Technology Transfer at The Hong Kong Polytechnic University

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Abstract

A challenge in technology transfer is to manage the complex assimilation process which requires the mutual adaptation of organization and technology to gain leading edge. This paper describes a model and an enabling (industrial/academic collaboration) mechanism to transfer and assimilate best practices through information systems development in SME. A case study will be provided to illustrate the application of this model to manage the assimilation of Manufacturing Resource Planning in a SME to support concurrent manufacture.

1. Introduction

1.1. Practice of SME in Hong Kong

Nearly 96% of manufacturing companies in Hong Kong are Small Manufacturing Enterprises (SME) (less than 50 employee) and can be characterized as export-oriented companies. Most of them are Original Equipment Manufacturers (OEM) and have production plants in China. The company in Hong Kong serves as a logistic center offering value added services like procurement, production planning, engineering design and finance administration, etc. to support production in China. Their operations are closely linked with the bigger business enterprises from the United States and other countries through a network of subcontracting processing arrangements [11]. Most of them are small in size and rely on the experience of staff to manage the day-to-day operations. They do not have systematic procedures to govern the running of business. The methods of management will change in accordance with the managerial style and the educational background of the product managers in charge.

1.2. Operations excellence making use of IS/IT

When a manufacturing company is small, the operations are simple and the market is stable, these kinds of management practice are acceptable. However, when the company grows bigger and bigger, its product lines become wider and more complicated in terms of variety and batch size and the market requirements are changing rapidly, it will eventually come to a situation that the whole production management system would be very inefficient. To survive, they have a need to use information system to manage operations to compete-in-time. Compete-in-time [5] (i.e., compete on the basis of order fulfillment lead time) is the notion that advocates the smart use of information system and information technology (IS/IT) for concurrent manufacture.

1.3. Constraints facing SME in IS/IT exploitation

A survey [8] indicates that most SMEs in Hong Kong are interested in using information systems at a company-wide level to reduce delivery lead time, improve operational flexibility and reduce inventory towards operations excellence. However, from the SME owners perspective, they can not afford to divert attention away from running the business and keeping it under control. This constrains the options a manager could take when (1) he does not have immediately available relevant data to support his case for an IS budget, (2) he does not have the surplus manpower with the right skill levels to support the IS implementation, (3) he does not have the technological base to support the assimilation of emerging technology. In this regard, the transfer of IS technology for assimilation for competitive advantage is considered as a critical issue in operations management.

1.4. Challenge in successful technology transfer

Besides the aforesaid constraints, Jones [12] points out a number of situations for debate in successful transfer.

- New technologies are not evaluated on their merits, but only on the numbers of users
- Lack of appropriate training given to users
- Setting unrealistic goals and objectives in executing technology transfer project

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- Obsolete policies and standards inherited in the organization that inhibit collaboration
- Failure to perform basic research on software problem areas (knowledge of tools and methodologies available in the market for application)
- Lack of solid data to measure effectiveness of performance in technology transfer (difference in perception about improvement or impact on practices between sponsors, agents, implementers and users) can lead to invalid conclusions

1.5. Evolving nature of business and IS

IS technology transfer is totally different from the transfer of other technologies (say the transfer of laser technology in material processing). Considering the nature of information systems, they do not only offer a new platform of organizing data and information but also imply a new style of working in a company-wide sense. The application of MRPII (manufacturing resource planning) for production planning and control is a typical example in this case [4, 13]. At first glance, MRPII is only a database system which can generate job and material purchase orders for production and inventory control. In fact, the running of MRPII demands stringent coordination and teamwork between departments which is totally different from the tenets advocated in scientific management. Moreover, the requirements of an IS will change with the evolving business over time. As the competition becomes more globalized, the requirements of information system to support business growth also changed. This evolving nature of business and of IS makes the transfer and assimilation process more complex and difficult to manage.

1.6. Structure of this paper

This paper advocates the use of case study research as an instrument to learn about the process of technology transfer and assimilation. Section 2 describes a model in technology transfer and assimilation. This model highlights the importance of managing two periods (technology buy-in period and capability acquisition period) in exploiting an imported technology. Section 3 identifies three major issues critical for success in implementing a manufacturing information system in a SME. Section 4 proposes an enabling mechanism to create a "win-win-win" situation to sustain the acquisition of a competence to support a new style of management in an organization. Section 5 articulates the theory of technology transfer and its practice at The Hong Kong Polytechnic University (PolyU). Section 6 gives a case study to illustrate the shortening of order fulfillment time via the transfer of the information system for assimilation in a SME over a six-year period. Section 7 discusses the future research direction. The final section concludes the case study research is useful to support an SME in formulating and implementing an operations strategy.

2. Technology transfer and assimilation

2.1. Definition of technology transfer

Technology transfer means a transfer of knowledge or services from one place to another place or any geographical shift in this world [1, 15]. Technology here refers to knowledge, perspective, principle, theory, concept, framework, methodology, tools, techniques, mechanism or skills associated with implementing an information system to support concurrent manufacture in an organization. Technology may appear as MRP philosophy, but its assimilation (MRP philosophy) may not be widely reported in the literature. The successful transfer of technology involves a combination of aggressiveness as well as working smartly to build a distinctive competence for profitable business. The notion of assimilation of MRP philosophy may be conceived as a complex and interactive sequence of activities necessary to exploit new knowledge. The people involved acquire understanding in building a competence in applying the technology to work smarter in the organization.

2.2. Make or buy decision

As previous studies in the management of innovation [1, 4, 15] have shown that successful transfer of MRP philosophy enhance economic performance of the organization. The two major alternative approaches to assimilate a technology to make continuous improvements can be labeled "make" or "buy", i.e., either developing a new technology in-house or absorbing a new technology which has been developed outside the company. The "make" approach to innovation is normally adopted by those companies who prefer to build and develop technology and competence to use the technology in-house for competitive advantage. In contrast, the "buy" approach is followed by organizations pursuing a strategy to flexibility adapt available technology or best-practices to make management process innovations.

2.3. Positioning of SME in technology exploitation

Being small and with limited resources, it is more advantageous to have the technology transferred into the SME for exploitation to gain competitive advantage. They are more concerned with the "how" of accelerating the acquisition of competence in assimilating imported technology to maintain the lead in the competition. The emphasis here is on innovative adaptation of "buy-in" technology to gain a leading edge (i.e., technology exploitation) and not on research and "in-house

developed" new technology (i.e. technology development) to make a difference.

2.4. Technology transfer and assimilation model

Traditional technology transfer models mostly focus on the mechanism (the "how") of transfer without considering the overall objectives of IS technology transfer and the magnitude of change in the organizational culture. The assimilation of IS technology to make organizational innovation should be viewed holistically when addressing: (1) "where we want to go", (2) "what we should do" and (3) "how to make it happen" at each phase of technology transfer and assimilation model. In a boarder sense, the exploitation of an imported technology has to go through three intersecting cycles: technology development, transfer and assimilation (see Figure 1).

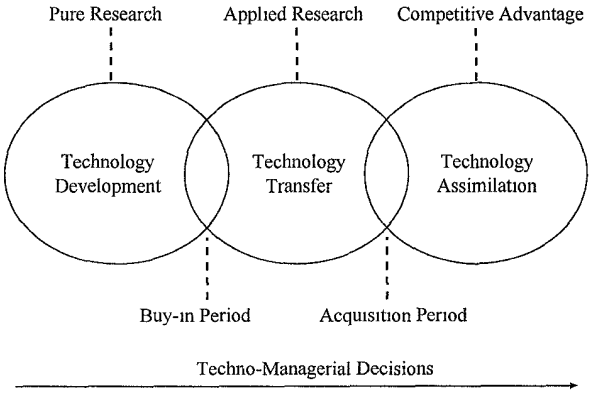

Figure 1. IS technology transfer and assimilation model

The ISTA model emphasizes the nature of activities in the two periods: the "technology buy-in" period and the "capability acquisition" period. The management of these techno-managerial activities is critical in determining the success of technology transfer and assimilation [13].

2.4.1.Technology buy-in period

The challenge in levering IS technology in a SME for competitive advantage lies in its transfer and assimilation to build a capability for company wide integration. A SME may have an early start in demonstrating where the technology might be fruitfully employed when it acquires an IS technology from the outside. However, as the technology platform advances, the SME may find itself holding onto a "yesterday" technology if efforts to sustain the deployment of the technology is not maintained. It is vital that immediately after the imported technology is secured, it is used and is accepted as part of the existing infrastructure. Otherwise its obsolescence and commitment in its updates might not be supported.

2.4.2. Capability acquisition period

Getting commitments in using the imported technology has ramifications for integration into the existing operations. The potential users may be ignorant of the potential contributions that imported technology could make in their operations. The users have the knowledge and the insights of their operations. They could guide the direction of customization of the imported technology for local benefits. However, they lack development know-how. Therefore, the wide-spread and use of technology demands the articulations of concepts, principles, theories, skills and methods appropriate for the diffusion and the innovation of uses. If this could be achieved economically to support company wide integration the SME could evolve a core competence unique to itself to survive in the competition.

2.5. Benchmarking of Practices in Hong Kong

In addressing the issue of "how" to transfer a technology for assimilation in a SME, one might agree that there is merit to sustain the development of the technological base in-house for competitive advantage. This is a contemporary issue in information systems strategy formulation. A survey of 40 SMEs in Hong Kong with cross border operations was conducted [8]. It was found that more than 60% of SMEs in Hong Kong would like to collaborate and form alliance with external associations such as universities to exploit the power of information systems (see Table 1).

Preferred mode of collaboration	Respondent
Strategic alliance with customers and suppliers	44%
Collaborate with university for joint research	22%
Build an informal network with external partners	22%
Co-develop with IT system houses	16%

Table 1. Preferred approaches to exploit the power of IS

Regarding the priority of tasks in IS technology transfer, about 40% of the respondents preferred to acquire competence to make organizational innovation through system implementation projects (see Figure 2). Amongst the technology transfer issues, "continuous education of users to acquire a capability in using IS as a tool to make innovation" was given the highest ranking. (see Figure 3).

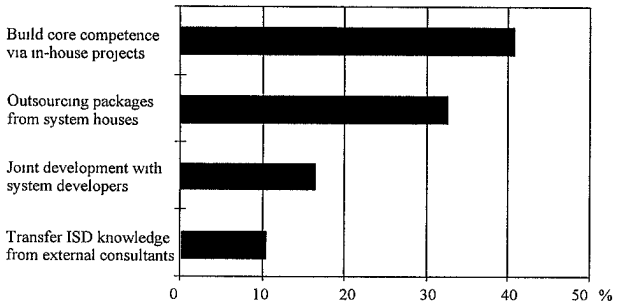

Figure 2. Preferred IS technology transfer mode

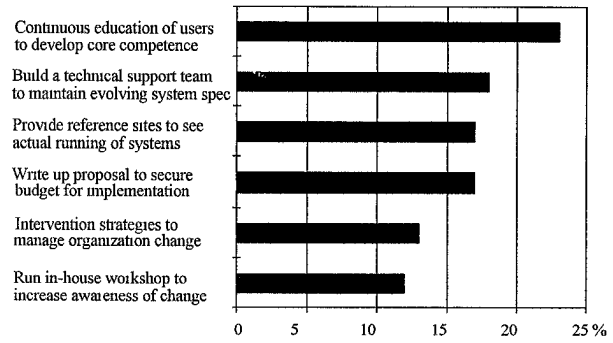

Figure 3. Priority of issues in IS transfer and assimilation

3. Major issues in MRP technology transfer

3.1. Parallel mode of working

The integration of business operations through the cultivation of knowledge workers with competence to smartly use decision support technology for concurrent operations is a new paradigm in manufacturing for the 21st century [6]. MRP is a decision support technology in production scheduling. The transfer and assimilation of MRP to enable parallel mode of working in an evolving business context requires a paradigm shift. This paradigm shift challenges the mental model in learning and working for workers of a hierarchically structured organization. It calls for a new educational paradigm

3.2. Major issues in ISTA strategy formulation

It is assumed that successful MRP technology transfer could build a distinctive competence to assimilate imported technology to make continuous improvements in an organization to attain concurrent manufacture to gain leading edge. Of creating such competence through the implementation of MRP particularly in SMEs, three major issues must be taken into account. These issues include (1) alignment of business and technology transfer objectives, (2) institutionalization of an enabling mechanism to support the cultivation of champions to sustain the transfer and assimilation of imported technology to make innovations and (3) networking of champions through the expansion of the technological base to support growth.

3.2.1. Alignment of business and technology transfer objectives. *Vision*: Top management commitment and user support should be the basic criteria for successful technology transfer and assimilation. However, the prime concern of most small OEMs is on whether the products can be manufactured in time to deliver to customer. In order to create a supportive environment to transfer and assimilate an imported technology for competitive advantage, the objectives of technology transfer must be aligned with the business objectives.

3.2.2. Institutionalization of mechanism to sustain infrastructure. *Infrastructure*: The presence of a relationship network amongst the champions in the technology recipient organization is a critical success factor in a technology transfer project. At least one senior executive in the organization should be willing to take the leadership, line up his subordinates and collaborate with other senior executives to experiment a new way of working making use of IS. If none such champion initially exists, he should be identified and groomed. To facilitate the formation of this relationship network, a change agent could be deployed to devise a strategy to make organizational interventions. This avoids the generation of organizational defense leading to a slow down in the technology transfer and assimilation process. This change agent should be seen as a naïve person and taking a neutral position. He should be promoted as coming from the reference sites sharing similar best-practices.

3.2.3. Networking of champion cells for growth. *Technological base*: Since SMEs normally do not have a surplus cash flow, they rarely make large capital investments on any computer aided systems [2]. For them, the system should be cheap and should run on an economic and a widely available IT platform so as to keep system migration costs down. Furthermore, SMEs rarely have the resources to invest in the maintenance of complex databases. Therefore, the IS/databases being used should be simple so that maintenance is easy, understandable and takes less effort.

4. Technology transfer enabling mechanism

4.1. Collaborate to compete

SMEs may wish to grow from OEM to ODM (Original Design Manufacturer). To support the growth, they look for a mechanism to acquire more skills in marketing and in new product development. They could look for the technology suppliers to source the relevant technologies for product innovation. They could open up more sales

offices overseas to establish a sales network for their own products. These should be done in parallel in order that the market information from the sales offices could be channeled to the design office for customizing a new product. They lack the capabilities to drive this change because their strengths have been with adapting production to meet their customers request for changes.

4.2. Industrial/Academic linkage

One alternative [13] was that they could collaborate with PolyU to formulate a manufacturing strategy to make continuous improvement on their operations. The PolyU has the expertise in most areas of manufacturing management particularly in the development of manufacturing information systems. The company could collaborate with PolyU to build up a core competence to gain competitive advantage in a global marketplace. Their experience have been that they had played a part in the PolyU enabling mechanism to support industry and had found that the collaboration with PolyU contributed an impact on the management of their operations [3].

4.3. Collaboration infrastructure

The enabling mechanism (see Figure 4) at the PolyU aims to create a win-win-win situation amongst the three parties: PolyU, Industrial company and Sponsor. (1) PolyU contributes research manpower and ideas to the industrial company for formulating their manufacturing strategy. (2) Industrial partner contributes real life data to academic in PolyU to formulate and validate their theories. (3) PolyU contributes market insights to Sponsor to formulate strategy to support research that benefits the industry company. (4) Sponsor commits funds to expand support from PolyU to industrial company. (5) Industrial company promotes the extent of achievements in industrially sponsored project. (6) Sponsor continues to support research program by PolyU that benefits industries.

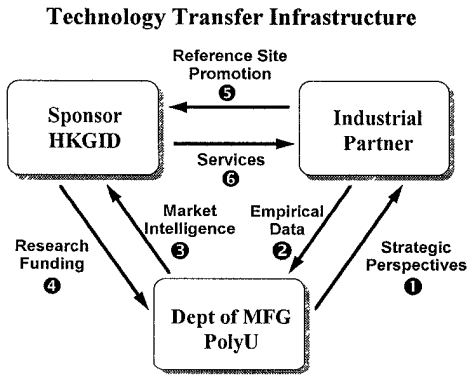

Figure 4. The enabling mechanism

4.4. Milestones in IS transfer and assimilation

Our approach in transferring technology for organizational innovation is divided into three milestones: short term (1-3 years), medium term (4-6 years) and long term (7 or more years).

- Short term: Recruit a researcher to identify champions in the industrial company. They work together and decide whether they should make or buy a technology for assimilation. The researcher serves as an agent to devise experiments with the champions and test them with real life data. Through the experiments, the researcher articulates a new paradigm of working and learning. The champions share this mental model of action learning [4,5] and acquire self-discipline in managing an information system development project.
- Medium term: Groom more champions to expand the collaboration infrastructure in the industrial company and multiple the assimilation of technology. The champions with the acquired skills from previous experiments serve as mentors to guide the formation of more project teams across departmental boundaries for co-design of information system development projects. This accumulation of champions in the company forms a platform to support acquisition of skills to work independently and in parallel with others.
- Long term: Shift the habit of working in the industrial company. This requires the support of case study reports to guide theory formulation and their subsequent validation with real life data to reflect the contextual factors affecting the implementation of theory. This can be best achieved with a new paradigm of education in collaboration research involving both the industry and the academic.

5. Theory and practice of ISTA at PolyU

5.1. Mission of PolyU

The Hong Kong Polytechnic University (PolyU) has the mission in providing education and training of students in an academic and professional context. These can be translated into the following objectives among others:-

- To conduct research activities, where appropriate, in collaboration with other academic institutions, in Hong Kong or elsewhere, or with industrial, commercial, professional or public services organizations.
- To collaborate with and maintain close links with industry, commerce, public services, the professions and the community generally and to develop appropriate support mechanisms which will contribute to industrial, commercial and community development.

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- To promote partnerships between higher education, Government, appropriate Government agencies, industry, commerce and the professions, in addressing strategic issues related to the social and economic development of Hong Kong.

Case study reports are useful to guide the formulation of operations strategies to manage cross border manufacturing in Hong Kong. The PolyU is very keen on promoting exploitation research which involves the application of theories to specific areas or for specific purposes, contract research which leads to the delivery of a product or process. One example in promoting such type of research is Teaching Company Scheme (TCS). Under the TCS, research associates registered for a higher degree at the PolyU will undertake research directly related to the needs of client companies under the joint supervision of the academic staff and an industrial supervisor. These projects have been extremely successful in bringing the University and the private sector together and significant funding for the schemes have been obtained from industrial and commercial sponsors.

5.2. Range of research activities in Manufacturing Engineering Department

The Department of Manufacturing Engineering is responsible for the education and training of professional engineers to meet the needs of the manufacturing companies in industry both in Hong Kong and those which have invested directly and indirectly in Southern China. There are five main themes of study in the Department: (i) Manufacturing and Materials Technology; (ii) Control and Automation; (iii) Quality and Reliability; (iv) Manufacturing Information Systems and Management and (iv) Design for Manufacture [9]. One aspect in the training of professional engineers relates to its collaboration with industries to conduct joint research projects under an industrial context for theory building and validation. The type of this joint research projects currently undertaken is wide-ranging. In the domain of manufacturing management, the linkage with local industries has been doing applied research on:-

- Soft automation,
- Quality function deployment,
- Performance benchmarking and
- Business process development.

5.3. Putting theory of ISTA into practice

To see the theory of ISTA put into practice, the attention is focused on the process of writing up a case study report to reflect the lessons learnt in transferring and assimilating information system research results to increase competitive advantage in a company. From the perspective of the change agent, there are four levels of success in technology assimilation: (1) individual level, (2) group level, (3) company-wide level and (4) inter-company level. These four levels can be validated through the writing up of a case study report. Over time, the researcher validates the technology assimilation activities through (1) concept translation (2) infrastructure building (3) management process development and (4) application system for replication.

Concept translation: The imaginative use of information system that embeds a new concept of operations to support business strategy to compete-in-time can begin with re-design of the business processes to make them more integrative and effective. The journey to make changes can be risky. To have the changes accepted and made operational as an integral part of the business involves crossing many disciplines. This demands a show of support in management behavior which can be gained via action and changing over to a new mindset. The change agent together with the manager in charge of the operation must learn to take leadership, provide a vision and translate the vision into a deliverable plan to drive the use of the information system. For the outcome to be useful, the manager is opening a part of his operations to intervention by the relevant researchers. Their participation will raise eyebrows. They stake their reputations in the project. The funding body also will be challenged to justify the fact that its decision to approve funding in the research project was indeed a good decision.

Infrastructure building: The organization needs to identify a champion to take initiative to prioritize an information system for development. He is expected to assemble a team of colleagues to review procedures used in providing a product or service. The aim is to identify a project to take on for prototyping and system implementation. A researcher is engaged to help preparing the presentation in order to seek consensus and support in the development of an information system. Together both teams of people (from the industrial organization and from academia) discuss and clarify the boundary of the project to be broken down into a collection of mini-projects for implementation. Each mini-project is expected to make incremental changes and shift the mindset of the project participants. The design, development and implementation of these changes are continually used to give results that are integrative as and when they become feasible.

Management process development: From a management point of view, the management of transfer and assimilation of imported technology is consistent with the philosophy of total project management. A project is formulated,

structured, evaluated, designed, developed and implemented concurrently in a series of mini-projects by the staff and for the benefits of the organization. They will be performed in a sequence to enable integration for early results. These activities are complex and their co-ordinations are difficult. The challenge lies in the empowerment of the participants to communicate, clarify and understand essential tasks to do and to allocate the resources to do them. Their executions must not only gain technical but also social acceptance. In the development of the above management process, the role of the champions and the responsibilities of those who are working with the champions are clarified. The ultimate aim is that the participants can work independently and they can re-group into active members of a newly formed team to carry out the tasks as and when the circumstances ask for them. The new mindset of working is necessary to sustain the momentum of change.

Application System for Replication: It can be difficult to repeat the concept in another company through the implementation of an application system because each company has its own unique settings which can vary widely between companies even within the same industry. A case study highlights the contextual settings of the events to provide an insight into what could go wrong when certain actions are not taken in the situation. This avoids re-inventing the wheels when formulating a technology transfer and assimilation strategy. A case study is relevant for replication by other companies when its contents highlight (1) a preview of state-of-the-art theories relevant in the field (2) an espoused theory for experimentation in the case organization (3) a summary of experiences gained and lessons learnt in the transfer and assimilation process together with the contextual factors and (4) a synthesis from the lessons learnt into a model that can be adapted and validated by another researcher in other reference sites and be quoted for benchmarking.

6. Case Study

6.1. Case background

When a manufacturing company is small and its operations simple, its production management system, be it manual or computer-aided, would operate efficiently. However, when it grows bigger and bigger and its product lines become wider and more complicated in terms of variety and batch size, it will eventually come to a situation that the whole production management system would be very inefficient. The Teaching Company, Wang Sang Bakelite Electrical Manufacturing Company, hereinafter called WSM, was coming to this cross-road. WSM tried to improve its operational efficiency by implementing a company-wide information system program but it failed in 1984 and again in 1986. In the first time they found the software very rigid and lacking in the availability of appropriate data to feed the computers to generate reports. In the second time, they tried to customize the software in-house. While some of the aforesaid problems were solved, more user-related problems were encountered.

Like most manufacturing companies in Hong Kong which moved their production facilities to China and retained their management team in Hong Kong, WSM encountered a lot of difficulties in managing manufacturing operations across the border (i.e., HK/China). WSM was a typical Chinese-based small manufacturing company. It heavily relied on the experience of executives and not the organizational systems (such as policies, regulations & procedures) to plan and control production. This managerial style might be acceptable when the company was small and the market was stable. However, when the business was getting bigger, it became more difficult, or even impossible, to recruit such reliable and experienced executives to run the business. There were strong needs to improve logistical support, reduce the inventory and respond faster to the changes in customer order and so on. Therefore, better production planning, control and co-ordination of operations were required.

In 1989, the management began to re-examine how computerization could help in these circumstances. Most of the operational staff were apprehensive of computerization. Their perception was that computer systems were too inflexible especially when they had to deal with frequent order changes. They expressed their distrust with the excuses "too busy to spare the time to learn the computer systems" and they were "too difficult to use". Fortunately, a few executives who shared our view and believed that was in deed an opportunity rather than a threat for promotion took the initiative and spent time on evaluating "where" the computer systems could help in efficiently managing their daily operations.

6.2. Co-design in IS Development

The participants of a co-design project [2] came from the academia and the executives of the company who contributed funding. A two way transfer of knowledge was facilitated through the creation of a channel amongst participants. The dialogue that followed facilitated communication amongst the executives participating in the co-design of information systems development process. The academics put the theory to test in the company and got feedback from the use of life data. In the context of solving a problem in its natural setting, the company extracted practical knowledge and extracted principles and

theories in exploiting IS/IT for competitive advantage. The management got new insights for channeling funds that gave an impact on practice.

6.3. Evolution of WSM over 6 years

It was recognized that the measurement of effectiveness in technology transfer was necessary to justify the continuation of further collaboration. The transfer and assimilation of IS that embedded a new management philosophy would change the operational behavioral of an organization. It could not be implemented over night and the results could not be seen over a short period of time (say 1 year). A behavioral change should be a continual process. The critical success factor should be managed to keep the momentum of change going year after year. The emphasis should be put into the expansion of champion infrastructure (number of champions) in the organization. The following summarizes a series of IS development projects over the last six years done in the industrial partner organization. The order fulfillment lead time, which was particularly important to an OEM firm, and the change in the physical structure of an organization were used to measure the effectiveness of the IS development projects. The projects implemented in WSM are summarized as IS development projects (also see Figure 5). It is interesting to note the spread in the uses of IS across departmental boundaries over time. The history gives an indication of the expanding user base which also signals the flattening of the organizational structure and the transfer and assimilation of manufacturing information systems for company-wide operations:-

1989/90 Company structure: Functional organization
Warehouse stock status project: Conducted a feasibility study to computerize inventory control procedures at the warehouse. Three Higher Diploma students were involved. The line users came from warehouse and stock allocation. A prototype was developed and ready for testing
Technology transfer (TT) mechanism: ISP (Industrially Sponsored Project) [2] at Higher Diploma students level

1990/91 Company structure: Functional organization
Part number project: Prepared samples of data to test run the inventory prototype. A Degree student was involved. The user group was expanded to include warehouse, stock allocation, purchasing and office administration. Most (over 80%) of the inventory data was captured and clarified
TT mechanism: ISP at BEng students level

1991/92 Company structure: Project team based organization
Inventory control project: Tested the enhanced inventory prototype to improve user interface with live data. Another Degree student and a Postgraduate research student joined. The user group was further expanded to include production and distribution. Various procedures such as stock taking, materials receipt and materials release were introduced to improve the operations effectiveness
TT mechanism: ISP at postgraduate students level

1992/93 Company structure: Project team based organization
Bill of materials project: First Teaching Company Scheme in the company. The teaching company associate conducted a series of procedure review to articulate user requirements for the planning and control of materials for prototyping. Material Requirement List and Picking List were two major reports identified for improving operation efficiency
TT mechanism: TCS at M.Phil level

1993/94 Company structure: Project team based organization
MRP project: Developed and implemented text-based prototypes to generate Material Requirement List and Picking List. User group was then further expanded to include middle managers and not only just line executives. A review on material issue procedure from Hong Kong to China was performed in order to find out a better way to organize production tasks to reduce order fulfillment time
TT mechanism: TCS at M.Phil level

1994/95 Company structure: Time based organization
Product group consolidation project: Restructured the company organization into three autonomous product groups. Used IS to support product groups for rapid information exchange. The remuneration schemes for WSM in Hong Kong was revamped. This cut down the order fulfillment cycle time from 118 days to 78 days on the average. At the end of 1995, another Teaching Company Scheme was initiated. The objective of this scheme was to build a competence in the unit staff to smartly use information system to further reduce the order fulfillment cycle time.
TT mechanism: TCS at M.Phil and Ph.D. level

1995/96 Company structure: Time based organization
SBU support project: Transferred an PolyU in-house developed "Button Technology [7]" to creatively use and extract company-wide information for decision support. The Teaching Company Associate and three Higher Diploma students were involved in developing a shipment scheduling system for company-wide use. One SBU was nominated as a pilot unit to experiment an innovative approach to involve users to rapidly customize an information system. Action learning workshops were held in the company to build a competence of using "Button Technology" for making organizational innovation.
TT mechanism: Mixed TCS and ISP at both postgraduate & undergraduate students level

1996 - Company structure: Exploring the possibility with partners for strategic alliance

Network organization project: Planning was underway to collaborate with material suppliers, IT vendors and other technical associations to co-design an Electronic Ordering System making use of Internet to shorten materials supply chain.

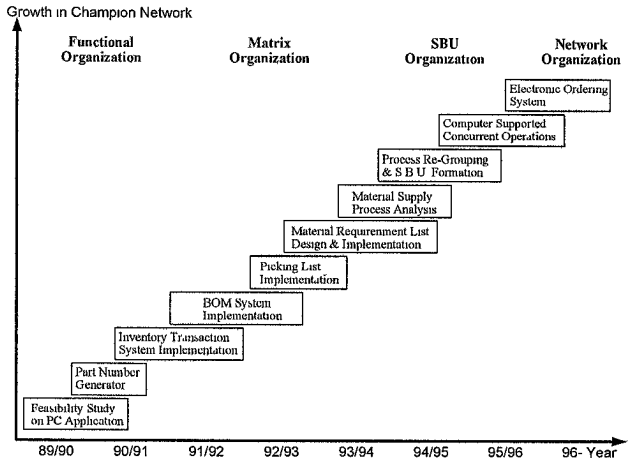

Figure 5. The development of manufacturing information systems to support business growth

7. Discussions

7.1. Implementation issues affect the formulation of an operations strategy

The case study in this paper highlighted the need for preparatory work to be done before computerization. It involved tasks that typically were related to data capture, work simplification and networking staff across functional boundaries in collaborative teamwork. If improperly attended, they could become critical factors that influence the formulation and implementation of an operations strategy.

7.2. Co-design as a new approach in information system development?

It was a challenge to develop and implement information systems that supported a manufacturing operation as it was growing. From a researcher perspective, before specifying an information systems solution, the method used and processes involved in the existing operations should be reviewed for co-design needs. The objective was to turn problems into opportunities for defining the terms of reference of IS development projects. It would be wise to be aware of "what to do" and "where to make the most out of the collaboration". Intuitively, one of the earliest steps was "asking the right question". In the group activities, users, management team and the researcher asked themselves: "Are we solving the right problems?" Answering this kind of question was an innovative endeavor. It was assisted with creativity enhancement techniques such as presentation of a case, chairing a meeting and brainstorming, etc. Diverse areas were examined such as strategy, structure, education, training, incentive.

7.3. IS development project for developing multi-skilled workers?

The transfer and assimilation of technology in the industrial/ academic collaboration context (via Industrially Sponsored Projects /Teaching Company Scheme) would inevitably result in the use of IS with a behavioural change of executives in the case organization. This form of co-operative on-the-job improvements, if successfully cultivated, would sustain the development of a new style of management. This was accompanied by the executives acquiring a competence in developing and using IS smartly for decision support

7.4. Option for SME to formulate their operation strategy?

Specific IT exploitation bears distinct options in the coordination process and in the structuring of production planning and control functions for cross border manufacturing operations. This is consistent with the leading practice of business redesign which is typically expressed in terms of information technology capability. The redesign of repetitive manufacturing by remote control is still evolving and will take years to establish. Repetitive manufacturers, especially those small ones which typically have a relatively weak IT infrastructure, are encouraged to collaborate with the academia and participate in schemes such as ISP/TCS to get implementation results earlier.

8. Conclusion

One does not get an answer to a question that was never asked. If technology (interpreted in a broad sense to include integrated planning and control, management information systems, flexible incentive schemes and so on) was available and not promoted for use in manufacturing, the technology transfer and assimilation process would be a lot slower. This paper advocates the use of Industrially Sponsored Projects / Teaching Company Scheme to articulate the enabling mechanism and the practice at PolyU to assist local companies in implementing manufacturing information systems as a means of formulating and implementing the operations strategy in the case organization and contributes knowledge in

bridging the gap to put the theory of technology transfer into practice.

- Case study research is an appropriate strategy in the study of assimilation of manufacturing information system to streamline operations for continuous improvement
- Enabling mechanism for technology transfer and assimilation is necessary to accelerate SMEs to make organizational innovations.

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