous-Group	27.0	3.4	50.0	22.5	7.5
(N) = Total No. of OJT incidents	100.0 (37)	100.0 (29)	100.0 (14)	100.0 (80)	100.0 (67)

Table 14 - Methods And Learning Situations (Off-J-T)

	<u>Japan</u>	<u>UK</u>
Internal seminar	53.6%	52.2%
Internal course	10.7	17.4
External seminar	28.6	13.0
External course	7.1	17.4
(N) = Total Off-J-T incidents	100.0 (56)	100.0 (23)

(b) For formal off the job learning, Japanese engineers tend to rely heavily on classes and seminars rather than formal courses. In most cases, the teacher or trainer is a specialist within the company. It is also quite common for the companies to invite specialists from universities or supplying companies to deliver a class or seminar on specialised subjects. Proportionately, British engineers tend to attend more formal courses both inside and outside the companies. There are, however, complaints from British engineers that knowledge and skills acquired from these courses are not connected with their present tasks or career goals.

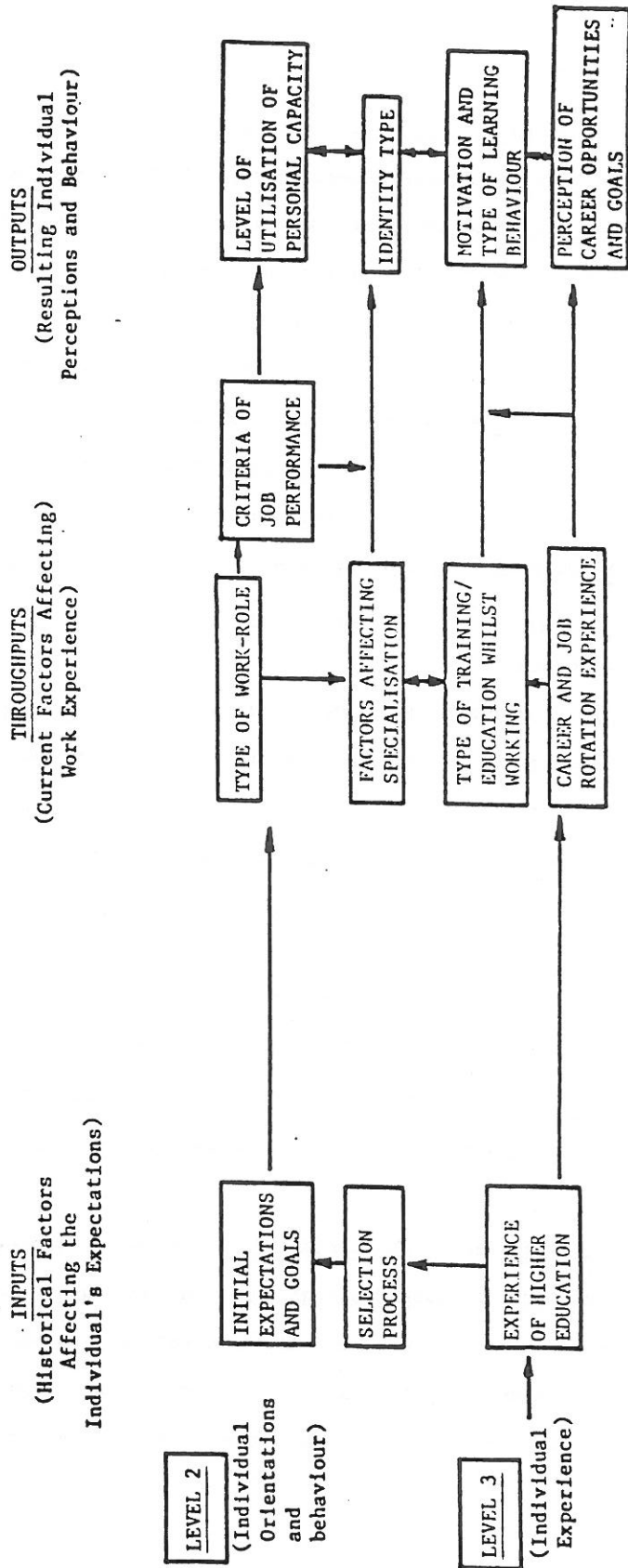
### INDIVIDUAL CASE ANALYSIS

The above is an overall quantitative analysis of the monthly report data. Three important questions can be raised based on the above observations.

- (1) Why do the Japanese and the U.K. engineers display different patterns of behaviour, particularly with regard to their perception of the meaning of 'learning' and 'training', the type and range of knowledge and skills acquired and the methods and situations under which learning took place?
- (2) How do individual attributes, work roles, career orientations and professional identity of engineers affect their learning behaviour?
- (3) To what extent do organisational variables, such as management style, work group relations, career systems, organisational sub-cultures and manpower development policies affect the engineers' motivation and effectiveness of learning?

All these are crucial questions which need to be explored further in our research. At this stage of our study, as the focus of data collection is at the individual level, we do not have sufficient data to answer question (3). (This will be explored in the next stage of our research, see p. 56-58) However, based on our individual case data, it is possible to gain some insights into questions (1) and (2). Figure 2 shows a model of Individual Learning Behaviour.

FIGURE 2 Model of Individual Learning Behaviour



It appears that at the individual level, the engineers' career goals (whether or not these are consistent with their present work roles), the perceived career opportunities and their professional identity are all important factors affecting the engineers' motivation and behaviour of learning. The data collected so far relates to individual career experience and individual perception, orientations and behaviour as far as learning is concerned. Based on such data, we can classify the engineers according to their career goals, their professional identity and their learning behaviour pattern:

#### 1. Career Goals

Broadly speaking, there are five different types of career goals desired by the engineers in our sample (this is based on their answers to the questionnaire):

- (1) Academic Career (To become a researcher in universities or research institutes)
- (2) Managerial Career
- (3) Technical Specialist Career
- (4) Non-technical career (in marketing, sales etc.)
- (5) Individualised career (such as becoming self-employed, consultancy or leaving engineering completely, 'etc..')

In our Japanese sample, those with (3) a 'Technical Specialist Career Orientation' are the most dominant type, followed by (2) those who want a 'Managerial Career', then (1) 'Academic Career', in that order. Very few of the Japanese engineers aspire to move into a 'Non-technical Career' or to pursue an individual career outside the firm. In the U.K.



sample, those with an (1) 'Academic Career Orientation' have not been encountered (this can be partly explained by the fact that we do not have research engineers in the U.K. sample). The majority of the U.K. engineers wanted to pursue a (2) 'Managerial Career'. (This is despite the fact that the U.K. sample is much younger than the Japanese sample and a high proportion of them have worked in the engineering field for less than 3 years.) In contrast to the Japanese sample, a smaller proportion of the U.K. engineers appear to want to pursue their career as a 'Technical Specialist' and a relatively high proportion of the U.K. engineers would prefer to move to non-technical areas such as marketing or sales (4), or to pursue their own career outside their firms (5).

## 2. Identity Types

In relation to their career orientations, our sample of engineers tend to display 5 different identity types (this is based on their attitudes expressed in the monthly report data):

Type I Manager (with a technical background)

Type II Technical Specialist Problem Solver (Expertise is the basis of identity)

Type III Corporate Organisational Member (It is important here to identify as a key member of the work group and/or the firm)



Type IV Scientific Professional (The identity here is that of a scientist)

Type V Uncertain Identity (The engineers' role is fundamentally rejected as satisfactory to the individual)

Analysis of the monthly report data from the individual engineers seems to indicate that the majority of the Japanese engineers have an identity of Type III with elements of either Type II or Type IV. Their identities appear to be consistent with their present technical roles in the organisations. The U.K. engineers tend to have identities of either Type I or Type II or Type V. A high proportion of the U.K. engineers tend to perceive their present technical roles as undesirable and not connected with their ultimate career goals.

### 3. Learning Behaviour

Behind the learning behaviour pattern displayed in the monthly reports, four different basic approaches to learning can be distinguished:

(1) **Individual Technical Problem Solution:** Each problem is seen as a 'technical' problem which needs solution, but the problems stand alone and are not necessarily connected to future problems.

(2) **Demonstration of Project Knowledge for Managerial Success:** The learning of skills or of areas of knowledge is related to the importance to the individual of being able to demonstrate his/her personal capacity to solve a problem i.e., it demonstrates current or future managerial capacity. This approach, therefore, includes the learning of technical knowledge as a basis for managerial performance.

(3) **Creative Intellectual Curiosity Orientation:** This is a 'pure science' or professional orientation which is usually demonstrated by a tendency to pursue a number of enquiries simultaneously and cross-tracking between problems.

(4) **'Student' Based Study of Knowledge 'Gaps':**

(A) The approach here is to learn skills and knowledge because it is thought that such knowledge will be necessary for possible future jobs, i.e. it is not related to project problem solving per se, but learning is motivated by a perceived general knowledge gap.

(B) Learning can also be motivated by a specific knowledge gap whereby the individual realises that he/she does not have the specific skills or knowledge for a particular task. Learning the basic skills and knowledge as a 'beginner' is therefore necessary in order to cope with the demands of the task.

The 'Individual Technical Problem Solution' and 'Demonstration of Project Knowledge for Managerial Success' types of learning behaviour tend to be found more frequently among the U.K. engineers. The majority of the Japanese engineers, as revealed through their monthly reports, appeared to adopt a 'Student' Based Study of Knowledge 'Gaps' (Type A)

approach to learning. We encountered a few cases among the U.K. engineers who displayed a Creative Intellectual Curiosity Orientation in their learning behaviour, but this type of approach is rarely found in our Japanese sample.

#### 4. Examples of Cases

The above observations are the researchers' subjective interpretations of the limited individual case data. These tentative findings need to be verified and tested at the stage of the individual interviews. At the current stage of our study, we would prefer not to present the tentative findings in the form of statistical correlations of the major variables used in our study but would rather illustrate our observations through a number of concrete individual cases as a basis for discussion. The following pages present our analysis of six cases, three from each sample. The cases were selected according to their career orientations, namely technical, managerial or a career orientation other than these two. In each case, we examined the engineers' personal background, the learning activities reported, the approach to learning as displayed by the pattern of learning behaviour revealed in the monthly reports and his professional identity. (Note that all the six cases presented below are male engineers. We have only two female engineers in our sample (one in each country) who have been reporting regularly and, in fact, one of them has left the company and consequently dropped out from the project.)

U.K.: Case A

THE PERSON

Education : Bachelor in Electrical Engineering  
 Job Function : Development Engineer  
 Age : 24  
 Length of service : 6 years

CAREER GOALS

At the time of first job : Technical career in large firm  
 At present : Technical career in large firm

LEARNING ACTIVITIES

This engineer displays a strong motivation in his learning activities. He reported 8 OJT incidents and 4 Off J T incidents over a period of 5 months which is well above the average figure for the U.K. engineers. Out of the 8 OJT incidents reported, 7 of them were learning through technical problem solving by himself. On one occasion the close involvement of the group leader was mentioned and on another occasion he mentioned 'talking to many engineers in the laboratory for the ideas to (solve) the problem'. On each occasion, the engineer mentioned he spent time on reading and studying notes in order to solve the problem and understand the theories behind it. Each learning incident was also systematically followed up by further reading and self study of the subject and then by applying the knowledge and skills acquired in practice. Each learning incident was seen as leading to further learning and further application of the knowledge acquired in practice.

It is also interesting to note that among the 4 Off-J-T incidents reported, 3 were in fact studying and reading in private time and the other one was going to an exhibition of technical equipment. Over a three month period, the engineer reported spending a total of 48 hours of his own time reading and studying design techniques and theories. This private study was not aiming at technical problem solving as such but was seen as a way to gain 'a better understanding of the programme', 'to understand the principle behind the theories ...' and also to improve self-confidence at work. As the engineer himself said, after spending 8 hours studying one subject: 'I have a better understanding of the programmes than any other engineers who have had many more hours of experience with the software.'

TYPOLOGY OF LEARNING BEHAVIOUR

This engineer demonstrates a creative intellectual curiosity orientation to learning. Learning is not seen as purely for solving independent technical problems but is also for the sake of understanding theories and principles which are useful for future problems. For this engineer, learning seems to have occurred in a 'spiral way' in which each learning incident is seen as arousing motivation for further learning. This is a highly effective type of learning behaviour on an individual basis.

IDENTITY TYPE

This engineer appears to regard himself as a technical specialist problem solver. Expertise in his technical field constitutes the basis of his professional identity.



U.K. : Case B

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**THE PERSON**

Education	: Bachelor in Chemical Engineering
Job Function	: Software development engineer
Age	: 24
Length of service	: 1 year 3 months

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**CAREER GOALS**

At the time of first job	: Management or technical career in large firm
At present	: Academic career or management career in large or small firm or move into sales/marketing areas

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**LEARNING ACTIVITIES**

Over a 5-month-period, this engineer reported 4 OJT and 3 Off-J-T learning incidents. All the OJT incidents reported were spontaneous learning on an individual basis or self study. Only on one occasion did the engineer mention learning from more experienced engineers. All the OJT incidents reported were concerned with learning technically specific knowledge and skills in order to cope with the demands of the task. Learning is basically for filling in knowledge gaps as the individual did not have background training in the field to which he was assigned. Each learning incident was seen as independent.

The three Off-J-T incidents reported included attending a one-week computer course and two formal appraisal sessions with the section leader and the head of the department (requested by the engineer himself). The objective of the appraisal sessions was to discuss the engineer's request to be put on some form of supervisory or management training course. The request was turned down on both occasions. The reason was he was too young and should concentrate on more technical aspects of the work. The engineer felt that he was being 'dissuaded from taking professional qualifications'.

This is a case demonstrating clearly how the non-identification with the technical work role affects his perception and motivation for learning. Technical skills and knowledge were acquired for the sake of filling in knowledge gaps to cope with the present demands of the task. The ultimate goal was to be put on a 'proper' training course for pursuing 'professional qualifications' in order to move quickly into managerial positions.

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**TPOLOGY OF LEARNING BEHAVIOUR**

Motivation for pursuing technical skills and knowledge is low. The approach to learning here is a 'student' based study of knowledge 'gaps' (Type B).

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**IDENTITY TYPE**

The engineers' role is rejected as satisfactory; the aspiration is to become a manager eventually. A perceived lack of opportunity to move into managerial positions at an early stage in his career appears to lead to high frustration and puts the individual in a state of uncertain identity.

## U.K. : Case C

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**THE PERSON**

Education	: Bachelor in Electrical and Electronic Engineering
Job Function	: Development Engineer (Team Leader)
Age	: 27
Length of Service	: 9 years

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**CAREER GOALS**

At the time of first job	: Technical career in large company
At present	: Management career in small company

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**LEARNING ACTIVITIES**

9 OJT incidents were reported over a period of 5 months. Out of these, 7 of them were learning through meetings with others. On 4 occasions, the individual reported learning some kind of general organisational skills and knowledge. On 3 other occasions, technical general knowledge was acquired which was seen as useful for improving his capacity for technical management. Out of the 9 OJT incidents reported, only two of them were concerned with learning technically specific knowledge through self study.

The engineer also reported 4 Off-J-T incidents, two of which involved attending seminars in the technical field and the other two were formal management training courses. The knowledge and skills acquired were evaluated as useful for broadening his general technical knowledge and managerial skills which in turn are useful for his future career prospects.

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**TPOLOGY OF LEARNING BEHAVIOUR**

This is a clear case illustrating an approach to learning whereby the learning of skills or areas of knowledge is related to the importance to the individual of being able to demonstrate his personal capacity for current or future management. The learning of technical knowledge is seen as a basis for managerial performance.

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**IDENTITY TYPE**

Here the identity of the engineer is that of a manager.

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## Japan: Case A

THE PERSON

Education	: Master's degree in physics
Job Function	: Development engineer (electronic devices)
Age	: 25
Length of service	: 2 years

CAREER GOALS

At the time of first job	: Technical career in large firm
At present	: Technical career in large firm

LEARNING ACTIVITIES

This engineer reported 8 OJT incidents over a period of six months; 6 of these were formal OJT in a group situation organised by the company and the other 2 were spontaneous learning, again in a group situation. The type of knowledge and skills learned was largely technical. On 3 occasions the engineer reported learning technically specific knowledge which is directly related to his own tasks and the tasks of his work group. All new knowledge and skills were seen as useful both for present tasks and also for future projects. On 4 other occasions the type of knowledge and skills acquired was largely theoretical knowledge outside his own specialisation which the individual evaluated as 'very useful for future work and research'. On each occasion, the individual suggested follow-up action by carrying out further discussions and meetings with other engineers. It is also important to note that on 5 occasions the engineer mentioned the role of his own group leader and/or leaders and specialists from other project teams in helping to acquire the new skills and knowledge.

Over the same period, the engineer also reported 7 off-J-T learning incidents. 6 of these were internal seminars organised by the company which lasted for a few hours and the other one occasion was going to attend an exhibition in his technical field. On 5 occasions, the engineer reported learning new technical knowledge outside his own specialisation which was seen as useful for his future project. The two other Off J T incidents were English language lessons organised by the company. The individual regarded improving his English ability as important 'as this is the criteria for deciding whether to send me abroad to attend international conferences'.

TPOLOGY OF LEARNING BEHAVIOUR

Learning is highly systematic and well-organised. Knowledge and skills are acquired not for the sake of technical problem solving per se but mainly for broadening the technical basis which is seen as useful for future tasks and projects. This type of approach to learning is a 'student' based study of knowledge 'gaps' (Type A). However, the objective of filling in knowledge 'gaps' is not because of the lack of adequate knowledge for coping with the demands of the present tasks but learning is seen as a 'natural' part of daily working life in order to move ahead in one's career.

IDENTITY TYPE

Individual technical knowledge and skills are seen as an important basis for 'scientific excellence' and good performance of the work group. The individual here displays a strong identification as a member of the group as well as a scientific professional.

## Japan : Case B

THE PERSON

Education	: Master's degree in electronic engineering
Job Function	: Development engineer (electronic devices)
Age	: 36
Length of Service	: 11 years

CAREER GOALS

At the time of first job	: Academic career
At present	: Academic career

LEARNING ACTIVITIES

This engineer reported 9 OJT incidents over a period of 8 months. Among these, none were concerned with learning technically specific skills or knowledge. On 7 occasions, the engineer reported learning general organisational knowledge and skills (such as knowing more about work activities in other sections or departments, the state of technological development in other companies, improving communications among members of his group and between his group and other sections, etc.) On the other two occasions, he mentioned improving his English conversational skills (through attending an international conference and visiting companies abroad) and learning how to use a word processor. All the OJT incidents reported were spontaneous learning either by himself or in a group situation.

This engineer was undergoing a one-year internal management training course. 8 Off-J-T learning incidents were reported over the same period. All these were part of the management training course within the company and each lasted for one or two days. The contents of the course were mainly basic general management skills such as labour legislation, finance and accounting, decision-making process, recruitment and human resource development, etc..

TYPOLOGY OF LEARNING BEHAVIOUR

His approach to learning can be classified as a 'student' based study of knowledge 'gaps' (Type A). Each new piece of knowledge learned is evaluated as important for giving him the basic skills for further 'self-development' to become a supervisor and to understand more about the general work environment of the organisation.

IDENTITY TYPE

Although this engineer supervises a team of 5 engineers, he does not perceive himself as a 'manager' (note: the definition of manager in Japanese companies differs from that in the U.K.). This engineer's identity clearly lies in his sense of belonging as a corporate organisational member.

## Japan: Case C

THE PERSON

Education	: (not clear)
Job Function	: Development Engineer (Computer Hardware)
Age	: 32
Length of service	: 8 years

CAREER GOALS

At the time of first job	: Management in large firm
At present	: Management in large firm

LEARNING ACTIVITIES

Over a period of 4 months, this engineer reported 9 OJT incidents. On all occasions, the engineer reported learning new technical knowledge and skills related to his own specialisation. All new knowledge and skills were evaluated as either useful to his present or future projects. On most occasions, the engineer reported trying out the newly acquired knowledge in his projects. Out of the 9 OJT incidents, 6 were informal group learning (spontaneous 'study circles') and the other 3 were spontaneous individual learning situations.

Off-J-T did not appear to have much importance in this case. Only two Off-J-T incidents were reported over the same period. One one occasion, the engineer reported attending a half-day course organised by the company on 'telephone manner' training. The other was an English conversation training session, the purpose of which was to prepare him to present a paper at an international conference in the U.S.

TYPOLOGY OF LEARNING BEHAVIOUR

Learning was highly systematic, well-organised and occurred on a continuous basis. The approach to learning was basically a 'student' based study of knowledge 'gaps' (Type A) but this engineer also displayed an element of creative intellectual curiosity orientation in his learning behaviour. Each new piece of theoretical knowledge acquired was seen as connected to his present or future projects and would need to be applied in practice.

IDENTITY TYPE

The identity of this engineer is that of a scientific professional. It is interesting to note that despite his orientation to pursue a managerial career, the central interest of this engineer was in acquiring new technical knowledge and skills. 'Technical excellence' is, perhaps, seen as an important basis for becoming a good team leader or manager.

## DISCUSSION

The project is still in the middle of data collection in both countries and firm conclusions must be premature. What can be said is that both sets of data analysed in this report - the career background questionnaires and the monthly reports - do suggest some interesting questions. How far can we explain differences in individual patterns of learning by individual characteristics and experience within each society? How far are they a product of company organisation and policy? Although the typical explanations of behaviour are affected by the cultural emphasis on the individual in the United Kingdom and the group and the company in Japan, the reality must be that both sets of factors are important in both countries. The precise configurations are likely to be different in each society and also between firms within those countries.

The monthly reports also raise the question of the effectiveness of the patterns of learning reported. Can learning processes be improved? If so, in what ways? A number of more specific questions can be raised here.

1. What aspects of the learning behaviour reported could be improved?

Are the cognitive frameworks used by the UK engineers too narrow?

The emphasis on technical problem solving could be the result of a framework for learning which is rooted in a narrow specialisation. In particular, one could question how far such engineers display a systems perspective, which is so necessary in the technology field (18).



There is a key debate here on the subject specialisation at school and university which is such a major characteristic of the British education system. There has certainly been much discussion on the need to develop a wider interest and awareness among British and American engineers in scientific subjects outside their own specialisation and in social, economic and organisational issues (19). Some British universities are moving towards a general engineering model for their undergraduate courses and there is a debate on the range of subjects really needed for specialists in the electronics field.

**Is the motivation for learning of the UK engineers too practical and instrumental?**

The monthly reports seem to show a heavy emphasis on the immediate task and even where there is a recognition of the need to master a new programme or area of knowledge, this is for a specific and urgent practical purpose. If true, this must reflect the engineers' perception of what they are paid to do - of the real requirements of the role and of the criteria by which their performance is rewarded. Clearly, this issue needs to be investigated in research laboratories, as well as development teams before such an emphasis can be properly established. A lack of clear career prospects might also, of course, be responsible for such thinking.

**Why are young British engineers so interested in becoming a manager?**

Some of the detailed comments written by the engineers show a strong orientation towards acquiring experience and possibly qualifications that will allow them to be promoted as fast as possible to a managerial

position. A significant minority of young engineers in their twenties believe, according to the career questionnaire, that they already have exercised a managerial position. The general perception that engineering is of low status and that salaries do not properly compare with those in other managerial areas, particularly finance, may be responsible for such ambitions. The problem is partly the fact that managerial ambitions seem to arise even for young engineers who have not yet completed their professional or technical training and partly the possible implication that the desire for further technical development may be eroded. Certainly in the United States research seems to indicate that the best technical performers aspired most to a managerial career (20).

**Why is learning claimed to be an almost entirely individual experience for the UK engineers?**

The monthly reports seem to indicate that British engineers are largely learning on their own. It may be that this is exaggerated and that the part played by others is being ignored. The perceptions are certainly highly individualistic. Most engineers are working in project groups and these are recognised as the source of learning requirements. However, if it is true that individuals are largely learning on their own, is this an effective process? Is the problem related to the fact that learning may be seen as a way of increasing ones own technical competence - or managerial competence - so that new jobs can be sought outside the firm, if necessary?



**Is the development of subordinates seen as a crucial part of a manager's job?**

There is little in the UK monthly reports to indicate that managers try to develop their staff. In particular, it seems necessary to enquire how far young managers perceive the development of their staff as a crucial part of their role. This is not simply a need for line managers to become more paternalistic. The complexity of new technology increases the need for learning to be conducted by co-operative and systematic search procedures, which cannot be carried out by individuals entirely on their own. Management organisation of learning programmes is essential and support for learning is probably essential for continuous motivation.

**Why do Japanese engineers appear to adopt a 'student' type of learning behaviour? Is this effective?**

There is much evidence from the monthly reports of a wide variety of learning among Japanese engineers which is followed in the form of the acquisition of knowledge which may be required for future roles. There are two possible problems here. The process of studying is rewarded directly through the appraisal schemes of many Japanese companies (21) as part of policies of encouraging professionalisation and this could lead to the reporting of learning simply to gain a better appraisal. Secondly, the range of subjects covered is large and sometimes not directly connected with immediate tasks so the relevance may be questioned. Interviews are obviously necessary to check this point.

**Why are there so few detailed accounts of learning from technical problems in the Japanese engineers' monthly reports?**

This may be the opposite of the U.K. problem. Can one argue that Japanese engineers do not appear to use daily work problems as an opportunity for learning? Is there too much dependence on formal OJT programmes organised throughout the company? Such programmes may suppress individual creativity and innovativeness. It is interesting that the study seems to show that even the one third of the Japanese engineers in research laboratories do not often display a 'Creative Intellectual Curiosity Orientation'. (There may be a bias here in the fact that the Japanese engineers may have tended to report group learning situations and ignored the individual situations.) Creativity clearly depends on unstructured and inter-active discussion and experimentation and there is a large debate at present in Japan on the issue of how to develop greater creativity among R and D staff.

**Should greater opportunities be developed for learning through external formal education and training and professional contacts?**

Much of current Japanese education and training practice emphasises internal company OJT and this is reflected in the monthly reports. Systematic development of technical capacity may require a much greater involvement of company staff in professional work, in research between companies and in work involving universities, in Japan and abroad. There is some evidence that such needs are perceived by Japanese engineers, but are not necessarily reflected in company policy (22).

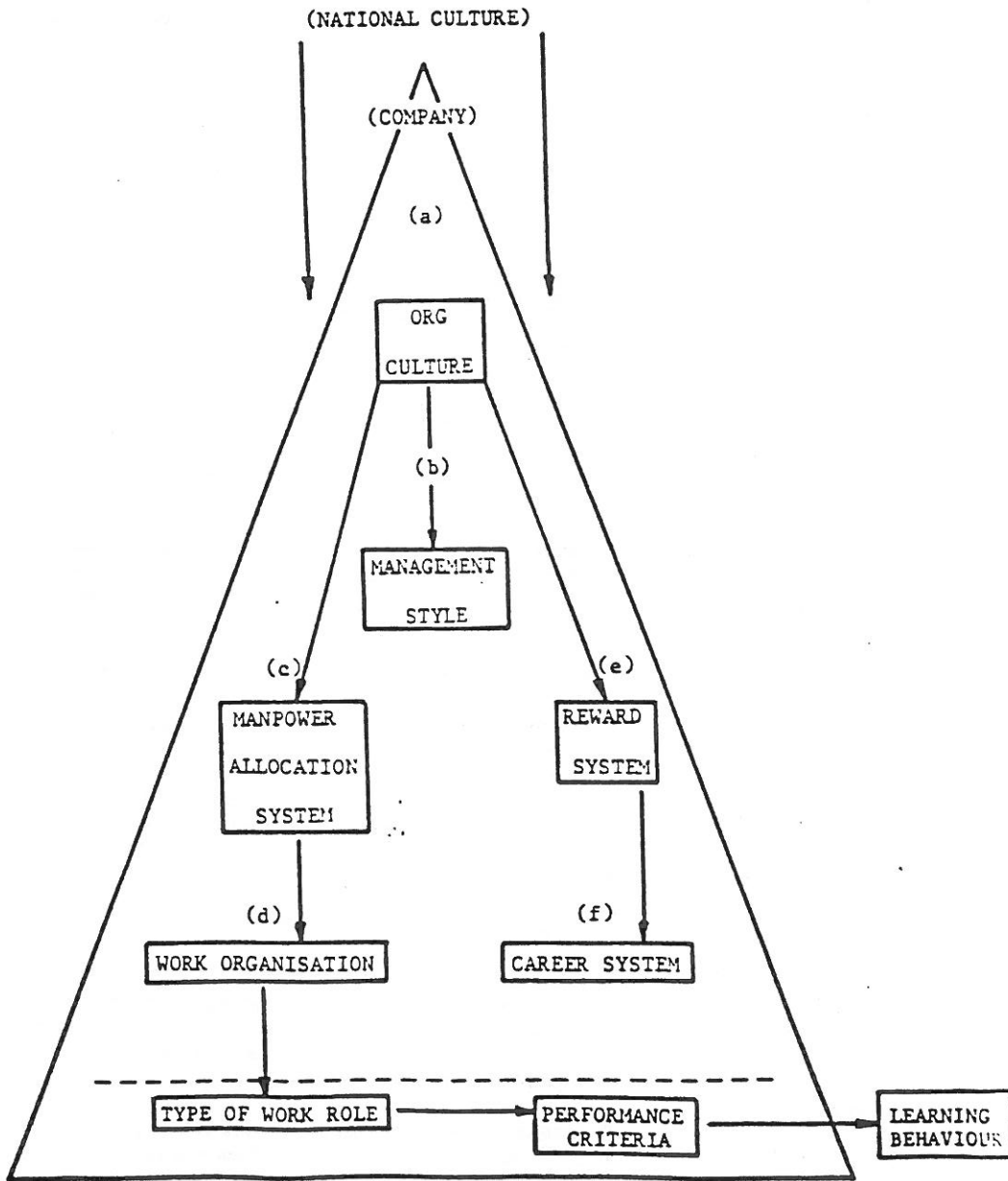
2. The influence of organisational factors?

Work roles are largely determined by organisational requirements and local cultural and social norms. As argued above, learning behaviour is likely to be partly explained by work role demands. The next step in the research therefore has to be to explore the organisational factors in each company that affect individual learning behaviour, identity and the utilisation of capacity. Figure 3 shows the type of factors which may be most important in this process.

FIGURE 3

CONCEPTUAL FRAMEWORK AND MODEL:

THE INFLUENCE OF COMPANY ORGANISATIONAL PROCESSES AND POLICIES  
ON LEARNING BEHAVIOUR



Each company will differ in terms of its precise organisational culture and systems and their possible influence on each engineer. To guide research, however, Figure 4 lists the most important aspects, which, according to other studies (23), may tend to dominate company organisational life in Japan and the U.K. Such generalisations may not be true of the companies in the study and even if true they may not be important determinants of engineers' behaviour. The project will be directed to testing such arguments.

Figure 4 Organisational Factors likely to influence learning behaviour in Japan and the U.K.

Factors	Japan	U.K.
Organisational Culture	Top Management led educational self-development. Scientific orientation adapted for commercial use.	Financial control dominant. Marketing gaining importance. Research important in laboratories.
Management style	Personnel decisions taken by Team Leaders within overall company policy.	Individual managerial autonomy allows great variety of practice.
Manpower allocation system	Decided by senior management on performance early in career.	Decided by Training Department then by middle management and by personal choice.
Reward system	Seniority system modified by moves towards ability rated appraisal. No salary differential between management and specialists.	Salary increase and bonus for high performers and for managers.
Work organisation	Small project teams in interrelated research, development and production organisations.	Project teams and segregated research and development
organisation.	Constant change of projects and roles.	Customer service teams important for information technology firms
Career systems	Professional rank and specialist career developing as equal to managerial positions.	Managerial posts prior to technical except in research.



**SOME POLICY IMPLICATIONS FOR THE UNITED KINGDOM.**

**1. Policy Issues**

Starting in the autumn of 1988, it is planned to hold a number of policy seminars at the School on the implications of the research, especially for U.K. firms. The following issues seem to be most important.

**Issue One**            **Recruitment of university graduate engineers**

If there is a crucial problem in large manufacturing firms of mis-utilisation of the skills and capacities of young graduate engineers, why recruit them? Could these jobs not be better carried out by technician engineers (level C)? Is it feasible to recruit level B graduate engineers after their initial professional training has been completed? What type of changes in reward levels and promotion/career routes would be necessary in order to make this possible?

**Issue Two**            **Professional Training of Level B engineers**

Many graduate engineers in the U.K. engage in post-graduate studies, but the basic model for professional qualifications is an undergraduate specialist technical degree plus a period of work experience and work assignment tests, supervised



through the Professional Institutes. The 1992 European Community liberalisation of the labour market means that the U.K. has to accept engineers from other Community members with licenses, usually from the State, after completion of a lengthy university or vocational school training, often to a post-graduate level. It seems an appropriate time to consider the establishment of two year Masters degrees as a new basis for Professional (Chartered) engineering status. Such programmes could be based on company supported Teaching Companies to provide the practical project experience, supervised by university and company staff. Sponsorship of engineers by companies might be switched to this post-graduate qualification from undergraduate degrees.

**Issue Three      Conversion Courses**

The shortage of information technologists might be best ameliorated by an expansion of conversion courses for non-technical university graduates at local universities. A one year course could lead to a special post-graduate Diploma, probably suitable for basic software engineering. A further two year course could be considered as a basis for Professional status. Again companies might consider sponsoring such students and providing essential practical experience.

**Issue Four      Employment status of engineers**

One implication of changing the arrangements for achieving professional status could be to establish a clear difference in status between students still studying for their post-graduate qualifications - who would not be employees - and professional engineers who would be offered full employment rights and career possibilities. Technician engineers who could be accepted for professional training would also be students.

**Issue Five      Post-professional training**

These changes would allow the companies to concentrate their development programmes on post-professional training which could last for up to ten years, say from the mid-twenties. The lines of this training have been sketched above; they would include career designed job rotation, management training, self-development projects, assignments overseas, writing of conference papers, etc. The crucial problems are that of financing and organising such programmes. It is clearly crucial to relate the training to actual project work, but not to restrict it to immediate project problems. Project supervisors therefore need to be involved in organising and monitoring the programmes, but more senior technical staff need to plan and evaluate the results.

**Issue Six      Reward Systems**

The research uncovered many hygiene factors, especially for young engineers, which seems to be important (housing costs, salary levels, fringe benefits, etc.). These are closely related to the problems of living costs in the south part of the U.K. More fundamentally, there is the problem of how to provide a promotion and career system which will attract engineers to companies, at least for a medium-term career of, say, ten years. The crucial factor seems to be the opening up of senior managerial positions to those specialising in the technical function. One possibility would be to provide a mid-career training programme (for those in their late thirties) with new job opportunities linked to the programme, which would broaden the experience of the engineer.

**Issue Seven      Work Organisation**

The design and leadership of project groups seems to be a key factor in the effectiveness of development programmes. Is it possible to devise arrangements so that senior technical staff can sometimes lead such project groups? Could project teams be developed which would move together from assignment to assignment? Could there be more use of research teams following their projects into the development and production stages?

## 2. Learning from Japan? An Experiment in a U.K. Firm

There is now considerable debate in the U.K. on whether there are lessons to be learnt in the education and development of engineers from Japan. Among the ideas which are of considerable interest are:

- the use of constant job rotation to ensure that technical staff have the widest possible experience and stimulation from different fields.
- using senior management presentations of the results of project work to improve recognition of learning and emphasise this in the appraisal of technical staff.
- the writing of conference papers and the encouragement of patent registration to improve the professional and scientific recognition of technical achievements.
- the development of team building processes for project groups, combined with the recognition of collective achievement.

The research project is designed to provide evidence on the utility of these and other ideas in the possible improvements of learning behaviour for technical staff.

An example of one company - GPT (GEC Plessey Telecommunications) - can be given as a concrete case in which current policy changes are beginning to be affected by the ideas coming out of the research.

(1) **A New Company**

On the 1st April 1988 the new company was formed with annual sales of £1,200 million, capital assets of £600 million, 24,000 employees worldwide and an annual investment of £200 million each year in research, development and marketing, with another £100 million invested annually in capital equipment. The company resulted from a merger of the telecommunications interests of two of the largest electrical and electronics companies in the UK, GEC and Plessey.

(2) **GPT and the Research Project**

GPT is particularly interesting from a number of points of view. First, many of the UK engineers participating in the international research project work for GPT on a number of different sites. Second, GPT has also piloted the Professional Development Record of the Institution of Electrical Engineers (on which the documentation for the international research project is based) as well as a new career development logbook, being piloted by the Engineering Council. Third, GPT is intent on developing rapidly a new culture and style of management radically different from that of its two parent companies.

(3) **The PDR: A British Initiative**

Taking firstly the progress of the PDR as a self-development tool for technical staff, there is considerable evidence that it is indeed an invaluable approach for those committed to using it. Only a proportion of engineers have responded, but positive comments have been received from those who are using it most.  
e.g.:



'Since starting to use the PDR I have made my first departmental move with the company. I believe the process of sitting down and forcing myself to plan for several years in the future helped me to make the correct "career move".'

'Stimulated me to start an Open University course. I have almost completed the "Architectures and Operating Systems" module of the M.Sc in "Industrial Applications of Computers". I would like to do the whole M.Sc.'

'As a record the PDR provides a useful medium in which to record data which might otherwise be easily lost.'

'It has helped me to define both my short term and my long term career aims. It is proving invaluable as a record of my professional development.'

GPT now intends to issue the PDR to all 330 new graduates joining the company in 1988. At the same time each new graduate will be assigned a mentor, an engineer with 4 or 5 years experience in the company who works in a department different from that of the graduate.

(4) **Personnel Database for Career Planning**

Work is currently in hand to develop an integrated Personnel Database for GPT, with a Skills Database as an integral component. This latter will provide the company with access to details of the education, career, training, skills and career objectives of all employees. Input to the database will be by the employees themselves accessing their own records via visual display units. Updating of this database will be triggered by the annual performance appraisal of the employees, thus leaving the responsibility for the accuracy of the database records to the employees themselves.



(5) **Organisation Styles and Structures**

Although the history of the parent companies has emphasised hierarchy and rather mechanistic structures, GPT is likely to develop much more flexible and fluid management and organisation structures. The availability of the Skills Database by Personnel, Training, the Technical Directorate and the Businesses is a vital factor in developing and utilising the skills of the 24,000 employees and implies that employees will be liable to constant job change and innovation.

(6) **Innovation**

A deliberate strategy to 'Manage Innovation' is being discussed within the Company. Possible components of this strategy might include:

**'Leap Frog' Communication**

Engineers might be encouraged to by-pass their immediate supervisors and go directly to the person most likely to help with any particular design problem.

**Hiring 'Mavericks' (non-conformist personalities)**

This recognises that creative people may often be unconventional in behaviour and attitudes. 'Heavy handed' supervision can destroy creativity and innovation.

**Diversified Talent Base**

The proposition is that innovative ideas are more readily generated amongst employees from different backgrounds.

**Pragmatic Functional Organisation**

The policy would be for functional demarcation lines between design groups to be highly fluid. Novel or new approaches to problems might be welcomed from outside working groups.

**Time to Innovate**

Managers might be encouraged to allocate time solely to supporting new ideas. Engineers would perhaps be encouraged to spend part of their working time on developing innovative ideas.

**Appointment of a special manager for innovation**

Such a person might be responsible for spotting new ideas and helping their promoters to win the support of their managers.

**Motivation and Reward of Innovators**

These need not necessarily be financial. For example there is likely to be much more formal recognition by Directors of excellent work performed by employees with letters, presentations, etc. 'Pinball Rewards' ('PACHINKO') would be an approach whereby successful innovators are given the opportunity to continue innovating, in other words to "play again", while those less successful will be transferred to more straightforward development work.

(7) **Implications**

Some of these approaches may be of interest to Japanese companies looking for the development of greater creativity. For their part, British companies are starting to learn from Japanese of the benefits of regular working group learning sessions, study group presentation sessions, formalised in-company regular technical inputs for high-flying engineers, regular accessing of abstract databases and encouragement of presentations of papers at conferences and the registration of patents. In turn the Japanese might learn from the British use of courses for Senior High School leavers to obtain degrees by part-time study and through Open University degrees, as well as the study of MBA's and M.Sc's part-time and through Open Learning by graduates.

It is clear that the research has already started a process of dialogue and of diffusion of ideas on personnel management. The experimentation stage is now just beginning.

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Form 1  
TRAINING  
OFF-THE-JOB

Name: ..... PROFESSIONAL DEVELOPMENT RECORD

1. Date	2. Duration	3. Description	4. Assessment	5. Follow-up
January 12, 14, 26 (Tuesdays)	4:30 - 7:00	Part time BSc in computer studies.	New mathematical concepts learned. Relevant to passing the course. May be of some use if work in the future.	A number of suggested exercises were given and for practice. No time found yet in work to do them.
14, 21, 28 (Thursdays)	4:30 - 9:00		Many further knowledge of Pascal useful for career prospects in programming	
25, 1983	1/2 day	Optical Fibre Appreciation course given at regional training school.	New knowledge. Not relevant to current work, but gives an insight into work done by others within the company	None necessary.

Name..... PROFESSIONAL DEVELOPMENT RECORD

Date		Description	Assessment	Follow-up
From	To			
19.1.88	1 1/2 day	<p>Design Review Meeting. Meeting to discuss the Design of current project, which is nearing completion. Representatives from design, manufacturing, purchasing etc.</p>	<p>I was at the meeting in order to represent software engineering. It was the 1st meeting of this type that I have attended. Very informative demonstrated how a formal meeting should be held.</p>	<p>no action to be taken.</p>

PROFESSIONAL DEVELOPMENT RECORD

Notes and Explanation.

1. Objectives.

In the middle of a period of rapid technological and scientific change, it is clearly necessary to update one's knowledge both on theory and the use of new technology constantly. This can be done by Off the Job education and training courses or by On the Job training (OJT). Engineers often feel that there is a lack of time for such professional development and it is important to find out how much actual learning is taking place and the methods by which it is being facilitated. Questionnaires are not very useful for this purpose; it is necessary to record the actual detail of learning opportunities as they happen. This record is designed to allow engineers to record the most important learning opportunities in a systematic way over a six month period.

2. How to complete the record forms.

a. Two forms are provided.

Form I is for Off the Job education and training.  
Form II is for On the Job training provided formally e.g. coaching and instruction by a more experienced person, and for learning which takes place spontaneously e.g. in a meeting or through self-study at work.

b. Form I (Off the Job)

Columns 1 and 2 are for the date and duration of the training course.

Column 3 is headed Description. You should record:

- i the title/subject of the course
- ii who was the teacher
- iii the place it was arranged

Column 4 is headed Assessment. You should record:

- i the main point(s) where you feel important pieces of new knowledge, important new skills etc. were acquired.
- ii why you feel this new knowledge or new skills are important to you. e.g. because of a new project, useful for future work, necessary for promotion, etc.

Column 5 is headed Follow-up. You should record:

- i what type of follow-up action seems to be necessary.
- ii what type of follow-up action did you actually take?

c. Form II (On the Job)

Column 1 is for the dates and period of the learning activity.

Column 2 is headed Description. You should record:

- i the type of learning opportunity e.g. formal OJT or more spontaneous learning or self study.
- ii the situation in which it took place. e.g. in a group meeting or individual meeting with one person, alone by yourself on the job.
- iii any key person who helped you to learn effectively.

Column 3 is headed Assessment. You should record:

- i the main points where you feel important pieces of new knowledge, important new skills, new understanding, etc. were acquired.
- ii why you feel this new knowledge or new skills are important to you. e.g. because of a new project, useful for future work, necessary for promotion, etc.

Column 4 is headed Follow-up. You should record:

- i what type of follow-up action seems to be necessary.
- ii what type of follow-up action did you actually take?

3. Recording and Collection of Forms.

- a. We have provided five copies of each form. Please photocopy as many blank forms as you need. You may find that you only record one learning opportunity in a week, or you may find you have five, six or more. Only record what you judge are important incidents for you personally.
- b. Each month please give the forms to the secretary of the engineers group who will send them directly to London.
- c. Please use the forms for discussion in the group when it meets. Comparisons may be interesting.
- d. We will discuss the forms with you individually next Spring.
- e. If you wish, a representative of the research team will discuss the exercise in a group meeting.