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ABSTRACT

Intended to help course designers and other professionals infuse the teaching of the social implications of technological change into existing technical and further education (TAFE) courses in Australia, the guide has four sections: (1) a chapter called "Why Teach Social Implications"; (2) examples that were collected from the 11 of 245 TAFE colleges that indicated they had at least one course that included the teaching of the social implications of technological change; (3) a curriculum framework that includes seven models of social implications of technological change; and (4) 20 references. (CML)

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TEACHING THE SOCIAL IMPLICATIONS OF TECHNOLOGICAL CHANGE

WILLIAM HALL

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INTRODUCTION

The purpose of this publication is to provide straightforward help on the teaching of the social implications of technological change within TAFE courses. It should be especially useful to course designers.

The report has three main sections. First, there is a discussion of the meaning of the social implications of technological change and why it is important to teach social implications in TAFE courses. Second, examples are given of how social implications may be taught, including examples from TAFE colleges. Third, a curriculum framework is suggested.

A major difficulty in preparing the report was that most writing on the topic has been in the area of science (not technical) education, and this writing has been for high school teachers (not TAFE lecturers). However, what has struck me is that the arguments used (but not, of course, the examples) are usually precisely applicable to TAFE. Therefore, I have used those arguments and printed extracts where they are helpful.

Nowhere is it proposed that there should be a new module developed or a new subject offered entitled "social implications". What is urged however is that all TAFE courses should incorporate the social implications of technological change.

This need not displace other content; what is needed is an awareness of the numerous opportunities that already exist for teaching such an important (but frequently neglected) topic.

1. WHY TEACH SOCIAL IMPLICATIONS?

DEFINITIONS

By the "social implications" of technological change, I mean the ways in which technological change can affect people (individually or in a group) and the ways in which people can themselves bring about such change. Technology can be defined as 'a disciplined process using scientific, material and human resources to achieve human purposes' (Harrison 1986). (This is the definition adopted by Project Technology in the United Kingdom and is further explained in Section 3 of this report.)

REASONS FOR TEACHING SOCIAL IMPLICATIONS

Some years ago I gave eight main reasons for teaching the interactions of science, technology and society in high schools (Hall et al. 1983). Six of these reasons are equally relevant to TAFE (the other two are specific to schools) and two others have been added:

- technological change is an important part of our culture and, as such, should be understood by everyone;
- it is important to have informed citizens in all walks of life;
- there is a widespread concern for the quality of life, especially the impact of changes to technology on this quality;
- there is a need for everyone to exercise social responsibility at work when technologies change;
- there should be a 'values' component in technical education. This is especially true when dealing with technological change;
- there needs to be recognition that changes in technology are practised within a social context and so the teaching of changes should not be isolated from people;
- technological change is having a huge impact on employment, with an ever increasing rate of change;
- technological change is making an impact on education (both what is taught and how it is taught).

Each one of these eight reasons is discussed later in this section.

One of the best, recent, reports on technological change was published by the Australian Department of Science and Technology (McCann, Fullgrabe & Godfrey-Smith 1984). The aim of the report was to:

- examine technological change in a social context and identify the issues involved;
- consider means by which Government policy and technology policy in particular, can take into account and evaluate further the social implications of technological change.

The report's findings (quoted in the document's Summary) are shown below. They are given in full because of their importance and usefulness.

> The technology-employment debate is no longer preoccupied with whether technological change should be encouraged, prevented or slowed. The important contribution of technological change and innovation to economic growth is widely accepted. There is now more concern with achieving socially responsible technological development, the amelioration of adjustment problems associated with technological and industrial change, and the equitable distribution of the benefits of technological change.
>
> There are conflicting views on the effects of technological change on aggregate employment. The literature suggests that factors other than technological change should receive most of the blame for the current high levels of unemployment. Many studies draw attention to the potential of the diffusion of microelectronic technologies to create a situation in which economic growth is not matched by growth in employment (i.e. 'jobless growth'). Measures should be considered to reduce labour force participation and to distribute the wealth arising from future technological change including the reduction of working lives.
>
> Technological change has already caused a substantial structural shift in employment away from the primary and secondary sectors and toward services. There is widespread agreement that technological change has a significant impact on skill requirements, reducing demand for unskilled and semi-skilled work, making some existing skills and occupations redundant, and creating the need for new skills. Continuing research is needed into the effects of technological change on specific

skill requirements and occupations. A comprehensive training and education effort is vital in order to ensure satisfactory development of Australia's human resources.

Changes in the structure of employment, to which technological change contributes, cause considerable hardship for individuals, groups and regions. A major challenge facing society is to minimise this disruption. These problems are likely to be unevenly distributed within the workforce. Problems involving unskilled and semi-skilled workers have already been mentioned. Other groups, such as women, migrants and older workers are also vulnerable.

Technology itself should not be regarded as immutable. The design and manner of introduction of technology is a matter of social choice. Associated organisational change, skilled management, and the practice of consulting and involving employees in decisions, are important in this regard.

The role of managers is crucial in determining the balance of social and organisational costs and benefits of technological change. A comprehensive approach to the management of human resources is called for, encompassing management practices regarding training and skill development, work design, career prospects, the work environment, health and safety, involvement of employees in decisions, and industrial relations.

Technological change raises fundamental social issues, such as the distribution of wealth and decision-making, power, values and attitudes regarding work, leisure and income, ethical questions related to medical and biological developments, and the role and purpose of education. There is a need for further research, and an increase in community debate on these important issues. The political system, and Parliament in particular, should take the lead in community debate.

Adoption of the concept of recurrent education, in the form of retraining to update work skills or education for a continuing awareness of technological and social issues, will assist social adjustment. It is important that the recent trend away from full-time education in Australia be reversed. There are some recent encouraging signs that this may be starting to occur.

There is a conspicuous lack of detailed research into technological change in Australia. In particular, there is a lack of research at a disaggregated level, focusing on particular groups, regions, occupations

> and industries and into the broad social issues. Without an adequate research effort, effective responses will be difficult, and informed debate impossible.
>
> There are many areas of government policy which are relevant to policy development regarding technological change. These include science and technology, industry, communications, law reform, education, training, employment, industrial relations and manpower planning. This has important implications for overall government administration, and highlights the need for integration and co-ordination of policy in particular areas.
>
> (pages 1-3)

These findings provide powerful reasons for including the social implications of technological change in TAFE courses, but this will only be possible if there is continuing recognition that TAFE courses must offer more than opportunities for basic skill training. This is important because answers to "Why?" and "What if?" questions matter, as much as answers to "How?" questions. The social implications of technological change are primarily concerned with "Why?" and "What if?". Answers to these questions produce course objectives which do not stop at knowledge and skills; attitudes also become important

Studies indicate that in this country we fall short in educating the population about science and technology. Australian attitudes towards science and technology and the future were surveyed in 1985 and reported by Eckersley (1987). The report concluded that "community understanding of, and involvement in, science and technology are still far from adequate" (page 5). If even basic understanding is inadequate, how can the present technological changes be grasped?

Frequently, social implications (when they are treated at all) are treated superficially, the sole emphasis being on how people are (usually negatively) affected by changes to technology. This is especially true at high school. For example, "pollution is bad, factories produce pollution, therefore factories are not nice places to work in" is the naive approach adopted in some schools. The fact that we enjoy our high standards of living because of factories is completely ignored. The story (told in all industrialised countries) of the party of school children about to start a guided tour of a factory and being told by the teacher that "if they didn't work hard they would end up here" is worth repeating in this context.

The point is this: that many TAFE students will already be pre-conditioned with regards to the social implications of technological change and the existence of that pre-conditioning will need to be recognised. Not to deal with social implications issues in the positive environment of a TAFE college could be doubly harmful, reinforcing a negative attitude.

Of course, the contrary approach (that schools should have as their sole aim the preparation of students for work; therefore a skills-based curriculum developing wholly positive attitudes towards industry and commerce should be encouraged) is equally questionable.

A useful summary of the new technology's impact on (especially USA) labour markets, and some predictions about school curricula and teaching, are given by Apple (1987). The author's concern is to raise ideological and ethical issues relating to the role of schools, especially in view of economic pressures. Those concerned about the nature of schooling should read the cautions which are presented in this report (which was prepared for the Commission of the Future).

The rest of this section of this report will be devoted to amplifying the eight reasons (given earlier) for teaching the social implications of technological change. It should be noted that these eight reasons are not mutually exclusive.

TECHNOLOGY AND TECHNOLOGICAL CHANGE AS A PART OF OUR CULTURE

Technology and technological change are important parts of our culture and, as such, should be understood by everyone.

The everyday applications of technology are commonplace. The impact of technology at the personal and family levels is so well known and so much a part of our everyday living that it is unnecessary to give examples in a report such as this. (Whether they are understood will be questioned later.) However, we should not assume that this acceptance of technology is commonplace at the national level, as an OECD report pointed out:

> We were struck by what seemed to be a widespread Australian view of technology as in some sense external to national life. This is in part, no doubt, a consequence of Australia's historical idiosyncrasies. A high proportion of the techniques used in Australian industry (although not in agriculture) are indeed imported from overseas, mostly by foreign-owned companies. Australia has a tradition of importing technical and professional workers, rather than (or as well as) educating them from childhood. The country's institutions for labour/management relations are such that new technical procedures are frequently seen as being imposed "from outside" on local factories or offices, often with minimal consultation. (OECD 1986, page 13)

This raises important questions on how technological changes are introduced, questions about industrial democracy and about management training. Such questions are important to TAFE courses.

Even at the personal level there can be appalling ignorance of technological change, as the following amusing extract from the 10/7/69 edition of the satirical magazine Punch illustrates:

> I have picked up a pretty sound working knowledge of electrical matters. It is not comprehensive - I still can't fully understand why you can't boil an egg on an electric guitar - but when I jot down a summary of what I have learned, I marvel that I have never been asked to write for the Electrical Journal:
>
> 1. Most electricity is manufactured in power stations where it is fed into wires which are then wound around large drums.
>
> 2. Some electricity, however, does not need to go along wires. That used in portable radios, for example, and that used in lightning. This kind of electricity is not generated but is just lying about in the air, loose.
>
> 3. Electricity becomes intensified when wet. Electric kettles are immune to this.
>
> 4. Electricity has to be earthed. That is to say, it has to be connected with the ground before it can function, except in the case of aeroplanes, which have separate arrangements.
>
> 5. Electricity makes a low humming noise. This noise may be pitched at different levels for use in doorbells, telephones, electric organs, etc.
>
> 6. Although electricity does not leak out of an empty light socket, that light socket is nevertheless live if you happen to shove your finger in it when the switch as at the "on" position. So if it is not leaking, what else is it doing?
>
> 7. Electricity is made up of two ingredients, negative and positive. One ingredient travels along a wire covered with red plastic, and the other along a wire covered with black plastic. When these two wires meet togetner in what we call a plug, the different ingredients are mixed together to form electricity. Washing machines need strong electricity, and for this a booster

ingredient is required. This travels along a wire covered with green plastic.

8. Stronger electricity cannot be used for electric razors. Electric razors make a fizzing sound when attached to a power plug.

9. Electricity may be stored in batteries. Big batteries do not necessarily hold more electricity than small batteries. In big batteries the electricity is just shovelled in, while in small batteries (transistors) it is packed flat.

10. Electricity is composed of small particles called electrons, an electron weighing 1/1.837 as much as an atom of the lightest chemical element, hydrogen, unless the Encyclopedia Britannica is a liar.

Of course, the extract is a light-hearted jest. However, amongst the general community there is similar appalling ignorance of the workings and the implications of more recent technologies.

At every level of society there is ignorance of technological change; at the local and national levels there frequently appears not to be even an understanding of the important technology- culture link. This link includes industrial democracy, retraining, attitudes toward quality and towards health and safety, etc. Forging of the link should start at school, but rarely does this seem to happen.

Recently I wrote (Hall 1988b) about the need for compulsory school technology courses and in that article I made the following point:

> Most schools continue to educate students for one main aim: a place in higher education. The successful students go to university and the less successful go to a CAE. The failures go to TAFE colleges. Such an approach is not surprising because teachers themselves are 'successful' products of the present process. They have their own status to maintain.
>
> Australia is a land of not two, but three cultures: the arts, the sciences and the technologies. The technologies are not as highly regarded as the arts and the sciences by those who are in a position to influence young people. However, the technologies are at least as important, and I would argue that they are actually more important, to today's students than the arts and the sciences. I don't want to replace the other cultures, I just want a better balance.

> If our country is to have any sort of future, then technology education must attract intelligent, committed students. If the arts and the sciences are themselves to have any future, technology must be strong. If the arts and the sciences are to be relevant to the country's needs, artists and scientists must (at least) be technologically literate. I would go further and state that artists and scientists must be technologically practical.
>
> The work done in universities and CAEs is not being condemned. It is the assumptions that are made by school teachers and by higher education lecturers concerning the nature and importance of that work, as compared to what goes on in TAFE colleges, which is being criticised. I claim that the ignorance and prejudice in schools can largely be changed by the introduction of school technology as a major part of formal, compulsory education. This approach worked for science (exactly the same prejudice and ignorance were true of science when it started to emerge as a school subject) and it would work for technology.
>
> For too long the school curriculum has been dominated by the needs of higher education. Indeed, until recently, the older universities had a stranglehold on matriculation examinations. Even today we have school subjects which are acceptable for university entrance and those which are not. It is time to recognise that more students now enter TAFE than enter both universities and CAEs combined. Therefore, TAFE's requirements should be the major consideration when deciding the school curriculum.
>
> One final point, if we are living in a technological age, with the latest industrial revolution taking place and at least one more revolution possible before 2000, surely technological literacy and the ability to act and to solve problems in a technological environment are minimal requirements of our school curricula?
>
> (Hall 1988b, page 54)

And minimal requirements for TAFE curricula, I could have added, because TAFE does also have an important role in teaching technology and its rate of change as a part of culture. It is not just the responsibility of schools. And TAFE's responsibility is the purpose of this report.

IMPORTANCE OF BEING INFORMED CITIZENS

Kenny (1985) has described the provision of a "liberal" complement to the vocational core of a course at the Royal Melbourne Institute of Technology which was built on Kaut's four basic questions of life:

- Where do I stand?
- What can I know?
- What ought I to do?
- For what can I hope?

It is important to have informed citizens in all walks of life.

Although Ziman (1980) was mainly concerned about science education when he wrote the following, the same argument nevertheless holds good for technical education when the social implications are not mentioned, and when skill training by itself is claimed to offer solutions to all problems.

> By referring admiringly to a few standard examples where basic research has opened the way to remarkable technological progress, and by setting contrived problems within the narrow terms of such applications, the science teacher typically presents a very one-sided view of technology. The actual capabilities of scientific technology in meeting human needs, the actual range and relative priority of such needs, the economic and political circumstances in which science is to be applied, and many other aspects of cultural and social reality are entirely ignored.
>
> Science education is thus one of the sources of another manifestation of scientism - the belief that disease, poverty, hunger, violence and all other evils of the human condition can be done away with by the deliberate application of scientific knowledge. The most extreme form of technological optimism holds that everything that is technically possible (for example, the construction of artificial space colonies, or the multiple cloning of human beings) must eventually be done. This doctrine is now a little out of fashion, but it is only a modest extension of the widely held belief that anything that one would like to do must eventually prove to be technically possible.
>
> From this belief there arise many misconceived public policies, such as the 'campaign against cancer', or reliance solely upon the techniques of birth control to 'fix' the population problems of developing countries.

> Here again, it is important not to fall into the contrary attitude in which all the ills of mankind are blamed upon the progress of science and technology. By failing to give a balanced response to the question 'What can science do?', conventional science education provides no rational defence against sceptical, antiscientistic pessimism. (Ziman 1980 pages 43-44)

Exactly the same concerns can be expressed about 'technology', 'technologists', 'technicians' and 'technical education'.

If TAFE courses are to be regarded as education rather than merely the acquisition of a narrow set of techniques or skills training as well as a belief in technological change as a panacea to civilization's ills, then not only the techniques associated with technology should be learned but also their limitations, their impact and their use within a particular approach to problem solving should be recognised as important issues.

Some of the most important decisions presently facing this world need a good general understanding of technological principles if sensible decisions are to be taken about major changes. An example I am fond of giving is that of the energy crisis and changes in fuel technology, not understood at all if a spurious model of machine is given which ignores the second law of thermodynamics; but readily understood if the more correct model is taught, as shown below:

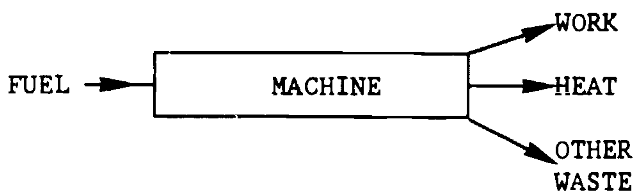

Figure 1: Model of a machine

How many of our students have even a basic grasp of the social implications of technological principles such as this, thus being able to discuss (say) legal implications of technological change?

CONCERN FOR THE QUALITY OF LIFE

There is widespread concern for the quality of life, especially the impact of changes to technology on this quality.

A dramatic example of the "quality of life" issue is when builders' labourers strike because a heritage building is threatened with demolition. Most quality of life issues are much less dramatic than this, although some of the conservation battles have involved many large groups of people.

The Australian College of Education at its Silver Jubilee Conference had as its theme "The human face of technological change". In a stimulating paper, Dorothy Green (1984) said the following:

> I wish I had more confidence in the statement of the Minister, The Hon. Barry Jones, that intellect, imagination plus technology equals progress. I wish I also had more confidence in his statement that the choice is up to us. I can see no evidence that the people at large were ever consulted about some of the most far-ranging technological innovations of our times, the introduction of nuclear power, for example, to mention only the most revolutionary. Certainly, authors were never consulted about the new mechanical devices for printing books, and the consequence is that they have to put up with longer delays in publication and a greater crop of misprints than ever before. When Henry Handel Richardson sent the manuscript of her last novel to Heinemann's in November, 1938, she received the first proofs back in three weeks, and the novel was out in 1939. With the new technical wizardry now available it can take anything up to six years to publish a book.
>
> In the political arena, the main use of television seems to have been to make it easier for political candidates in the grip of fantasies to act them out in real life, with a walk-on cast of millions. It is difficult to feel enthusiastic about the promises of instant communication at any hour of the day or night, which includes sight, sound and feeling, if we have as little to communicate as some of the sports stars interviewed by TV reporters. I wish some of this technology could be used to prevent the structure of the English language from being destroyed by functional illiterates in the mass media, but I see little hope of that. (Green 1984, page 53)

This concern for the quality of life can be applied to numerous everyday examples. However, I am not so pessimistic as the author of the preceeding quote. The fact is that ordinary people can influence decisions. But they can only do this if they are knowledgeable and understand the technological change/social implications link.

Albert Baez (renowned USA physicist and educationalist) has claimed that to enrich the quality of life, education must inculcate the four cs: curiosity, creativity, competence and compassion. TAFE courses certainly emphasise 'competence'. How many deal adequately with the other cs?

SOCIAL RESPONSIBILITY AT WORK

There is a need for everyone to exercise social responsibility in the workplace, especially when technologies change. Social responsibility at work embraces a large number of issues such as occupational health and safety, quality, industrial democracy and even questions of privacy. In one of its information leaflets, the Commission for the Future raised important questions which are relevant (for example) to TAFE business courses:

> The transparency of electronic information raises other crucial questions.
>
> How can we safeguard the rights of individuals to protect their medical and psychiatric records, the details of their financial backgrounds, or even their spending and entertainment patterns from those who might use it against them?
>
> Even in your own home, behind locked doors and drawn curtains, microphones can pick up your conversations and computers programmed to search for particular names or topics can make your words easily available to either private or public investigators.
>
> Other electronic and video equipment can record the telephone numbers that you dial, all of your movements, even at night, and peruse any records stored in computers. Your computer and electronic mail can be intercepted.
>
> How much of this should be allowed? Can we balance the benefits of a more accessible information system with the right to privacy and autonomy? Who should have access to other people's personal records, and how should they be stored?
>
> Is monitoring and surveillance of the general population by government, the military or other organisations justifiable, or is it the beginning of George Orwell's fictitious Oceania of the book 1984?

How many of TAFE's business courses even briefly consider moral issues such as these?

People need to be made aware of their social responsibilities: they won't usually arise spontaneously. Any topics such as 'quality' are social responsibility issues, because if a quality culture is not quickly encouraged to permeate throughout Australian industry, the social future for the country is bleak.

"But", you ask, "should this sort of thing be included in TAFE courses?" The answer must be that if TAFE courses do not deal with such issues, they will not be covered at all. <u>In technical courses and teaching</u> there has never been a greater need to deal with the local, national and international technological change social contexts than there is today. This does not have to be highly theoretical; we are dealing with practical issues which have important practical consequences.

'VALUES' COMPONENT IN TECHNICAL EDUCATION

There should be a 'values' component in technical education. This is especially true when dealing with technological change. Technical education cannot be divorced from 'life'; it must (by its very nature) be humanistic in its approach if it is to be relevant to the students' and employers' needs.

The very purpose of technical education is to serve the needs of people; and those graduating from TAFE courses will themselves be living and working within society. This means that 'attitudinal' as well as 'knowledge' and 'skills' aims are important for TAFE courses. One example will suffice: an attitude of 'service' to the client, which should be common across trades. Australia does not enjoy a good 'service' reputation; frequently (and incorrectly) 'service' is confused with 'servility'. But the attitude of 'service' is of paramount importance.

The 'value' component is important for another reason. Futurologists have predicted that our society faces four major, problems:

- information explosion
- increased pace of change
- social problems
- importance of personal fulfilment.

All four have relevance to the work people do, and the fourth has special consequences for the values component of technical education. Successful European industries have long recognised this.

TECHNOLOGY IS PRACTISED WITHIN A SOCIAL CONTEXT

There needs to be recognition that changes in technology are practised within a social context and so the teaching of changes should not be isolated from people. People are being affected in very major ways indeed.

There seems little need to give account of the present restructuring within Australian industry and commerce because of the large amount of publicity given to it. The social context is changing rapidly. The main inter-relationships have been neatly summarized by Bill Ford in a variety of papers.

These inter-relationships are shown below:

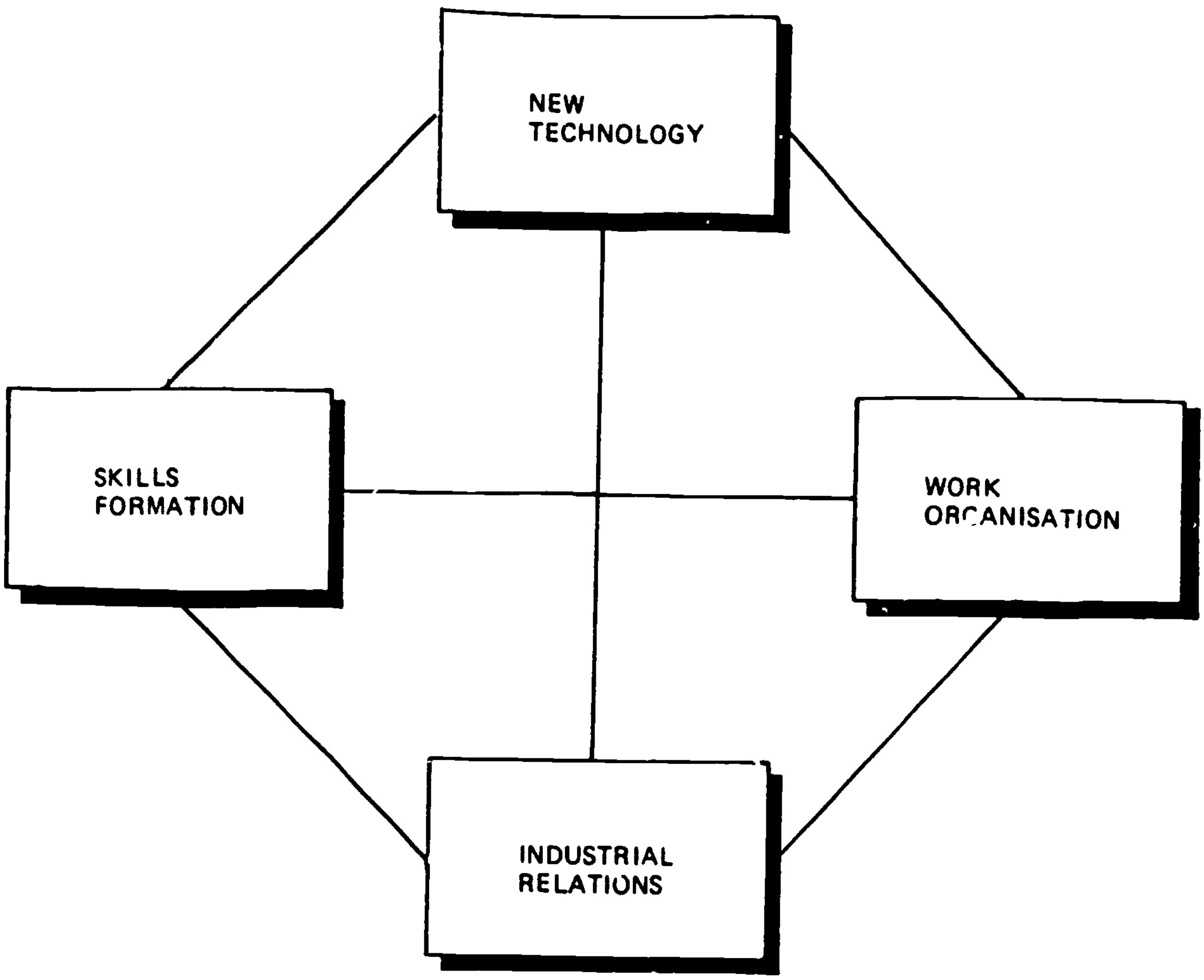

Figure 2: New technology and its impact on jobs (after Ford, 1987)

As the figure clearly indicates, TAFE students are done a very grave disservice indeed, if the social implications of technological change are not included in their courses. They will be ill-prepared for the changing workforce if social implications are ignored and (in attitude) could become the 1980s Luddites as a consequence.

TECHNOLOGICAL CHANGE AND EMPLOYMENT

More has been written in the past five years about the impact of technological change on employment than (possibly) on any other single topic. There are two, connected, main aspects to this: the changing nature of work (the types of jobs and how they are done; retraining and restructuring); and the emergence of key technologies. The United Kingdom Engineering Council has identified examples of these key technologies and they are shown below. The diagram is taken from a Further Education Unit/Engineering Council (1988) publication. Technologies have been classified into three groups:

- materials: the building block of products;
- components: the sub-assemblies of systems;
- manufacturing and process: the assembly techniques which combine elements from the other areas.

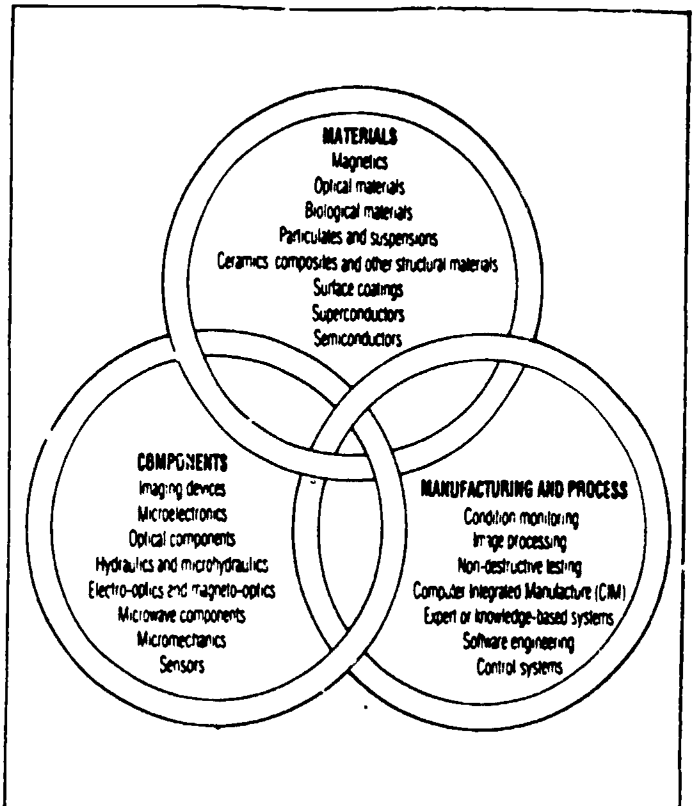

Figure 3: Examples of key technologies

Barry Jones has written extensively about the changing nature of work and his five sector analysis is fully described in his vigorous critique of Australian industry and commerce (Jones 1982). How many TAFE students are even broadly aware of Jones' main generalisations? Do they know that they will probably change jobs every few years and that retraining will be a fact of life? Do they know the reasons for this? Knowledge such as this will enable necessary changes to take place with much less trauma, and will help people to prepare for change.

IMPACT OF TECHNOLOCY ON EDUCATION

The impact of technological change on education takes two main forms: on what is taught (content), and how it is taught (process). A good example of 'what' was provided in a Centre report on the information technology within traineeships (Hall, et al. 1985). In that publication, Geoff Hayton gave examples of some of the newer computing and telecommunications manifestations of information technology, and of the processes involved in all information technology applications. These are shown below in figures 4 and 5.

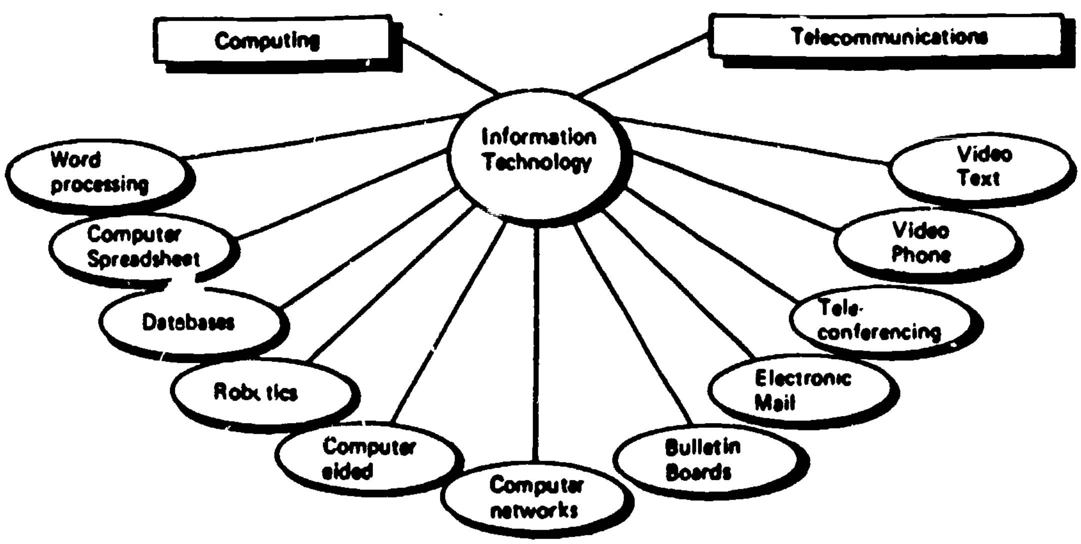

Figure 4: Some of the newer computer and telecommunications manifestations

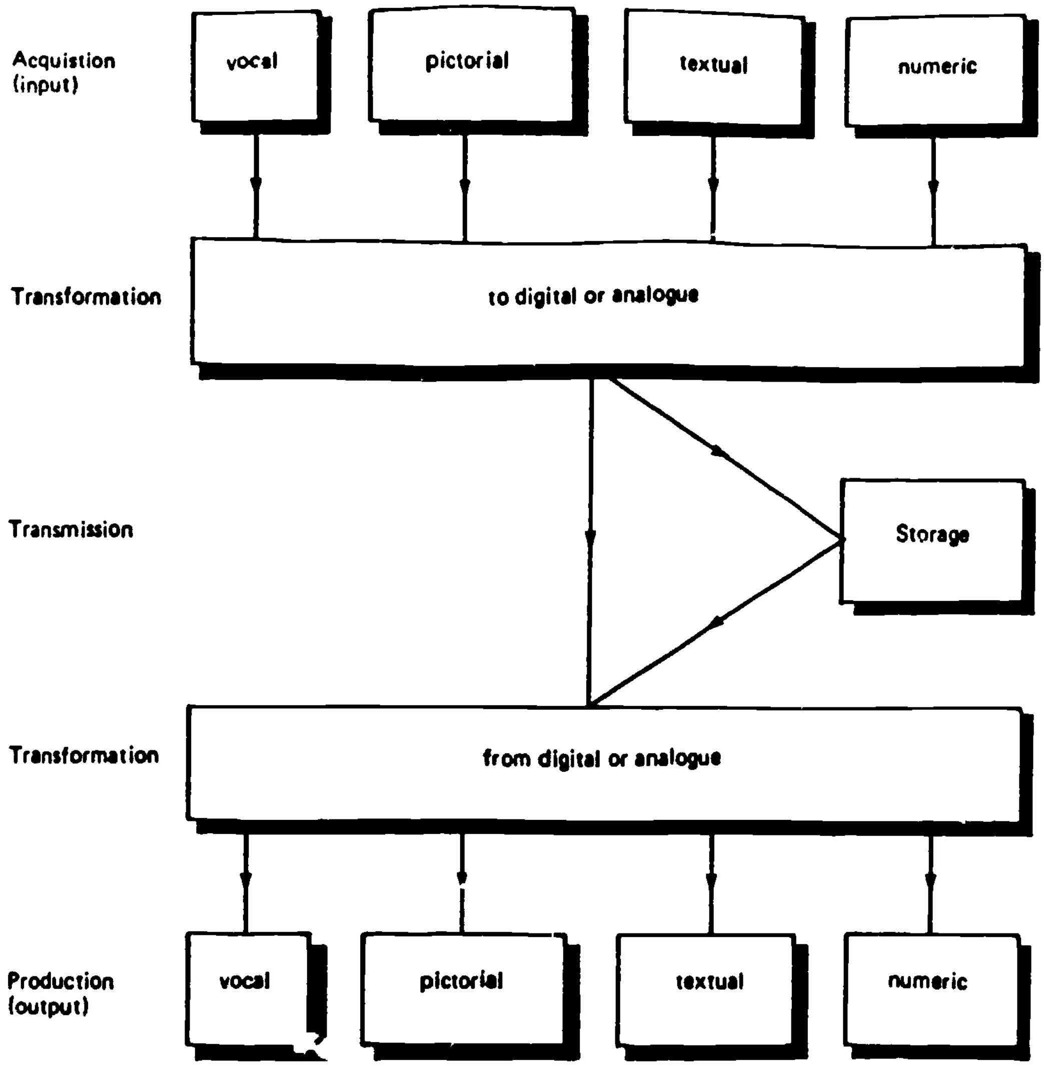

Figure 5: Process involved in all information technology applications of IT

The process of delivering education has been discussed widely in many publications where the satellite, the video disc, teleconferencing, etc. have all been described. The current jargon is "open learning", made more possible by the new technologies. An introduction to the importance of open learning has been described by Hall (1988a). Unfortunately, few TAFE lecturers seem to be taking full advantage of the newer technologies in their teaching.

THE IMPORTANCE OF "WHY?" AND "WHAT IF?"

What I have tried to do is show that the social implications of technological change should be a thread running through TAFE courses. The absence of the thread leaves the important "Why?" and "What if?" questions unanswered. The "How?" questions (leading to the teaching of techniques) are, of themselves, insufficient given the present rate of technological change. There is every indication that, whereas TAFE deals well with the "How?" questions, it is largely ignoring the "Why?" and "What if?" questions. The social implications of technological change are therefore being neglected. An important component of technical education is being left out.

2. EXAMPLES

When I started the project I felt certain that there would be a large number of examples of the social implications of technological change being taught in TAFE colleges. All 245 TAFE colleges were therefore sent a letter, a short questionnaire and a pre-paid envelope.

The questionnaire described the project and asked for the name of a contact person. (The Centre always gets an extremely high response rate to this kind of request.)

Only 11 colleges indicated that they had a course which included any material relevant to the project. All of these colleges were invited to send detailed material and six of them responded.

To check the reliability of the response rate, two large colleges were selected for further (case study) investigation. One of these had not returned a questionnaire and I felt certain that they must have examples of where the teaching of social implications of technological change was included in courses and which would be useful to the project. Therefore, a detailed interview was conducted. The interview confirmed that this college did not teach social implications.

At the second college every head of school was interviewed. All five heads of school said that while preparing for their interview, they had realised that their course should include some information on social implications of technological change. Most courses included nothing; and the few containing some information included facts about occupational health and safety (e.g. repetitive strain injury) or the applications of the computer, but none went further. One head of school described the changes occurring to the delivery of education, implying that some external students were being exposed to technological change because of these changes.

Another head of school said that its students were frequently at the mercy of salespeople. However, no attempt was made to make their students more discerning. Yet another head of school indicated that the teaching of social implications was left to the discretion of individual lecturers. His concern was the possible lack of vigor when dealing with such issues.

In all five schools, the "Why?" question was almost totally ignored and the "What if?" question was never covered. It was pointed out that staff who undertook retraining would be required to teach in this way.

The material sent by colleges included the following. One college in its computer science course has, as one of its main aims: "appreciation of some implications of computer use in contemporary society". This same college had a computer studies course, one of its eight aims being "to discuss the impact of computers in society" with topics of study which included "the social implications of the computer". A college of tourism and hospitality included as one of its nine topics in a food science and hygiene course: "historical developments in food and nutrition with particular reference to Australia". A food science course intends, as one of its aims, "to give students an understanding of food in our society".

One college stated that "all our course aims are affected by changes in technology, but we do not provide information to our students"!

Fourteen of the most recent national common core curricula documents were carefully analysed to determine what social implications material was suggested in them. Nine of them included nothing. Most surprising of all was the complete absence of comment on social implications in a document entitled Investigations of Training Needs in New Technologies (which covered lasers, ceramics and biotechnology). Of the five that did include relevant material, two restricted themselves to occupational health and safety issues.

Of the remaining three, the NCC Women at Work had as one of its six aims: "To provide an understanding of the work environment, and the capacities to operate effectively within it". One of the ten objectives in the course "Politics of women at work: women in the economy" was: "understand the effects of technological change on women in the workforce since the industrial revolution".

One of the course aims in the NCC Animal Care was: "an understanding and appreciation of the ethical, legal and welfare issues involved in the keeping of animals".

The NCC document which gave a thorough treatment of social implications was Core Curriculum Revision for Fitting and Machining (Ebsary 198?). The publication includes sections on "The present industrial scene" (with notes on change, dependency on technology, information systems), "Inadequacies in skills, motivation and organisation", "Recent developments", and "Metals and manufacturing in the 1990s". The report's educational recommendations included the following:

> Incorporate principles of Electricity and Electronics into the course, with safety issues given due attention. Control logic is a convenient link with Hydraulics and Pneumatics, and is an element of CNC machine tools and cutters.

There is at present a dangerous dependence on overseas technicians for maintenance of sophisticated machines. Extension into an extra stage 4 strand could be rationalised into a Mechanical/Electrical fitter classification. Previously difficult problems will be lessened as Unions tackle the demarcation issue with a vengeance, and TAFE should follow suit.

There should be focus on the evolving mental model in the student when designing the curriculum, rather than primary concern with content and technology. Problem solving, logical thinking, diagnostic skills, and systemic awareness need nurturing throughout the course, with room to make, correct and learn from mistakes without penalty, as in Logo programming.

Problems are frequently seen as barriers to be overcome by picking the right "cookbook" formula or prescribed routine. A robust mental model of relevant factors and the weight of their effect is far more powerful. It is one thing to know a formula or procedure, quite another to understand its meaning and implications, and why it is used.

Skills in communication as effective transmission and interpretation of information and intent should be given emphasis throughout, in report writing and verbal presentations. Clarity, relevance, lack of ambiguity and freedom from error should be related to both humans and machines, with links made to instruction manual interpretation, drawing, job planning etc.

The issue of technical staff having the required communication skills, or general studies staff having enough technical knowledge to give appropriate context and exercises, needs to be seriously addressed. Participatory work practices will fail without the above emphases.

Introductory programming of CNC machines, robots, microcomputers and PCs should be introduced with basics of information transfer as a natural follow-up from communications. CAD/CAM should be introduced in the same context, along with word processors, spreadsheets and databases used for workshop needs.

Modern integrated manufacturing demands an early awareness of the "glue" of information, which should be the focus while keyboard skills and computer awareness are obtained tacitly. (Ebsary 1987, pages 14-15)

3. A CURRICULUM FRAMEWORK

The purpose of this section is to describe a variety of structures which could be useful to curriculum planners when they are attempting to include the social implications of technological change in their courses. Such structures are important because they provide a framework and a logic for making decisions concerning what should (or should not) be included. To include a topic in a course "because it is a good idea, and might be useful or interesting" should not be the only criterion! The outcomes of decisions made in such a way quickly date.

There is probably a hierarchy of social implications, ranging from the presentation of everyday examples of the use of a technical skill and how it affects people, through to solving problems which have social implications. The hierarchy is shown below.

4. Adapting (technical) skills to solve a new problem having social implications.

3. Real-life problem solving in the actual environment using (technical) skills.

2. Using a (technical) skill in a college applied to an everyday problem affecting people.

1. Practical, everyday examples of the use of a (technical) skill and how it affects people.

It is fairly easy to find examples at level 1 (e.g. optical fibre and its effects on communication, desk top publishing and its effects on the printing trade) but it is much more difficult to move up the hierarchy. The following models should be of some help in this.

The next simple model is frequently used by those concerned to include social implications in science and technology curricula. It was first described and used by Hall (1973) and is based on an idea by Layton.

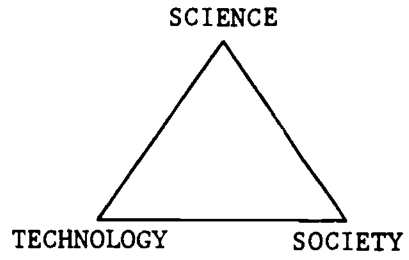

Figure 6: Simple S/T/S model

This allows six possible interactions which are shown in Figure 7. The figure and explanatory text are taken from Hall et al. (1983), where all six interactions are explained in some detail.

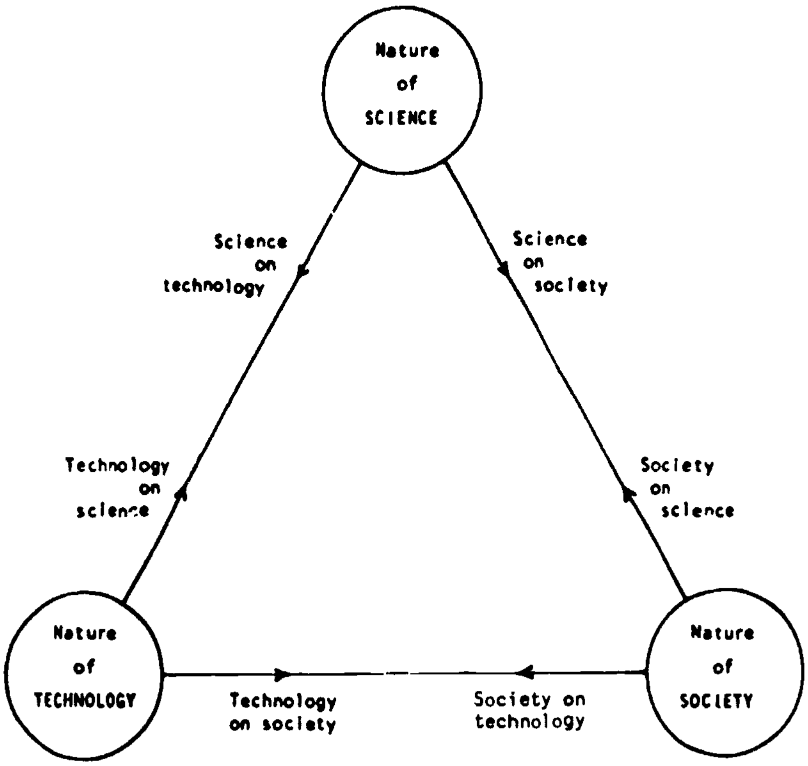

Figure 7: The six interactions

Analysis of these six interactions, and of the nature of science, of technology and of society as they bear upon the interactions, yields a set of statements that summarise large areas of the social implications of technological change.

Nature of science Science is a search for knowledge and understanding, carried out by humans according to the values of the society.

Nature of technology A definition of technology was given at the beginning of this report. Another, simpler, definition is: technology is the application of science and other forms of organised knowledge toward a specified practical outcome.

Nature of society The society is the human setting within which science and technology are carried out. The characteristics of a given society will affect the sort of science and technology it will develop.

Science on technology New scientific knowledge can lead to new technologies or modifications to those currently in use.

Technology on science New techniques, improved measurements or empirical advances can lead to new or revised scientific knowledge or theories.

Society on science Values and social norms influence the directions of scientific research, through funding and in other ways.

Science on society New knowledge or theories can affect the way people think about themselves, their problems and their social organisation.

Effect of technology on society The lifestyle of any group is critically influenced by the technology at its disposal.

Effect of society on technology Social norms, values and political processes influence the direction of technological change. (Hall et al. 1983, page 12)

The simple model shown in Figure 6 has limitations, especially when used in technical education. Therefore, a development of the model which I have been promoting is shown in Figure 8.

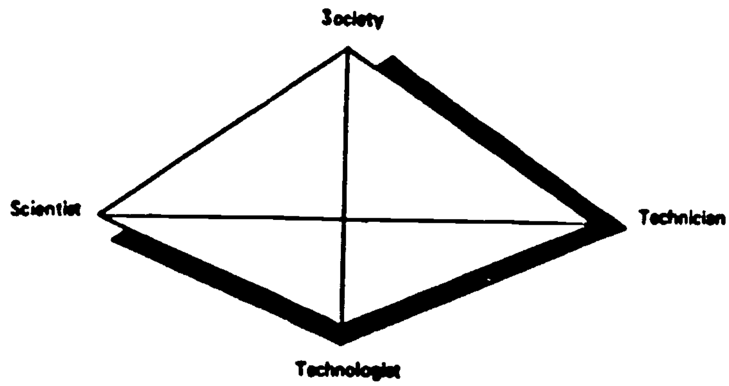

Figure 8: Social implications model

This is a development in two respects. Firstly (and obviously), the technical component is now included. Secondly, the emphasis is on people and what they do (scientist, technologist, technician) rather than just on the nature of science and technology, which can be rather abstract concepts devoid of practical implications. How is this model useful? A particular example will illustrate this.

This example uses the simple model shown in Figure 9.

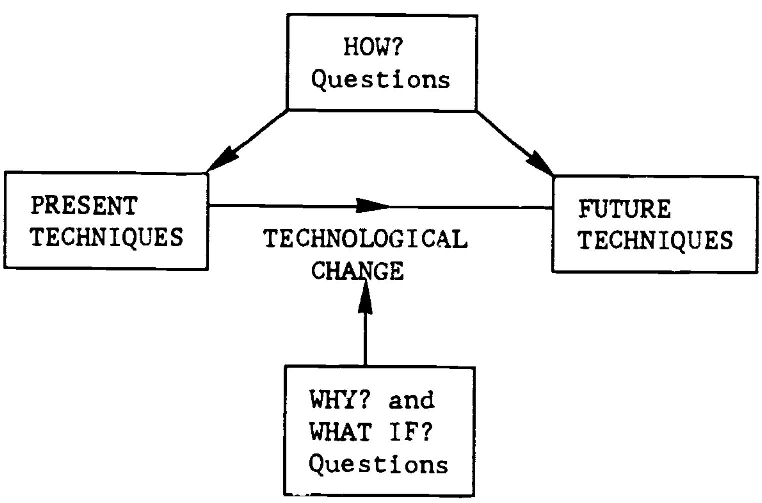

Figure 9: The How?, Why? and What If? Questions

In apprentice welding courses the emphasis is changing from manual methods to mechanical methods and (more recently) to automatic processes:

manual ---> mechanical ---> automatic processes.

One outcome of these changes is that a tradesperson is no longer responsible for templates. Instead, tapes are prepared in the drawing office or computer room. Machines are being manufactured that remove skills from the shop floor (just two or three switches are flicked instead); but increase the skills used in the computer room.

The "How?" questions can lead to teaching the new techniques, but they do not seem to mention "Why?" such changes are occurring. (They are occurring because greater speed and greater accuracy are being demanded. This leads us to the concepts of 'quality' and 'profitability'. The changes are also occurring because of working conditions; there is an environmental need for robots because of occupational health and safety concerns.)

Without an understanding of the "Why?" and "What if?" questions, the next stage in the welding technological change model (which is the acceptance of the computer as a workshop tool) will seem to be even more threatening for technicians.

This example illustrates why the social implications should not be ignored. These implications are a feature of Project Technology.

Project Technology in the United Kingdom has developed useful models for 'technology'. Their model for human capability is described by Harrison in Lowe (1987). It is reproduced below.

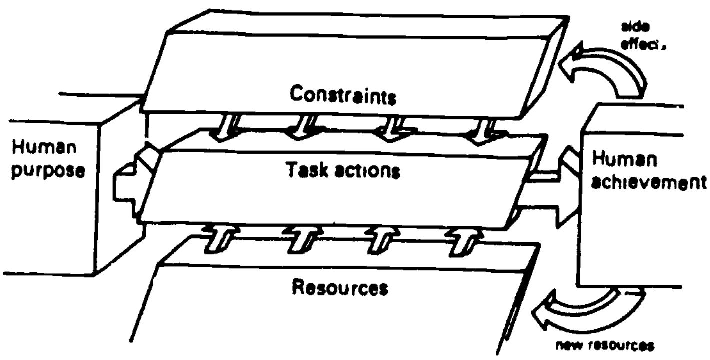

Figure 10: A model for human capability

The model is elaborated in the next figure, which is taken from Riquarts (1988).

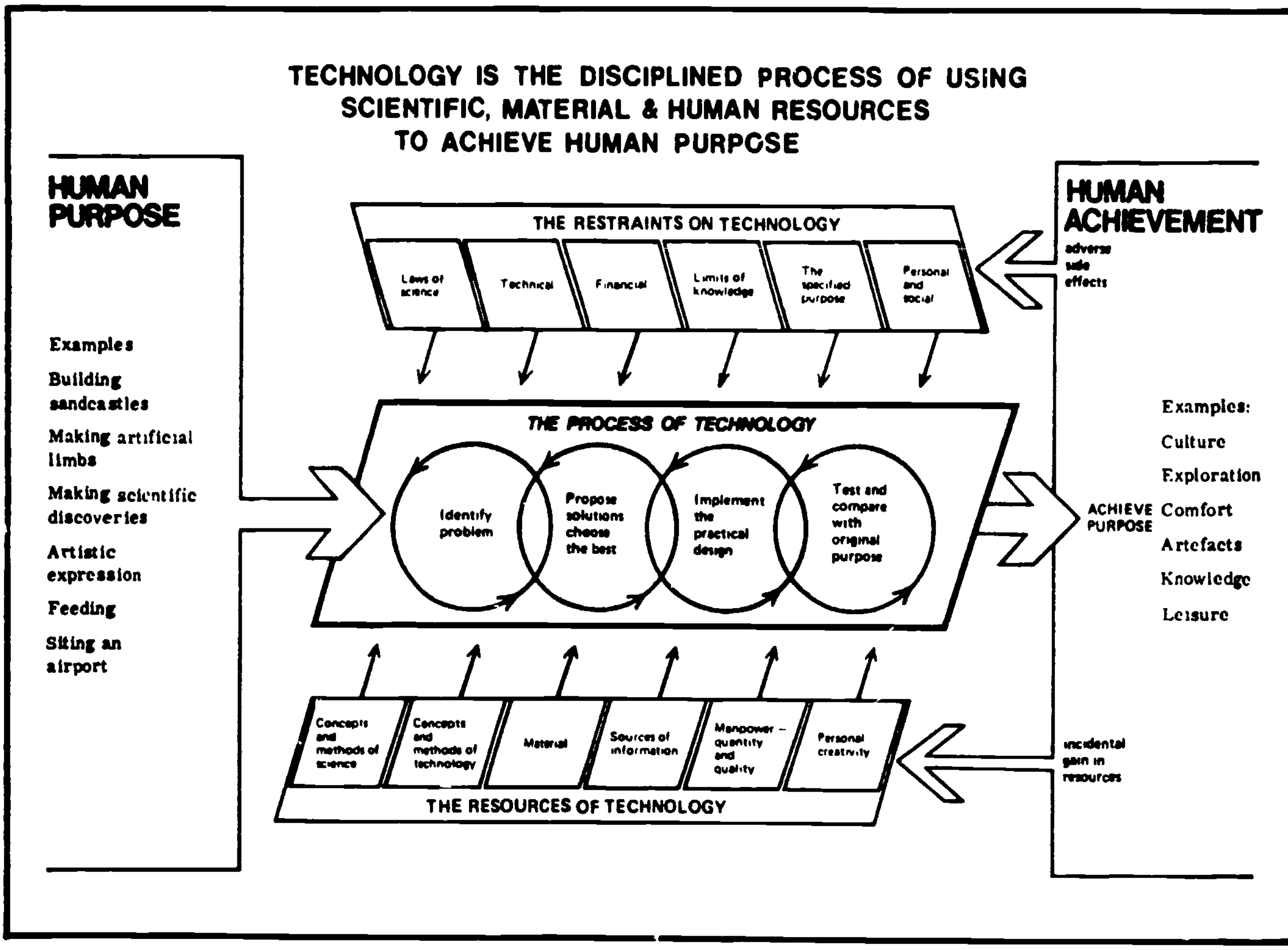

Figure 11: Technology model

The model is useful because it provides the following:

- a framework for resources of concepts, skills, materials etc.;
- a framework for considering purposes, values, effects and spin-offs;
- a pedagogy for learning to relate knowledge to the process skills of using it in the technological tasks of the real world;
- a pattern for research programmes to develop such frameworks and pedagogy. (Harrison in Lowe 1986, page 211)

Another model worth considering is based on the well-known objectives classification of knowledge, attitudes and skills. It is shown in Figure 12 and emphasises technical facility.

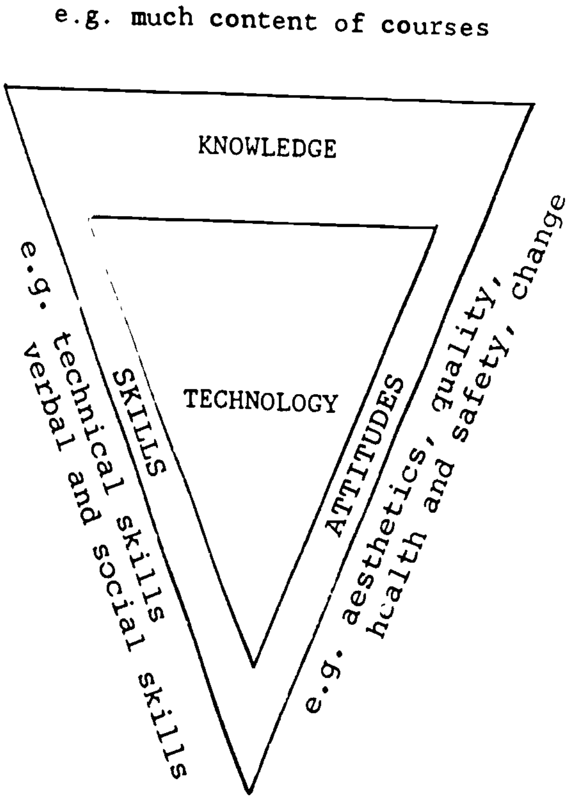

Figure 12: A technical facility model

It points to the importance of attitudinal objectives in TAFE courses, which can sometimes be neglected because they are hard to formulate and their achievement is difficult to measure, particularly in terms of "competency".

IN CONCLUSION

Teaching the social implications of technological change matters if students are to have an understanding of what is happening and why it is happening. Teaching the social implications should be a part of the educative process. Unfortunately, the "Why?" and "What if?" questions seem to be generally neglected. Such neglect cannot be justified and is especially a matter of concern in these days of rapid technological change.

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