THE HUMAN SIDE OF TECHNOLOGY TRANSFER A VIEWPOINT*

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It is argued that, despite evidence that technology transfer may not happen or may happen in unforeseen ways, exponents behave as if innovation will automancally occur and proceed without much further involvement by them with potential adopters. However, innovation implies change, which is not usually easy. Diffusion studies show that innovative products or ideas have to compete with what already exists and that there is a diversity of attitudes towards them. Consideration of failures often shows that the attitudes of people who are expected to change have been inadequately considered. The A VICTORY mnemonic provides a much better framework for understanding decisions people make. Apart from their perceptions often being different from those of the experts, people often work in an organisation or system which prevents knowledge being utilised or change being implemented. To improve the success rate of technology transfer, a well planned psychological operation is needed, based on studies of what persuades people of their need to change, and involving them at all stages of development of the new product or idea.

Keywords: technology transfer, knowledge utilisation, change, perception, psychological operation.

INTRODUCTION

In retrospect we can see the advantages of many of the technologies that have been introduced in our lifetimes or understand how they have come to be readily adopted. In most aspects of our daily lives - food, clothes, communication, transport, business and leisure activities - developments have enabled us to accomplish the routine tasks with greater speed, convenience, efficiency or comfort and to enlarge our range of pursuits in ways not foreseen only a few decades ago. Hindsight has little bearing on foresight, however.

The people responsible for some of the earlier innovations that we now take for granted have been perceived as people with vision. However, those same people or those in charge of the companies which developed their ideas have sometimes lacked

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vision when it has come to other people's ideas, and it is conceivable that similar biases afflict today's innovators. For example, Edison, inventor of the incandescent lamp and the phonograph, in later years believed that radio would never catch on. Simpson, pioneer of the use of anaesthetics for childbirth, also closed his mind to other innovations, becoming a strident opponent of the application of sterile dressings in surgery and of the idea that germs were implicated in infectious disease. The silk manufacturer Lister & Co. rejected rayon on the grounds that the public would never accept artificial silk, so its inventor Courtauld proved them wrong by forming his own successful company. Eastman Kodak is said to have turned down Carlson's invention of xerographic copying, on which Rank Xerox subsequently prospered. In the early 40s, the head of IBM estimated the world market for computers was five organisations. At the same time experts were forecasting the total demand for polythene would never exceed 50 tonnes whereas 25 years later it exceeded 5 million tonnes.[1]

Technology transfer and the broader concept of knowledge utilisation seem to be fairly unpredictable, if not downright capricious. Instant coffee and hamburgers caught on, but instant tea and textured vegetable protein did not. The petrol car has succeeded all too well, but the electric car never has. The rocket belt attained brief notoriety as a means of individual transport in a James Bond movie, but the motorless hang glider can be seen every summer over many a range of hills. *The* pill has transformed social relationships, but whatever happened to the male pill? Disposable nappies are in vogue, but whatever happened to disposable underwear? There are numerous other examples.[2]

All told, it has been estimated that only 1 per cent of innovations succeed.[3] Only about 20 per cent of forecasts of technological developments are realised, and many of these are optimistic with respect to timing.[4] Many of the examples given in this reference, such as plastic homes, synthetic foods, and jet cars, could be considered to be as much failures of technology transfer as of forecasting: the technology was there, admittedly at high cost, but it was not transferred because nobody tried to find out whether people wanted it.

These figures represent an extraordinary waste of inventive talent and business investment. Although some of the inventions seem unrealistic for individual people to want, there are other instances where they might be considered to be in the public interest, such as products utilising waste materials, conservation farming techniques, and procedures for protecting people against natural hazards.

Much of the voluminous literature on technology transfer and "extension" (which has been the term normally applied to technology transfer in agriculture) appears to have ignored both the arbitrariness and conservatism of human behaviour. It focuses on products and the inevitability of their adoption rather than potential users. If the users have been examined, it has often been more as predictable androids than as real people. Failure is incomprehensible. The innovative imperative, failing to consider peoples' choices, wrongly imputes any failure to the user's supposed irrationality.

However, technology transfer is about change - to people's ideas or actions. Peoples' attitudes are usually supported by considered thought or hard experience and

are normally rational. Change is not easy. People often prefer to stay with "the devil they know rather than the devil they don't know". Even if they have a more optimistic disposition, most people behave to a large degree as they always have, and with due consideration of costs and benefits. This is more rational than being captivated, in the way that many forecasters have been, by technological wonder and the spirit of the times.[5]

FOCUS ON INEVITABILITY

Diffusion studies provide an overview of how technologies spread, but are limited in delineating why they do so. For one thing, they have usually been retrospective and applied to winners, ignoring the insights that could result from studies of market failures. For another, they make the assumptions that all potential adopters are bound to take to the innovation eventually and, once adopted, the innovation will not be rejected. The term diffusion itself seems to imply that changes have been almost pre-ordained and, once set in motion, proceed inevitably to market domination.

The mathematical models frequently used can be classified as two kinds, causal and empirical.[6] There is considerable interest in the former for prediction of how an innovation might need to be marketed. Most of these are related to Mansfield's model, which considers investment attributes of an innovation.[7] Mansfield considered that the proportion of potential users that hold out against an innovation is related to the profitability of adopting it and the smallness of investment required. He also assumed an imitative or bandwagon effect, but did not allow for the opposite sort of imitation, where canniness and cautiousness are widely admired and copied while trailblazing is often rejected as foolhardy.

The empirical models in contrast are mostly analogous to biological models, for example exponential growth to occupy a new niche. One of these, the Fisher-Pry competition model, is perhaps the most widely used.[8] The Fisher-Pry equation is an exponential relationship between the percentage adoption of an innovation and time. It has been applied to many kinds of technology transfer, for example transport infrastructures, and also more widely to topics such as different economic theories and even the spread of democracy.

In practice, innovations frequently do not gain universal acceptance or even wide acceptance. Competing products do not always become extinct; for example, silk, leather and wool have not been ousted by synthetics, and there is a resurgence of interest in crafted and natural products, including foodstuffs. Many farmers are reluctant to adopt new conservation technologies being promoted by extension agencies,[9] and many of the public do not accept self-protective innovations and practices, often despite media education campaigns.[10]

FAILURE TO CONSIDER FAILURE

A well established diagram about industrial innovations (Figure 1) acknowledges the indirect influences of human variables involved in peoples' financial and educational backgrounds.[11] However, it still views the process overwhelmingly as a

form of technology push, with little real consideration of the needs and wishes of the people who make up its potential market. It should be noticed that in Figure 1 diffusion has arrows leading from it as if it is bound to happen and is not worth considering in detail (although the authors admit that this step is "by no means guaranteed"); 'adoption' is in suspense.

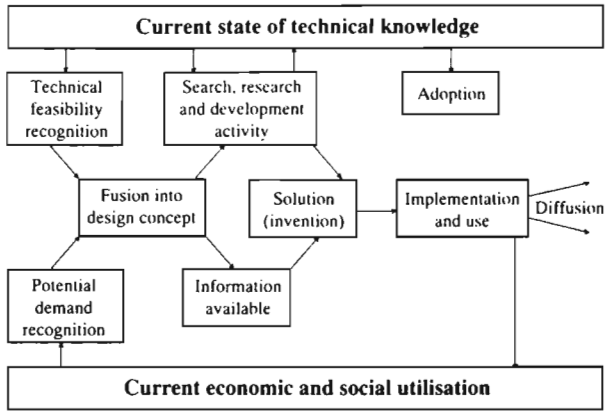

Figure 1 Diagram relating state of technological development and the social and economic environment to the process of technology transfer. (Adapted from Myers and Marquis).[11]

This typifies an attitude that is still common. A person works on an idea that is innovative, perhaps also socially useful, and appears to be viable if taken up. Only then, however, is thought given to how it actually might be taken up. But this is the most difficult part. This is where failure is endemic. For example, an innovative energy-efficient machine for making smokeless fire briquettes from old newspaper and waste coal was developed and patented by New Zealand industrial scientists in the late 1970s. However, nobody took an interest in it and nothing happened until last year, when a casual conversation at a conference roused the interest of the manager of a waste disposal service.[12] The prototype model is at last being used and could finally attract other users. However, this project was only saved from complete transfer failure by a chance personal contact.

Despite the abundant evidence of failure of technology transfer, it is rare for research on the subject to consider failure, just as it is rare for consideration of knowledge disavowal to accompany research on knowledge transfer. But the alternative outcomes of success and failure are complementary.[13]

Two recent comparisons that are unusual in covering both successful and unsuccessful technology transfers deal partly with the attributes of, and constraints on, potential users. One dealt with low-energy products and processes which the US Department of Energy wanted to push.[14] Common characteristics in those projects considered successful were that the work was done through innovative firms which

were able to generate a user demand, key decision makers were identified and worked with, and the whole operation was comprehensively planned. Common characteristics in unsuccessful examples of attempted transfer were that there was no commercial advantage in adopting the innovation, there was little planning in the approach to technology transfer, and reliance was placed heavily on pamphlets rather than personal contact with relevant people. The human factor was clearly important to success, and inadequate consideration of it was implicated in failure.

The other study was a statistical survey of the adoption of programmable automation throughout an industry consisting mostly of small companies[15]. The main boost to change was the existence or establishment of active social supportive linkages, so this was made a positive recommendation for public policies designed to foster modernisation among small manufacturers. On the other hand, the main obstacle to change was stated to be the "tenacity of tradition-bound organisations". It was even remarked that "a policy designed to more aggressively drive them out of business would presumably hasten the process of diffusion". Once again the approach was quite autocratic and treated people as pawns, failing to appreciate that the experts' perception of the new technology being superior is a subjective assessment not necessarily shared by the potential adopters.

In reality people differ in the weighting they assign to isolated developments in technology or different pieces of information, and the significance *they* attach to a scientific finding or innovation may be quite as valid as the different significance it had for the expert who made it. For example, people do not perceive hazards in the same way as experts who analyse them statistically:[16] "...just as scientists' estimates may need to be treated with something less than reverence, the views of the public may need to be treated with something better than contempt".

NEED TO CONSIDER PEOPLE

To really establish why transfers fail or succeed it is essential to know more about the people who might be potential users, whether the right ones have been targeted, and whether they have been approached in the right way. Diffusion studies are useful mainly in that they emphasise the factors of competition and diversity, and therefore have some bearing on human differences. A new product or practice is in competition with existing ones, and new ideas do not fall on open minds but have to compete with perhaps long-held or customary beliefs. People show great diversity. Some are open-minded, others are not. Even past experience is no guide to future behaviour.[17] Even though outdated, many practices seem to work well, and become firmly adhered to. From the user perspective, existing practices may be beneficial, economically or otherwise, so there is no perceived need to change. Prosperous times may allow bad practices to survive with the good, for example US management practices in the 1960s encompassed a range of effectiveness that only became apparent in the more competitive business environment of the 1980s.[18] Some people feel comfortable with routines and tend to become resistant to change, if indeed they were ever open to it. But others embrace change, sometimes rashly. Personality traits may have a bearing, although not always a clear one for predictive purposes, on adoption of new technologies by people.[19]

Individuals do not always make decisions in isolation, and group or committee decisions are seldom amenable to straightforward analysis, even in fairly homogeneous peer groups. Normal factors to be considered are that goals are often fuzzy, changeable, conflicting, or unrealistic, the number and relative assertiveness of different decision makers may not be appropriate for maximum effectiveness, and the influences that they are subject to may influence outcomes. For example, committee procedures inhibit or modify decisions and committees normally avoid radical change.[20] They may even fail to make decisions. Participants often have hidden agendas and their reasoning may be unspecified or unclear.

Finally, the social structure has a bearing, including whether men or women do the work that is to be changed, the ethnicity of people concerned, and the repercussions change might bring to social relationships.

A notable failure in this respect has been in agricultural extension with its overlooking the role of women in agriculture, typified in the following statement by an African woman: "This one they call farmer; send in teachers to teach him to farm (while I'm out growing the food); lend him money for tractors and tillers (while I'm out growing the food); promise him fortunes if he'd only raise cotton (while I'm out growing the food)".[22] It is quite possible that other attempts at technology or knowledge transfer have wrongly been directed at the male supervisor in a company or the male as presumed head of a household.

The New Zealand scientists attempting to find uses for Chatham Islands peat in the 1970s,[23] such as wax for making several products such as carbon paper, should have consulted their typists to find out that carbon paper was obsolescent because of developments in photocopiers.

Similarly the New Zealand scientist who developed nutritious protein flour from wool only tried it, as sponge cakes, on a local taste panel.[24] However, the people it was intended to help, in developing countries, would be unlikely to accept such a culturally foreign product when even a local critic considered it bizarre. Moreover, the whole concept of a world protein gap turned out to be an artefact, and was transformed overnight to one of malnutrition by a change to realistic baseline figures by a FAO/WHO Committee.[25]

WIDER VIEW OF INFORMATION TRANSFER

Probably the most widely used model dealing with why knowledge is or is not utilised from the point of view of the users and constraints on them was devised for introducing improved practices into mental health institutions.[26] It is equally applicable to technology transfer in manufacturing and agriculture and indeed to any studies of change and resistance to change. Known by the acronym A VICTORY it considers the following constraints:

Ability	Does the target individual or organisation have the funds to carry the risk, or knowledge and skills to change?
Values	Has the individual or organisation an open attitude to change? Or to this particular type of change?

Information	Is the necessary information available and are channels of communication open?
Circumstances	Are the individual's or organisation's ways of managing their affairs suitable? Is the climate right? Has the right person been targeted?
Timing	Can this change be fitted in? Must others happen first?
Obligation	Is there a felt need for change? Is there economic or legal or other pressure to change?
Resistance	What perceived negative consequences might result?
Yield	Is there a payoff? What's in it for them?

The improved explicative power of this model can be illustrated by some of my colleagues' attempts to persuade local government authorities to incorporate knowledge about natural hazards in their locality into their town and country planning procedures. A survey done with the former multiplicity of authorities in New Zealand showed that, in general, small authorities lacking finance, effective information channels, and expertise did not use this information.[27] Among larger authorities there were examples of various kinds of knowledge disavowal. Since then local government has been completely reorganised into fewer, larger units, and the *Resource Management Act 1991* makes it mandatory for them to obtain and make hazards information publicly available. Apart from the increased effectiveness of our own knowledge transfer activities, stimulated by restructuring of this organisation, greater knowledge utilisation has been induced by these changes to the constraints and incentives on the new authorities. They would now score well on ability, values, information, circumstances, yield, and of course, obligation. The legislation has helped to overcome some of the resistance to publicising earthquake hazards in their territories owing to the disincentive it might present to urban and industrial developers they were hoping to attract.

Work on farmer adoption of conservation practices can also be interpreted in the same framework.[28] Many farmers do not have the ability to carry the risk of the capital cost of a new practice plus the potential loss of a season's crops. Their values may make them resistant to innovations that conflict with farm objectives such as maintaining flexibility. Information from different sources may be equivocal and therefore ignored. Their circumstances may be such that both complex innovations and individual practices/tools may be unacceptable, though for different reasons. Other priorities or a reluctance to be a trail-blazer make the timing wrong. Strong media presentation of land degradation may be counterproductive to producing an obligation to change, because the farmers' own problems are perceived as relatively slight compared with those portrayed. Farmers resist new practices that reduce their options, as many do, and finally, the more costly the new practices are the less likely they are to be adopted. This study argues that there are not barriers to adoption, but resistance to adoption is reasonable and rational from the farmers' point of view.

PSYCHOLOGICAL OPERATIONS - HOW TO PROCEED

In order to increase the effectiveness of technology transfer, we need to have a plan of operations centred on the people who constitute potential users of our technology or information and the environment in which they make their choices. It is not unlike the wartime strategy of psychological operations.[29] We need good intelligence about these people preferably derived through our being part of their social group or having work associates who are. Are we approaching the right people? What are they like? What are their information sources? What are their values? What are their likes and dislikes, fads and fancies? How do they make their choices? What constraints affect them?

Having identified various groups of potential users and, more importantly, the people among them who set the trends, we must work to become identified with those people so that they do not see themselves as being targets, but internalise our knowledge or adopt it as their own.[30]

Based on these considerations, the model used in Figure 1 should be modified considerably (Figure 2) if it is to show enhanced prospects of technology transfer. It needs to involve potential adopters at the outset, identified and characterised by the A VICTORY checklist, and linkages need to be maintained throughout the process.

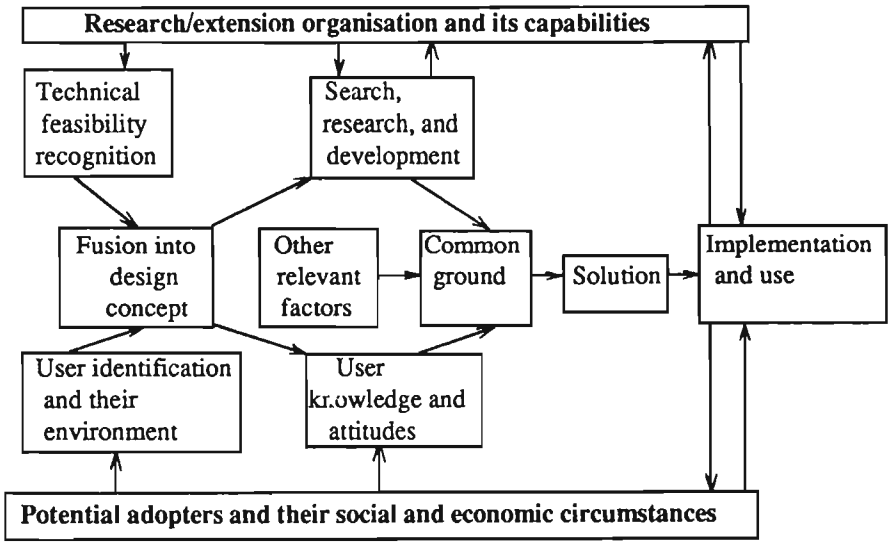

Figure 2 Diagram closely relating potential adopters of new technology/information to the organisation developing it to achieve effective technology transfer.

A successful recent technology transfer that can be used to exemplify the latter part of this process has been the joint development of bifocal contact lenses by a small Auckland company that produces contact lenses and by scientists at an industrial research organisation.[31] The company representatives through their close

dealings with optometrists throughout New Zealand found that a younger generation that had adopted wearing of contact lenses was ageing and starting to need bifocals. Existing bifocal contact lenses had a poor reputation, but the prospect of reverting to wearing spectacles did not appeal to most of this group of customers. The researchers developed a complex computer programme for the lathe used to grind the lenses. It was based on the changing geometry of the eye as it moves, so that the lens positioned itself automatically and reliably with eye movements. In this case Figure 2 can be used to show the way that the people creating the demand were fully involved (a) at the outset, by being identified as a sector of the market, (b) during development, by participating in clinical trials and providing feedback on the comfort and reliability of the prototype lenses, and (c) in the implementation stage, by providing feedback about acceptable costs and value for money.

The key to this success, as with some of the successes mentioned by Schnaars, ranging from running shoes for everyday wear, to microwave meals, is correctly identifying a market,[32] which means dealing with people. Although not formally used in this case, the A VICTORY analysis would have provided a valuable framework for the initial stages of the market identification. It is not enough to have a great idea. The good news, however, is that big companies that are market leaders are often surprisingly myopic, so the small outsider stands a better chance than they do of succeeding with an innovation, possibly by being closer to the people who might be adopters.

It is much more difficult to transfer technology or knowledge in the public interest, such as conservation techniques in agriculture, energy conservation devices in the home, and self-protective measures against earthquakes. However, the same sorts of intelligence about potential adopters are required. Different social groups, their characteristics, and in particular their sources of influence have to be identified, as an integral part of the strategy for communicating with them. Once identified, the consultative links need to be used to the full.

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