Technology transfer in organisational development: An investigation into the relationship between technology transfer and organisational change

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1 author:

Morten Levin
Norwegian University of Science and Technology

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Morten Levin

Professor in Organizational Development, Department of Industrial Economics and Technology Management, The Norwegian University of Science and Technology, N-7034 Trondheim, Norway

Abstract: The main thrust of the paper is to argue that technology transfer enforces organization development. The point of departure is that technology is constructed through human activity. Values, culture and skills in the design process are built into technological artefacts. Operation of new technology invokes an organizational development process linked with the introduction of new technology. The major managerial challenge in technology transfer is to use the transfer process as a vehicle for creating a learning organization. The second part of the paper is devoted to pinpointing managerial challenges in technology transfer. These challenges, which emerge from the conceptualization of technology transfer, are discussed in detail. The paper concludes by presenting a case in which the introduction of new technology enforced large-scale learning processes.

Key words: change, learning, learning organization, organizational development, technology transfer.

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Biographical notes: Professor Morten Levin received a Bachelor in Mechanical Engineering, a Masters degree in Operations Research and did his graduate work in Sociology. At present he is Professor in Organizational Development at the Norwegian University of Science and Technology, Norway. His main research has been linked with organizational change both at organizational and community level. He has devoted much time and energy in studying and facilitating change in organizations where technology was a dominating factor and in recent years has focused his research activity on technology transfer.

1 Introduction

Technology is considered a key factor for successful operation of most industrial and service organizations. A conventional and undiscussed wisdom is that acquiring the most advanced technology will automatically secure high profits. That is a questionable position. Numerous bankruptcies in 'high tech' businesses show clearly how dubious this statement is. Utilizing new technology in an efficient way is much more complex than just buying technology with the thought that the road to prosperity is well paved. A comprehensive study on economic development and technology written by a group of senior economists and published by OECD in 1992 devotes substantial interest to the interplay between technology and organization. In the introduction to the report, the following problem statement is formulated:

> "An important dimension of technology diffusion concerns the absorptive capacity of firms and research organizations. Absorptive capacity refers to the ability of firms to learn and use technology developed elsewhere through a process that involves substantial investments, particularly of an intangible nature." [1]

This paper focuses on "... the ability of a firm to learn and use technology" and argues that technology diffusion involves "... substantial investments of intangible nature". In line with the OECD position, the focus of this paper is to clarify what it takes to learn new technology and to suggest important elements of organizational development processes necessary to be smart in utilizing the "substantial investment of intangible nature".

The unit of analysis is the organization. The aim is to deal with technology transfer as it might be seen from the perspective of the recipient company. The intention is to single out challenges for management actions. The starting point is an investigation of the concepts of technology and of transfer. This discussion is used to link technology transfer to organizational development, which in turn creates the backdrop for presenting a set of challenges to managers as they undertake transfer of technology to their own companies.

Technology transfer indicates that something is moved from a vendor or a developer and to a recipient company. A conventional position on technology transfer is that technology is developed and distributed according to a linear model, from basic research, via applied research, through engineering design and ending up with the process of implementation at the company level [2]. This position will be challenged. Technology transfer will, as a first rough sketch, be identified as a process in which a socially constructed technology is put into operation by new actors in a new setting. As employees in the acquiring company are involved in reconstructing technology through the implementation process, technology transfer is also an organizational developmental process. It might therefore be fruitless to think of technology transfer and organization development as two separate processes. Instead, I argue that technology and organization create a seamless web, where the whole process is a social learning and developmental process.

Based on this position, a set of managerial challenges are developed. At the end, an example from Norwegian industry shows how transfer of technology led to the creation of a learning organization.

2 Technology is human-made

A traditional and unproblematic understanding of technology is that it encompasses the machines and equipment necessary for transforming raw materials to finished products. Accordingly, technology is restricted to the tangible material artefacts. Given this understanding, transfer of technology is restricted to moving 'things' from a vendor or developer to an end-user. If this is a reasonable and fair conceptualization, the challenge in technology transfer is to find the right and best equipment, buy it and install it. The problem is then limited to selecting from a vendor's portfolio the most profitable or efficient machines and tools. The rest of the transfer processes is routine – install it, give employees some training, and high-quality products are then turned out. However, all experience from the field suggests that it may be not so simple and easy. It is worth questioning both 'technology' and 'transfer' in this context.

First, apparently, technology can be understood as physical objects, like cars, machines and tools. Second, technology can, according to MacKenzie and Wajcman be framed as using physical objects to perform tasks [3]. Driving a car or programming a computer is using technological artefacts to achieve desired goals of transportation or software development. Human activity will thus utilize technological artefacts to change raw materials into finished products. Third, technology is linked to knowledge that is necessary to operate the physical artefacts. Technology deals not only with the material artefacts, but technology has also a meaning component linked with skills and culture. Concluding from this discussion, obviously technology has three faces, all visible simultaneously. Technology is the material artefacts, how to use the artefacts to reach desired goals, and the knowledge of how to utilize it.

Emerging from this definition is an understanding that technology unavoidably links with human activity. A closer study of how technology is developed reveals different models for explaining how technological development is formed by social processes. Hughes takes on a historical framework, focusing on how actors in large technological systems interact to make new technology possible [4]. In describing and analysing the development of the distribution of electric energy for lighting, he ascribes to Edison the role of mastering the technological developments with his research colleagues. Another key actor handled the challenges of raising money from the development and some third person played a key role in establishing companies that could distribute and sell energy to potential users of electricity.

Pinch and Bijker model technological development as a complex social process in which actors, scientists, engineers, marketers and the business community interact in the same processes to develop new technology [5]. Engineers are not confined to engineering calculations, as they also engage in work on identifying market potentials. Economists do not restrict their attention to financial and economic deliberations, but will also have a say in how the final design should look. In this complex web of actors, interests and points of view, a social understanding emerges that one solution is the best. Closure is formed by a sort of agreement in which a majority of the actors have the power to state at a certain point that the technology is finally developed.

A further elaboration of this position on technology development is given by Latour [6]. He argues that actors first launch elaborate strategies supporting their own interests in the play for deciding what the new technology should be. By translating their interests to fit with others, larger alliances are built. This unification of interests can gain momentum to have a decisive influence on what new technology should be. Through the translation of interest, and points of view and alliances held together, new technology finds its shape. Thus, technology does not follow a scientific trajectory but is formed by conscious human actors.

Development of technology is, according to this argumentation, a social process in which the resulting technology cannot be separated from the actors engaged in shaping it. Skills, cultural knowledge and meaning are constructed as part of the technology. These intangible factors, which, with artefacts, make up the technology, will in turn put demands on the user. The ability to use the technology depends on managers' and workers' ability to understand what knowledge is built into the machines and tools, and to acquire the necessary skills to be able to operate it. This is the crucial point in technology transfer. Moving of equipment is not enough. Skills and knowledge understood in a cultural context must follow the machines, and this human-carried capacity cannot be packed in a case comparable to the machine's toolbox. Technology transfer will in line with this discussion consist of moving the physical objects, acquiring skills for operation and an understanding of the knowledge and cultural understanding built into the machines.

3 Technology transfer is learning

If technology transfer were as straightforward as moving machines, tools and equipment, it would be uninteresting for organizational theorists. Though managers for years thought and acted as if technology transfer were that simple, experience from the field pinpoints the problematic side of technology transfer. Normally little attention is paid to the implementation phase of the transfer process. Illustrative is Zuboff's argument that in a major rebuilding of a pulp and paper mill amounting to some US$ 200 million, not one budget item was assigned to training workers to handle the new machines and tools [7].

'Shipment' of human skills, knowledge and culture is on the contrary quite different from moving physical things. Let me use an illustration to clarify my position. In everyday language we talk about constructing a machine. That has intuitively clear meaning. In addition, as argued earlier, some social skills and knowledge are also built (constructed) into the machine while others are left to the operators. What is left for the operators is certainly also a result of the designers' decisions [8]. When a large Norwegian fertilizer plant rebuilt its entire operation, the design team hired consultants to interview every worker on what they actually did in their jobs. This knowledge was in turn used to design the new equipment, and operator skills were heavily used to model the automated plant [9]. It is important to be aware of the nature of these skills and knowledge necessary to operate machines and tools. Some of it can be described and made explicable by using figures and text communicated through manuals. This is the easily accessible element of the competencies necessary to operate the technology.

Skills are, on the other hand, more than what can be communicated in writing or in figures [10]. Skills and knowledge that are in the hands and heads of the designers (and are not explicable), and are expected to be present in the skills repertoire of managers and workers using the new technology, must be communicated through a much more complex learning procedure. These skills can best be 'transferred' through on-the-spot training or through experimentation or 'test and fail' with the newly installed equipment. One argument delivered by Don Schön is that professional skill can be acquired by a novice through working with a skilled person [11]. Translated to the design phase of new technology, this suggests that engineers and scientists must work with operators to develop the new equipment and to make it as easy as possible for the operators to utilize the new technology. Or, in the case of off-the-shelf technology, managers and operators in the recipient company might learn from working in a company where the new technology is used. Another important argument, as delivered by Collins, is that knowledge of technology is deeply rooted in societal culture [12]. Acquisition of these skills is based on long-term social exchange in the community. Cultural understanding is developed through living and learning in a society. Examples from technology transfer to Third World countries illustrate this point. Turn-key projects materialized for example as a steelworks in Libyan desert, never worked out until foreign workers took over key positions. In advance, a very thorough and comprehensive learning program had been launched. All workers were trained through it, but the effects were moderate. The new indigenous workers could not acquire the skills necessary to operate the plant, as their culture was shaped living as Bedouins herding cattle in the Libyan desert [13].

This led to a position in which transfer of skills and knowledge is considered much more profound than just including a training kit in the shipment of new technology. Some skills can be acquired through conventional training, while tacit knowledge has to be learned by doing. The transfer of skills and knowledge depends also on understanding the culture under which the technology is developed. Thus, skills and knowledge accompanying technology transfer are not a commodity shippable as a toolbox. They have to be acquired through a fairly complex learning processes.

The skills and knowledge necessary to operate new machines have to be constructed in the heads and hands of the people who are operating the new machines. Some will identify this as training operators to handle the new machines or tools, but training is too narrow a concept for this process. An instruction manual or a preformatted training program will never capture the wealth of knowledge that is both built into the physical artefacts or the skills necessary to operate it. Sometimes the necessary skills for operating technology are a part of our culture. Accordingly, training to utilize a technology is much more demanding [14]. This last point can be seen as part of common knowledge as it is formulated in slogans such as 'It takes decades to create an industrial culture'. Shaping a cultural backdrop that supports understanding of technology is something that working at company level will develop, but it will also depend on the general cultural level in the society. Further, I have argued that acquiring the tacit knowledge necessary to operate a plant can only take place using one's hands and head in operating the actual technology.

4 Use of new technology invokes organizational development

Moving the material artefacts from a vendor or a developer of new technology does not, of course, automatically make technology operate. Technology is only useful for the company when it can be operated by employees. First, this is an argument for the importance of making the necessary skills and knowledge accessible to operators and management. Second, the new machines and equipment will be introduced into an already existing organizational entity. New machines and routines must be integrated into the existing organizational pattern. Transfer of technology shifts from being a question of training, which we have already complicated by introducing both tacit knowledge and cultural skills as important factors, to a process of organizational development. Training has to be integrated into the organization, which means, of course, that operating a technology depends on routines in the interaction between workers and managers [15]. Introducing new technology also means changing routines of working.

Technology is made up of material artefacts, skills, knowledge and culture. The social interaction between employees constructs routines that emerge as the factual organization. Using technology implies the emergence of routines that make the technology work. The seamless web of technology and organization is kept together by routines linking man and machine. An implication of this argument is that the interface between technology and organization is crucial for the general performance of a company. A poor fit, either manifested through advanced technology that cannot be utilized by the workers and management, or having a superbly qualified labour force and low-grade technology, will result in poor performance of the company. It is essential to make the interface between technology and organization as smooth as possible. This is well-established knowledge produced by the socio-technical school many years ago [16]. The main argument in this thinking is that technology and organization together form the functioning, working organization. The efficiency of operation depends on how technology fits with human skills and competence, and vice versa. In designing an organization, sufficient attention should be devoted to handling this interplay. It is also evident that there is no general best way of organizing industrial work. The actual technology, manpower, markets and economic situation are all factors that count in designing the organization. A challenge for managers and the workforce together would be to construct this contingent organization. In this respect designing an organization is based on the members conscious decisions on how they will work together.

Development of technology is itself also based on the involved actors' choices. Then apparently both technology and organization are subject to choices, and the important imperative is to make decisions on technology and organization that enhance the development of an efficient organization. This represents a major management challenge.

What does it actually mean to design an organization? Drawing a blueprint identifying how one commands an organization does not necessarily lead to organizational routines that follow the organizational chart. In line with Nelson and Winter [15] an organization of routines emerges gradually through human interaction. In this way human activity constructs the organization. An organization will therefore result from the actual social interaction among members and the meaning constructed through this process. Planned activity to train employees to operate new technology has therefore the unmistakable quality of being an organizational developmental process [17]. This process is shaped by learning processes that support the construction of the organization. Organizational development (OD) is a process in which the organization changes its way of working based on the employees' participation. The core essence of an OD process will thus be the facilitation of learning to shape a new understanding and the skills necessary to change the organization. Creating a learning organization will, according to this line of argument, be facilitated through the OD process necessary to implement new technology in the organization. A major task will therefore be to ensure that the necessary organizational learning process takes place to be able to take advantage of the new technology, but also have a perspective on future challenges. As learning processes are initiated, a wise strategy will use the opportunity to create a continual learning organization. When the employees first start a learning process, it is mutually beneficial for the company and for the individuals to improve skills and competencies through support for the continuing learning effort. Thus a learning organization might emerge from a one-shot technology transfer process.

The skills and tacit knowledge necessary for operating the new technology must be learned, and at the same time the necessary learning processes will shape the working organization. Therefore, technology transfer is based on an organizational developmental process that links use of technology with organizational redesign. The major issues reside in questions of how to facilitate the necessary organizational developmental process. This confronts managers with several challenges.

5 Managing technology transfer is creating a learning organization

There are different models of what management should be. The conceptualization spans from dealing with individual characteristics of the manager, via administration of stable organizations, to a person responsible for pro-active strategy development. In this paper I take the position that management is the activity related to developing possibilities for long-term survival of the organization [18]. Given this pro-active position, the leadership challenges are two-fold [19]. First, it is important to understand the interplay between different resources that make up the business situation. These components are economic, technological and human factors, and these elements support in different ways the achievement of desired goals. The second important factor of leadership is to act to develop resources or allocate necessary resources to be able to pursue desired goals. Leadership therefore implies a cognitive capacity to understand and make sense of the interplay between different resources and to be able to initiate strategies and processes that can develop resources necessary for achieving these goals.

Technology transfer is conceptualized both as learning and the developmental process and as the movement of the physical artefacts. That poses several challenges to the management. First, it is a question of choosing the 'right' technology. A preferable technology is one that will be economically efficient to improve the position on the market and that can take advantage of or improve the efficiency of the organization. A major managerial challenge is to introduce new technology in the company (transfer technology) that both represents state of the art in the industry, and that will lead to an organizational developmental process that will increase the company's learning potential. Successful transfer of technology will enhance the organization's developmental capacity through bringing it to the technological cutting edge and support continual learning. Given this, technology transfer also prepares an organization for future challenges. Technology transfer supports both active and pro-active capabilities.

A successful OD process lined up with the transfer process does not emerge by itself. It must be consciously planned, and this is the challenge for the management. It is obviously necessary for the manager to have a working conceptualization of the relationship between technology and organization. This local theory (an understanding given the actual context of how technology relates to the organization) guides the manager's actions in initiating and facilitating an organizational developmental process. In the preceding section the socio-technical thinking was presented and I would stress the importance of this understanding given the challenges of technology transfer. Socio-technical thinking forms the basis for planning the developmental activity, where the next important step is to shape the organizational developmental process. It is important that the OD process is designed to support the learning process necessary to operate the technology, but it should also aim at creating a learning organization [20]. If the management is successful in supporting learning capabilities in the organization, a powerful structure is shaped for tackling future challenges.

Organizational developmental processes can be designed according to different models. Traditional models launched by Lewin in the early 1950s relied heavily on expert domination [21]. The experts made an assessment, prescribed necessary activities and facilitated the developmental process. Modern approaches to organizational development focus attention on the participative dimension [22]. The change process must be influenced and controlled by the people involved in the OD process. Participation is argued to be the tool both for enhancing learning and creating the ability to shape the learning organization. Given the discussion in the previous section, a technology transfer process will best be supported by initiating an OD process built on participation.

To sum up, the major management challenges in technology transfer are to choose the 'right' technology that best utilizes the economic, technological and human resources available in the organization. Further, the acquisition of new technology should be based on strategic reflections, where potential development of new markets combine with development of the organization, and should guide the decisions. It seems further logical that this selection process will be improved if the involved parties in the organization are given a say. An organizational developmental process aiming at integrating the new technology into the already existing organization can best be made as a participative process. The participation will create the necessary learning conditions to make the technology work, and that is the whole aim of the technology transfer process.

6 Challenges in managing technology transfer

The aim of this section is to describe the most important challenges in managing technology transfer. Arguments in earlier sections lead to the concept of technology transfer as a process designing a seamless web between technology and organization. The major issues in this change process are presented in the following. The intention is to link the theoretical positions with practical useful hints regarding technology transfer. I will not present a tool-kit for successful technology transfer, but the points made in this section highlight major elements of technology transfer. Given the actual business situation, the people at hand and the market situation, each manager has to make deliberate choices based on his own reflections. The 'challenges' as presented here will then function as a reminder. It is the management's responsibility to take the necessary action.

6.1 Choosing technology linking evaluation of product, market, organization structure and skills and knowledge as important elements of decision-making

Choosing the appropriate technology is a complex process. It must involve as many of the potential variables as is possible. The essence is to make strategic choices supporting both market enhancement and developing the organization. In this process of selection I argue for the importance of taking advantage of all available competencies in the organization, involving as many people as possible in the decision-making process. Further, the choice of new technology must have a dynamic perspective, as it must support a continual change process in the organization.

One key variable that must not be left out is how new technology can be operated by the employees. This leads to the following questions:

- How to decide what are the necessary skills?
- How to design a process in which the managers and workers can acquire the necessary skills to operate the new technology?

6.2 *Implementation is combining technology and organization*

The use of technology impacts on organizational structures and processes, so the implementation process should be designed as an organizational developmental process, where a socio-technical viewpoint supports the creation of such a process. Choosing the 'right' technology and the 'right' organization is like developing a strategic plan in which the potential development within the organization is matched with the potential of developing new markets.

6.3 *Implementation through participative processes*

Participation in technology transfer implies involvement in choosing the right technology, and participants learning about it as they are active in choosing it and have a hand in the necessary organizational design. This is instead of receiving blueprints for what the organization should look like. Following this line of reasoning, the implementation is not a problem any longer. At the time when technology appears in the workshop, it is already 'implemented' as the users know what to do. If the intention is to shape a high-involvement organization there is no way round using participation as the vehicle for reaching this goal [23].

6.4 *Using technology transfer as a vehicle for continual learning*

Always take a long-term view, both on what kind of technology is acquired and on how the skills and knowledge related to this technology will be used to support it. The technology introduced today will prepare for tomorrow's challenge.

7 New technology released a continual learning process – an example from a Norwegian aluminium company

In the early 1980s a Norwegian aluminium smelter was facing severe threats, both environmental and on the markets. The smelter emitted far too much toxic substance to the environment at the same time as the bottom fell out of the market. The situation was immediately threatening, but the whole industry was expected to be on a cycle with reduced profitability. Long-term survival was expected to depend on the company's ability to increase the efficiency of the operation. It was well known in the industry that other factories operating in other countries had a much higher profitability. The strategy was basically formed on a vision that bringing new technology into the company would be the vehicle for revitalizing the company. In the search for technology, a Japanese manufacturing company seemed to have the best available technology. This technology would both enhance the control over the process, and through that reduce the environmental pollution. Second, the Japanese-based technology had proved to be very efficient. After some hesitation, the company decide to go for this Japanese technology. While negotiating the contract, extensive visits between Norway and Japan took place. The result of these visits, which were dominated by managers and some very few union officials, was a recommendation to introduce the Japanese technology in a least two of the smelters.

The local Norwegian management saw the challenge as how to transfer the foreign technology as smoothly as possible. Many employees at all levels had to be trained. The problem was approached by establishing problem-solving groups at the shop-floor level. These groups consisted of workers, supervisors and metallurgical specialists who had the responsibility of both analysing the causes and taking appropriate actions. The study group was led by the supervisors of senior workers. The metallurgical engineers were only functioning as resource persons. Responsibility belonged to the people working on the pots. Throughout the Spring the problem-solving groups worked on finding causes, experimenting with the pots and developing new work routines aimed at solving the problem. Gradually they got a grasp on the low-efficiency problem, and by the Summer of 1994 the problem was solved.

In asking the chief metallurgical engineer whether this would have been a way of working 5–10 years ago, he clearly said 'no'. In those days a group of metallurgists would have met, possibly calling in scientists from the University and studied the problem from any possible angle. "If and when we came up with a solution, we would have been forced to convince the operations that our solution was valid and then we would have to go through the whole process of training people. When we know that the efficient operation of pots depends on good quality engineering, skilled operators and efficient working routines, then it is clearly a waste of time and resources not to involve the problem owners in solving their own challenges".

8 Conclusion

The aim of this paper has been to shed light on technology transfer as it can be viewed from organizational theory. The main idea has been to conceptualize technology transfer as forming a seamless web with organizational change. Technology is human-made, and organizations emerge because the members live their lives there thus constructing routines and meaning as they interact to solve the organization's tasks.

Successful technology transfer depends on human skills in enabling necessary organizational developmental processes to take place. In this sense technology transfer is organizational development for shaping a continual learning organization.

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