Factors Influencing Technology Transfer[1]

Kate Ehrlich
Honeywell Information Systems
300 Concord Rd
Billerica MA 01821

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ABSTRACT

This paper treats technology transfer as primarily a communication activity. Barriers to technology transfer can be erected by (1) organizational structures which inhibit the flow of communication between different groups; (2) the technology imposing specialized knowledge on the people who work with it; and, (3) the individuals themselves who have cultural biases which inhibit communication with people from different professional and experiential backgrounds. Some of these barriers can be overcome by creating small cross-organizational groups or partnerships, by increasing exposure to the technology, by rewarding joint work and by promoting people who are willing to champion technology transfer efforts within a corporation.

INTRODUCTION

The topic of technology transfer is gaining interest as companies, both large and small, struggle with the problem of producing and marketing technologically advanced products. In order to remain competitive, companies must manage the process of transferring technology from research groups to applications and to marketing groups who develop and market the technology as a product. This paper presents a brief informal introduction to some of the issues in technology transfer, especially as they might impact human-computer interaction. This field is becoming more involved with technology transfer as a result of connections with Artificial Intelligence and the recent emergence of joint research groups such as MCC.

MODELS OF TECHNOLOGY TRANSFER

In the traditional 'pipeline' model of product development, ideas and technology pass in sequential fashion from a research group through advanced technology, applications development, and marketing out to the marketplace. While efficient for production of standard products, this model lacks the flexibility to exploit new technologies at the rate at which they are introduced into the marketplace. An alternative to the 'pipeline' model is a structure in which the various groups - research, application development, marketing, and human factors, - work together as partners. As partners, individuals have the opportunity to short-circuit the bureaucracy that surrounds and inhibits traditional product development.

What is gained by treating technology transfer as a partnership rather than as a pipeline process? First, a partnership encourages continual sharing of information. By sharing information, groups get to learn about the technological failures as well as successes. Knowledge of failures can enlighten people as to the process of problem-solving as well as indicate limits on development of the technology. Second, in a partnership, people learn about other groups' activities early enough to anticipate their own activities. Third, the technology is stretched by being pulled from different directions rather than pushed by the technology alone or pulled by the marketplace.

Technology Push vs Demand Pull

In advanced technology marketing there is a continual conflict between 'technology push' and 'market pull'. In the marketplace, however, those projects which are pulled by demand are more likely to succeed than projects which are pushed by the technology (Gerstenfeld & Berger, 1983). In particular, the commercial success of technically advanced products is often more dependent on user acceptance than on the technology itself.

Those who develop the technology are also motivated to push the technology. This position can be characterized by "What do you mean they won't buy it? It has all these new advanced features and it works great." On the other hand, market pull emphasizes the customer's needs and requirements. This position can be

characterized by a salesman who might say "I can't sell that. What will the customer do with it?"

Under the 'pipeline' model, marketing has very little influence on the research group and vice-versa resulting in one group or the other exerting undue influence on the product. Under a partnership model, however, marketing people and researchers can communicate directly with each other. In this way, the researchers can develop some insights into how the marketplace might respond to the technology and build that insight into their research. The marketers in turn can get exposure to the technology early enough to help them prepare the sales and support staff who sell the product. This bi-directional input can help stretch the technology.

Professionals in human-computer interaction play an important role in the interchange between technology push and market pull. In particular they contribute to technology push by developing user interface technologies. They help market pull by developing interface designs that improve user acceptance of a product. Examples of user interface technologies include dialog management tools (e.g. Wasserman & Shewmake, 1982); voice products (e.g. Gould, Conti & Hovanyecz, 1983); and input/output devices (e.g. Lee, Buxton & Smith, 1985) as well as new user interfaces (e.g. STAR; Smith, Irby, Kimball, Verplank & Harslem, 1982). Researchers and practitioners also respond to market pull, by conducting research into human capabilities and limitations (e.g. Card, Moran & Newell, 1983); by doing applied research on particular problems (e.g. text editors, Embley & Nagy, 1981); by applying existing research (e.g. Black & Sebrechts, 1981); and by publishing guidelines and principles which can be applied to the design and evaluation of existing user interfaces (e.g. Smith & Aucella, 1983; Ramsey & Atwood, 1979; Norman, 1983).

BARRIERS TO TECHNOLOGY TRANSFER

There are many barriers that inhibit communication between groups. Barriers include organizational structures which limits communication between groups; the level of knowledge and sophistication imposed by the technology; and individual prejudices which inhibit easy communication with people of dissimilar backgrounds.

Organizational Structures

Many large organizations have developed layers of bureaucracy which promotes efficient production. These same structures can inhibit the more informal communication between researchers and developers which is essential to technology transfer (Katz & Allen, 1985). Inflexible organizational structures can suppress essential linkages and communication between research and development groups. A cause for the poor technology transfer between XEROX PARC and the rest of the company, for instance, is the lack of strong ties between development and research (Uttal, 1983).

Formal communication structures can lead to the NIH ('Not Invented Here') syndrome. This syndrome encourages people to treat any work which comes in from an outside group as automatically inferior or at best equal to anything that could have been developed by the home group. In this environment a development group can grow resentful and defensive of the technology and the researchers thereby hindering further development.

Technology transfer can be a very long and difficult process. In order to sustain the momentum of technology transfer it is important to have supportive managers and a corporate culture that will sustain and promote the work even though the initial group of professionals and managers working on a technology transfer project may change. A corporate culture which is not predisposed towards novel ventures or towards the kind of risks and dangers inherent in exploiting new technologies, will probably encourage formal communication and discourage informal cross-organizational communication. Managers who have a negative attitude towards technology transfer can discourage communication, limit resources and fail to reward individuals who do the work.

Technology

Much of technology transfer involves the sharing of ideas and concepts as well as transfer of technology as hardware or software. However, ideas and concepts can only be shared in an environment in which participants have comparable levels of knowledge and experience. But researchers because of their greater familiarity with the technology will frequently have more specialized knowledge than other groups. This disparity in knowledge and experience can make it very difficult for researchers to convey some of their ideas and concepts. For example, an AI researcher may find it difficult to communicate ideas about an expert system to a developer or marketer who has no knowledge of the field.

Poor communication between the groups can also mar decisions affecting when and how the technology can get developed. Advanced technology is constantly evolving making it difficult to judge when the technology has reached the right level of maturity to be passed from the research organization to the development group. Research that is transferred too early, before the ideas have fully matured, can lead to serious problems in developing the technology into a product. On the other hand, if there is too long a delay before transferring the technology there is a chance that further evolution of the technology in the research lab is not productive and that the window of opportunity for introducing the product into the marketplace has passed.

Scaling-up the Technology

A major decision point in any technology transfer venture is judging when and how to 'scale-up' the technology from a small research exercise to a full scale development effort. Streeter analyzed 18 projects at IBM, both ones

that were successful and ones that were unsuccessful. A major factor in predicting success was understanding the technology enough to judge how to control the scaling-up process.

One way of 'scaling-up' the technology is to transfer the technology in stages. The gradual exposure of the ideas behind the technology is especially important for transferring the knowledge that frequently resides in the researchers' heads. This gradual exposure, also known as the 'quick win' approach, entails that you "Find a 'quick win' that carries an important piece of the intended functionality of the system. This quick win should use conservative techniques and should make the power of the technology as visible as possible." (Kunz, Kehler & Williams, 1984, p. 53). Part of this process includes the development of an early prototype of the system which can be used as a demonstration and feasibility study (Smith, 1984; Streeter, 1978).

Individuals

Many of the problems of technology transfer can be traced to "cultural" differences between researchers and developers (Allen, 1977). These differences can inhibit communication and make it difficult for each group to establish credibility.

Some of these differences arise because the two groups may work and be familiar with different equipment, tools, and concepts. Frequently the researchers have access to advanced equipment whereas the developers will be working with older more conventional equipment and tools. For instance, a research group might be working with a dedicated high-powered graphics workstation whereas the development group might perform their work on time-shared minis or main-frames which were developed many years earlier. In this environment it can be difficult for the developer to appreciate what advances in technology are possible. The researcher on the other hand, might find it hard to understand the problems of the developer who is trying to work within the constraints of a less powerful machine.

Other "cultural" differences separate the groups and inhibit effective communication. Gerstenfeld & Berger (1983) point out that researchers and developer differ in goals, working norms and who they choose as their reference group. For instance, researchers are more interested in knowledge production whereas developers are more oriented to problem-solving. Because the researchers are motivated by scientific curiosity, they frequently act as if the technology is an end in itself. On the other hand, the developers, especially when prompted by marketing, can be more oriented to the needs and requirements of the users of the technology.

It is of course appropriate that the groups should differ in this way. However, the differing perspectives can clash when technology transfer emanates from the research group without prior involvement of the development group. A research group can frequently fail to appreciate the role the technology might play for the development group or how, if developed into a product it could be marketed. This lack of forward planning can result in an unclear delineation of the responsibilities and purpose of the project, which in turn can cause the project to fail.

OVERCOMING THE BARRIERS

Organizations, technology and individuals can create barriers against communication. In this section we will briefly describe some ways in which these barriers may be overcome.

Organizational Structures

Organizational barriers against communication can be overcome by creating small multi-disciplinary groups or partnerships. This is the approach behind many innovative activities in large organizations. Many large corporations are fostering internal venture programs in response to competition from small start-up companies (Shays & de Chambeau, 1984; Lovdal, 1984). These programs frequently encourage the formation of small groups who are protected from the bureaucracy of the organization and who are given the freedom and resources to follow their own direction. Products such as the IBM PC and the 3M Post-It notes got developed through this type of internal venture.

Technology

A major barrier to communication occurs because the researchers have more knowledge and experience with the technology than do developers or marketers. One way of improving communication is by systematically exposing groups to the technology. For example, the non-research groups could being developing familiarity by reading about the technology, attending seminars or by getting demonstrations of the technology. This initial exposure could be followed by hands-on experience with a prototype version of the technology or with advanced technology equipment. Familiarity with the equipment is frequently a necessary first-step to understanding the technology developed on that equipment. For instance, AI technology is frequently developed on specialized equipment such as a Symbolics workstation. People can get more actively involved with the technology by getting hands-on training , perhaps from the researchers themselves.

The success of the R1 Expert System is an example of how prior exposure to the technology can benefit development work. This system was initially in the hands of researchers at Carnegie-Mellon and then transferred to Digital Equipment Corporation where it was made into a product. One of the reasons cited for the success of that project was that the DEC engineers had developed their own in-house expertise with AI software projects and

technology before the involvement with Carnegie-Mellon and so were prepared to receive the technology (Polit, 1985).

Individuals

Communication across groups can be encouraged by transferring people for short or long periods of time from a research group to an applications group and vice-versa. Transferring personnel is considered a very important factor in technology transfer and is one which is frequently employed by many large corporations (Gerstenfeld & Berger, 1983). It is interesting to note that it is also one of the techniques MCC uses as a way of improving communication between the researchers and the shareholder companies.

Getting technology transfer started within an organization and keeping it going frequently requires a single individual who can "champion" the effort. That is, someone who has sufficient commitment and understanding of the work to be able to "sell" the project to management and even to the people involved in the work (James, 1983). These "champions" are individuals who not only excel at research but who also understand the organizational structures and can make those structures work for them (Gerstenfeld & Berger, 1983). These people should be self-selected rather than appointed by management. People who are self-selected have the motivation and commitment to maintain the high level of involvement that is required to keep technology transfer ventures going.

In addition to "champions", technology transfer needs a person who stands outside of all the groups and who acts as a technology transfer agent (Katz & Allen, 1985). This person can facilitate the many translation processes that characterize the move of ideas from a research environment to development and marketing (see Grantham this issue for more on this topic). An agent can also facilitate decisions about how, when and to whom technology should be transferred. This person plays an extremely important role in overseeing the whole technology transfer process. A somewhat similar role is played by human factors practitioners who have responsibility for integrating and translating research, technology and knowledge of users into the design of user interfaces.

SUMMARY

This paper treated technology transfer as a communication process. Organizational structures, technology and individuals can erect barriers to this communication and impair technology transfer. These barriers can also be overcome by viewing technology transfer as a partnership rather than as a sequential set of operations that begins with research and ends with a product.

Technology transfer is an extremely complex topic and one that resists easy explanation or prediction. In casting technology transfer as a communication process many salient features of the process have been described. However, other factors, particularly those which impact marketing have been left to others to describe. In the session at CHI'85, Grantham presented a technology transfer from a marketing perspective, while Miller and Williams gave case studies of the interconnections between technology transfer and human-computer interaction.

In trying to account for the many factors which can affect technology transfer it is important to remember that however it takes place, the technology should respond to some need whether that need is determined before or after the process begins. Indeed, the real challenge in technology transfer might be in translating technology push into market pull.

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