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Developing An Information Technology Learning Model In A Computer-Integrated Manufacturing (CIM) Context

by

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An Abstract of

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This research investigates how manufacturing firms use information technology (IT) effectively in a computer-integrated manufacturing (CIM) context to remain competitive. It presents an IT learning model based on the literature of end-user computing, continuous improvement, and CIM. The model hypothesizes that the effective IT utilization (i.e., used for decision support, work integration, and work planning) enhances the impact on work. The model identifies three induced activities (i.e., process improvement, skill enhancement, and software improvement) as continuous improvement efforts and hypothesizes that an individual's continuous improvement efforts create the effective IT utilization.

The model views three autonomous factors (i.e., learning capacity, learning motivation, and empowerment) as drivers that encourage an individual's continuous improvement efforts. Learning capacity includes systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers. Learning motivation refers to goal clarity, intrinsic motivation, and social norms. Empowerment includes autonomy, self-efficacy, and support.

The measurement instruments for learning drivers and continuous improvement efforts are developed based on an extensive literature review. After a pilot study, a large-scale study with 208 responses across CIM applications examines the relationships between IT learning drivers, continuous improvement efforts, IT utilization, and impact on work. The statistical methods employed include exploratory factor analysis (i.e., SPSS) and structural equation modeling (i.e., LISREL).

The data analysis shows that (1) higher levels of learning capacity lead to greater levels of continuous improvement efforts; (2) greater levels of continuous improvement efforts lead to higher levels of IT utilization; and (3) higher levels of IT utilization lead to higher levels of impact on work. However, results suggest that the paths from learning motivation to continuous improvement efforts and from empowerment to continuous improvement efforts are not significant.

The research examines an alternative model for a better explanation of the unsupported paths. This model hypothesizes that autonomous learning impacts directly on the IT utilization rather than through induced learning. The results indicate that learning in computer-mediated work is largely autonomous. Induced learning at an individual level is not a major contributor to learning in computer-mediated work. The

findings suggest that CIM managers should focus on creating a conducive learning environment rather than pushing individual continuous improvement efforts if they want to make effective utilization of IT.

Key words: Individual learning, Information technology (IT) learning, Effective IT utilization, IT impact, Continuous improvement, Learning drivers, Learning motivation, Empowerment, Computer-integrated manufacturing (CIM)

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Chapter 1: Introduction

Computer-integrated manufacturing (CIM) is an application of information technology in manufacturing (Hannam, 1997; Doll & Vonderembse, 1987; Harrington, 1973). CIM has been widely adopted by many manufacturing and/or engineering-service firms for achieving competitive advantage (Hannam, 1997; Veeramani, Bernardo, Chen, & Gupta, 1995; Thomas & Wainwright, 1994; Doll & Vonderembse, 1987; Jaikumar, 1986; Goldhar & Jelinek, 1985). However, many firms that have adopted CIM technology find that the intended benefits (e.g., productivity gains) from their large investment in CIM do not come out as they expected (Frohlich, 1998; Willcocks & Lester, 1996; Jaikumar, 1986). In a search of the explanations for this so-called productivity paradox, Jaikumar (1986) asserts that the intended competitive advantage of CIM comes from the effective use (i.e., how CIM is used) rather than the extent to which CIM has been adopted and used.

Effective use of information technology (IT) is considered as a major determinant of competitive advantage, productivity, and even personal competency (Doll & Torkzadeh, 1998). CIM is an integration of computer-based information technology with manufacturing processes. Its effective use requires new conceptual skills and a different type of learning and experimentation for its users (Doll & Vonderembse, 1987; 1991; Jaikumar, 1986; Kaplan, 1986; Huber, 1984). CIM is a computer-mediated technology.

Its effective use involves a mutual adaptation between the technology and its user (Weick, 1990; Leonard-Barton, 1988; Zuboff, 1982). The effective use of CIM is an on-going learning process, which demands continuous improvement in manufacturing processes and information technology on the one hand, and demands the individual end-users to continuously enhance their skills and expertise of the technology on the other hand.

The end-user has to continuously learn and/or improve both the manufacturing process and the information technology if one wants to use CIM applications effectively. The individual users of the CIM applications are engineers or specialists in the field (e.g., product design, product engineering, and manufacturing). They have accumulated their field knowledge and expertise for years. However, using CIM applications is different from using the traditional machine technology. For traditional machine technology, when an operator uses a tooling machine for one's work, the operator normally assumes that the working process (i.e., tooling process) and the tool (i.e., tooling machine) are constant. The more the operator runs the tooling machine, the more experience the operator obtains. Thus the operator becomes more proficient in running the tooling machine and produces more products in the same amount of time.

Using CIM for manufacturing tasks is intellectual in nature (Doll & Vonderembse, 1991). Effective use of CIM demands more mental activities than physical movements. Individual engineers build their skills and expertise of both information technology (i.e., CIM software packages) and manufacturing processes, as well as their on-going interactions when the engineers use the CIM application. The accumulated insights and knowledge from the applications are then used to improve the manufacturing processes and the software packages. The improved manufacturing processes and the enhanced packages in turn help the engineers obtain deeper insights into the software packages. The insights enhance the application of the software packages to more tasks. This cycle (i.e., mutual adaptation process) is characterized as plan-do-check-act (PDCA) cycle for improvement activities in continuous improvement literature (Deming, 1982). As the cycle goes on, the engineers continuously enhance their knowledge and expertise on the CIM application and then use the application more effectively. In other words, the effective use of CIM requires continuous improvement efforts and is an on-going learning process (i.e., mutual adaptation) (Doll & Torkzadeh, 1998; Weick, 1990; Leonard-Barton, 1988).

Learning is a fundamental requirement for a firm's sustainable existence in a rapid changing and dynamic environment (Garvin, 1993; Kim, 1993; Senge, 1990). A firm learns through its individual members. If a firm wants to build its core competence and competitive advantage on CIM, then the firm needs to understand how its engineers make effective use of the adopted technology. In order to use the technology effectively, the engineers or the specialists have to continuously learn the features of the CIM software packages and, whenever necessary, make changes, or the suggestions for changes, to let the software fit the manufacturing tasks better. Otherwise, as Dreyfus and Dreyfus (1986) note, if an end-user (i.e., an engineer) acquires an initial level of expertise but never develops past the beginner's phase, then the user can never make full use of the technology. Making full use of CIM software packages demands the engineer to conduct a series of improvement activities to make the work more productive.

Learning is a nature of human beings. However, management has discovered that people frequently resist the changes that must be made to alter reality (Schein, 1993; Senge, 1990; Beatty & Gordon, 1988). Making changes requires an endeavor that an engineer considers worthy of one's fullest commitment. The endeavor of continuous improvement does not come out naturally; it has to be motivated and maintained through certain driving forces. The challenge that is facing many CIM managers is what are the CIM learning drivers that can enhance the continuous improvement efforts of the individual engineers.

Variables such as cognitive style (Sadler-Smith & Badger, 1998), creative vision (Senge, 1990), and autonomy (Pintrich & Schunk, 1996) have been suggested as learning drivers or antecedents in strategic management, learning, and education literature. The identification of the variables facilitates the exploration of the relationship between the learning drivers and the behavioral outcomes (e.g., continuous improvement efforts) in information technology and the manufacturing context.

MIS literature has proposed several models for evaluating system success. Davis (1986) develops a technology acceptance model (TAM), which uses end-users' perception to predict usage behaviors. Cooper and Zmud (1990) propose an information technology innovation process model, which identifies initiation, adoption, adaptation, routine use, and full use phases for an IT innovation process. They argue that the full use stage represents a different phenomenon from acceptance or routine use. Doll and Torkzadeh (1998) have described a system-to-value chain, which includes causal factors, beliefs, attitude, behaviors (i.e., effective use), impact on work at individual level, and organizational impact. These models highlight the key elements in evaluating IT implementation success and suggest that while the effective use and the impact on work measure the outcomes of IT implementation, a full picture of the IT success also needs an understanding of its learning process and its individual user's learning drivers.

An information technology (IT) learning model is therefore developed to examine how individual engineers learn and make effective use of CIM applications. Building on the existing work in IT utilization and impact on work, the model identifies 1) continuous improvement efforts that lead to the effective use and impact of IT and 2) the learning drivers (i.e., antecedents) that encourage the individuals' continuous improvement efforts. Working in the CIM context, the research first develops and adapts measurement instruments for the model and then investigates the relationships between the learning drivers, continuous improvement efforts, IT utilization, and the impact on work. The research question for the dissertation is: In computer-integrated manufacturing (CIM), how can management create a continuous learning environment where individuals enhance their skills in using the technology and/or implement modifications of CIM applications to improve the impact of CIM on their work?

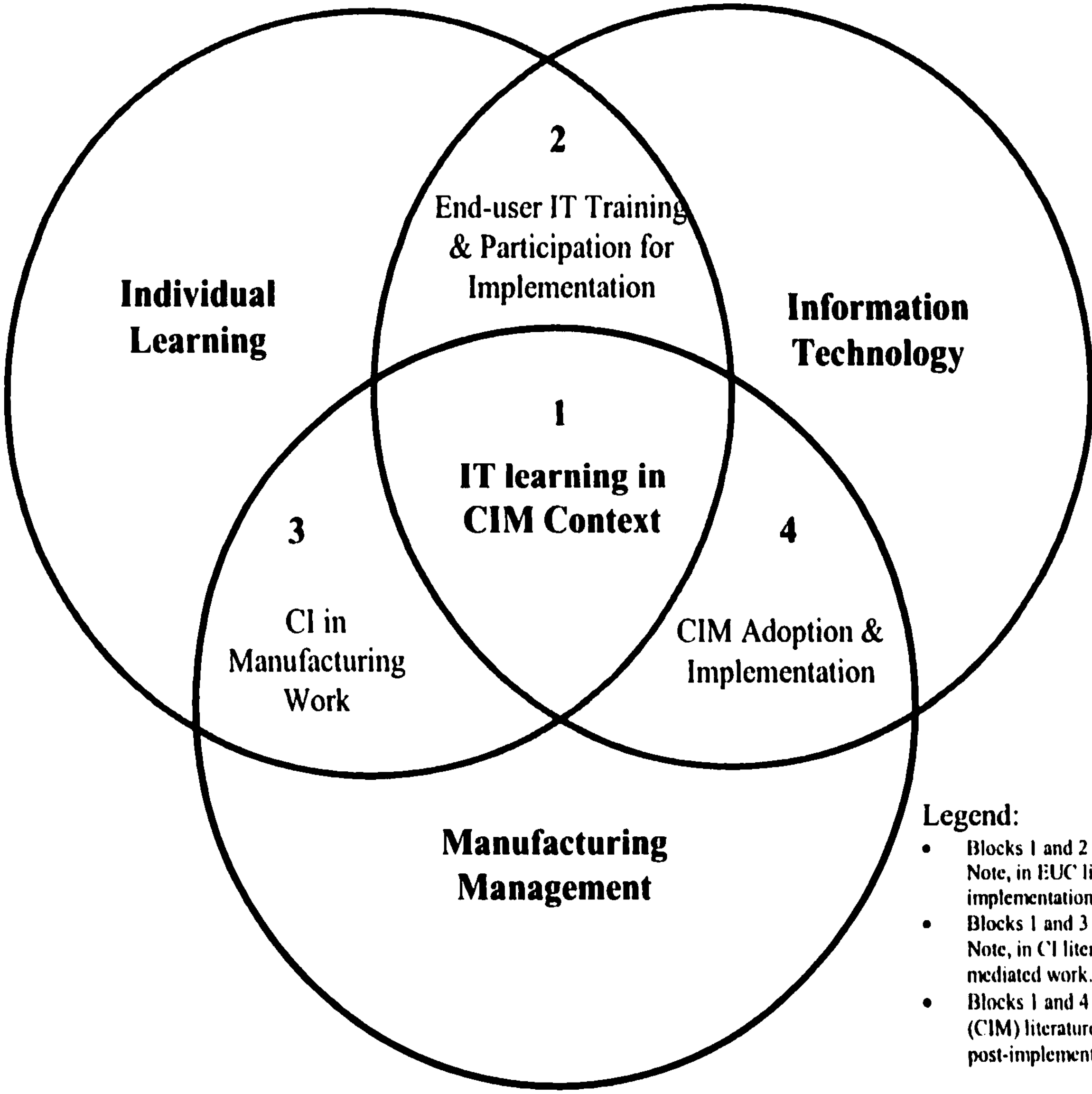
Chapter 2: Information Technology Learning in a CIM Context

The concept of IT learning in a CIM context is broadly based on individual learning, information technology, and manufacturing management literature (see Figure 2.1). The overlaps of these three research streams represent different research focuses. End-user computing (EUC) can be viewed as the combination of individual learning and information technology literature (i.e., blocks 1 and 2 in Figure 2.1). In the process of implementing IT, an end-user actively participates in the development of an IT system and then gets trained on how to use the resultant IT system. After the system has been adopted, the end-user has to continuously learn additional features of the system and apply them to work. The two blocks are labeled as end-user IT training and participation for implementation (i.e. block 2) and IT learning in CIM context (i.e., block 1). In EUC literature, block 1 is also referred to as post implementation IT learning.

The studies in continuous improvement (CI) are based on manufacturing management and individual learning literature (i.e., blocks 1 and 3 in Figure 2.1). The studies focus on how to produce quality products through the never-ending efforts to improve working processes, operators' skill proficiency, and equipment.

Most CI studies face two types of technologies: traditional machine technology and computer-mediated technology (e.g., CIM). Improving computer-mediated technology may require a different type of learning and experimentation for its individual users. The continuous improvement efforts can thus focus on machine technology or

Figure 2.1. Literature on Information Technology Learning in a Computer-Integrated Manufacturing (CIM) Context



Legend:

- Blocks 1 and 2 refer to end-user computing (EUC) literature. Note, in EUC literature, block 1 is referred to as post-implementation IT learning.
- Blocks 1 and 3 refer to continuous improvement (CI) literature. Note, in CI literature, block 1 is referred to as CI in computer-mediated work.
- Blocks 1 and 4 refer to computer-integrated manufacturing (CIM) literature. Note, in CIM literature, block 1 is referred to as post-implementation CIM learning.

information technology. These two categories are labeled as CI in manufacturing (i.e., non-computer mediated) work (i.e., block 3) and IT learning in a CIM context (i.e., block 1). CI literature refers to block 1 as CI in computer-mediated work.

Computer-integrated manufacturing (CIM) is the application of information technology in manufacturing (see blocks 1 and 4 in Figure 2.1). After a manufacturing firm adopts and implements CIM technology, its individual users have to learn how to use the technology effectively. This research labels the stages as CIM adoption and implementation (i.e., block 4) and IT learning in a CIM context (i.e., block 1). Block 1 is referred to as post-implementation CIM learning in CIM literature.

The overlap of end-user computing, continuous improvement, and CIM represents IT learning in a CIM context (see block 1 in Figure 2.1). While the block is described differently in different research streams, this research views it as post implementation IT learning in a CIM context, or IT learning in CIM, to reflect the common elements of the three research streams. Chapter 2 is arranged as follows. First, sections 2.1 thru 2.3 review the literature on EUC, CI, and CIM. Then, section 2.4 describes the IT learning in a CIM context. Next, section 2.5 discusses each variable specified in the model. And finally section 2.6 posits the hypothesis to be empirically examined in this research.

2.1. End-User Computing (EUC)

End-user computing (EUC) is one of the most significant phenomena in the information systems industry (Benson, 1983; Doll & Torkzadeh, 1988). In end-user computing, individuals who utilize the system output for decision-making also participate in the system development (Martin, 1982; McLean, 1979; Rockart & Flannery, 1983;

Doll & Torkzadeh, 1988). In their IT innovation process model (see the first three columns in Table 2.1), Cooper and Zmud (1990) identify six stages for technology innovation process: initiation, adoption, adaptation, acceptance, routine use, and infusion. Doll and Torkzadeh (1995) develop the effectiveness criteria for each stage (see the fourth column in Table 2.1). For example, end-user satisfaction is proposed to measure the effectiveness of the IT acceptance; and quantity use of the IT is viewed as a good measure of the effectiveness for routine use. For the infusion stage, the effective use or the usage patterns is a more appropriate criterion for the effectiveness measure.

In end-user computing, an end-user is broadly advocated to participate in the system development activities (Igbaria, 1990; Doll & Torkzadeh, 1989). Frohlich (1998) notes that the key players are different for different stages (see the fifth column in Table 2.1). Top management takes a leading role at the initiation stage. Project teams then take charge of at the adoption and adaptation stages. The teams involve end-users in the development activities and train the users whenever necessary.

However, for the acceptance, routine use, and infusion stages the key players are individual end-users. The end-users have to learn and make effective use of the technology to realize the full potential of the technology. They have to assume more responsibilities for the utilization of the installed system than they used to. System analysts, programmers, and operations staff are less directly involved in user support (Doll & Torkzadeh, 1989).

Table 2.1. The Information Technology (IT) Innovation Process Model with the Effectiveness Criteria and Key Players

Stage	Process	Product	Effectiveness Criteria	Key Players
Initiation	Scanning organizational problems and IT opportunities	Match between IT solution and its application in the organization	Cost-benefit and social impact	Top Management
Adoption	Rational and political negotiations to get political support	Decision to invest resources to implement	Decision to implement (yes or no)	Project Team
Adaptation	Application is developed and modified to meet user needs	Application is available for use	Developmental progress as measured by user acceptance, perceived usefulness, and ease of use	
Acceptance	Users are persuaded to use the application	IT application is operational	Use and user satisfaction	End-users
Routine Use	Usage of application becomes a normal activity	Standard operational procedures govern application use	Quantity of use in terms of frequency, hours, etc.	
Infusion (Full Use)	Users continue to grow in the skill and knowledge required to make full use of the application	IT application is used within the organization to its fullest potential	Usage pattern or the extent of perceived impacts in an organizational context	

Source: Cooper & Zmud, 1990; Doll & Torkzadeh, 1995; Frohlich, 1998

2.1.1. End-User IT Training and Participation for Implementation

Literature in end-user computing (EUC) suggests that training and participation are important for a successful implementation of IT. For example, user participation (Barki & Hartwick, 1994; Doll & Torkzadeh, 1989; Ives & Olson, 1984) and end-user training (Igbaria, 1990; Torkzadeh & Dawyer, 1994) are posited and empirically supported as the determinants of IT success. While other variables such as perceived usefulness and ease of use (Davis, 1989), perceived enjoyment, social pressure or norms, skills (Igbaria, Parasuraman, & Baroudi, 1996), and computer anxiety (Igbaria & Iivari, 1995; Compeau & Higgins, 1995[a]) are also proposed as the antecedents that affect the success of an information system, they are affected by end-user participation and training.

Literature in EUC has investigated how to measure the success or effectiveness of an information system. End-user satisfaction (Doll & Torkzadeh, 1991; Melone, 1990; Doll & Torkzadeh, 1989), IT adoption (Straub, Limayem, & Karahanna-Evaristo, 1995; Davis 1989) and diffusion (Moore & Benbasat, 1991; Ruppel and Howard, 1998; Harrington & Ruppel, 1999), effective IT use (Doll & Torkzadeh, 1998; Robey, 1979; Lucas, 1975), and the impact on work (Torkzadeh & Doll, 1999; Guimaraes, Gupta, & Rainer, 1999; Sethi & King, 1994; Igbaria, 1990) are recommended as candidate measures of information systems success. The literature has also developed valid and reliable measurement instruments for these criteria.

2.1.2. Post-Implementation IT Learning

While participation and formal training are important for IT implementation, on-the-job learning is more important for post-implementation activities. In end-user computing, individual users assume more freedom and power than they did previously in how to use the IT applications for their work (Doll & Torkzadeh, 1989). From a beginner to an expert, an end-user interacts directly with the application for one's work. The user has to continuously learn how to use the software package for tasks. He/she learns by mastering additional features of a software package and then applying them (i.e., both the known and the newly learned features) to different problems. With one's technical expertise, the user improves either the working process or the software package or both to make the work more productive. As the engineer (i.e., the user) uses a software tool for a manufacturing task, a PDCA cycle happens at an individual level (Deming, 1986). A completed PDCA cycle means that learning occurs. Making effective use of IT involves many learning cycles and activities.

End-user learning determines whether or not a firm can realize its IT potentials. While the learning at the end-user level is not equal to that at the organizational level, organizations learn through their individual members (Kim, 1993; Senge, 1990). Kim (1993) uses an observe-assess-design-implement (OADI) cycle to describe the individual learning activities. This cycle is similar to the PDCA cycle. According to Kim, the end-user learns by completing each OADI learning cycle. In each cycle, the user's actions (e.g., improvement efforts) are observable learning behaviors. The learning (e.g., new insights from the improvement efforts), in turn, reinforces or modifies the user's cognitive learning, which may trigger the next learning cycle (March & Olsen, 1975).

Several research models are available for predicting IT success. Based on Fishbein and Ajzen's (1975) theory of reasoned action (TRA), Davis (1986) introduces the technology acceptance model (TAM) that uses two specific beliefs (i.e., perceived usefulness and ease of use) to predict information system usage. Taylor and Todd (1995) compare TAM with two variations of the theory of planned behavior (TPB) (Ajzen, 1985; 1991) for explaining the behavioral intention of end-users. Igbaria et al. (1996) propose a motivational model that uses skills, organizational support, organizational use, social pressure, perceived complexity, usefulness, and enjoyment to predict the microcomputer usage.

In these models, system use is viewed as a dependent variable – a success measure. Doll and Torkzadeh (1991) describe a "system-to-value chain" of system success constructs from causal factors to beliefs, attitude, performance-related behavior, the impact on work at an individual level, and organizational impact (see Figure 2.2). Like the other models, the system-to-value chain views that the upstream antecedents (i.e., beliefs and attitude) predict the system use. Unlike other models, the system-to-value chain suggests that system use explains its downstream impacts of IT. While the models have not explicitly included individual learning behaviors, they provide excellent suggestions for how the end-user learning may affect the system success.

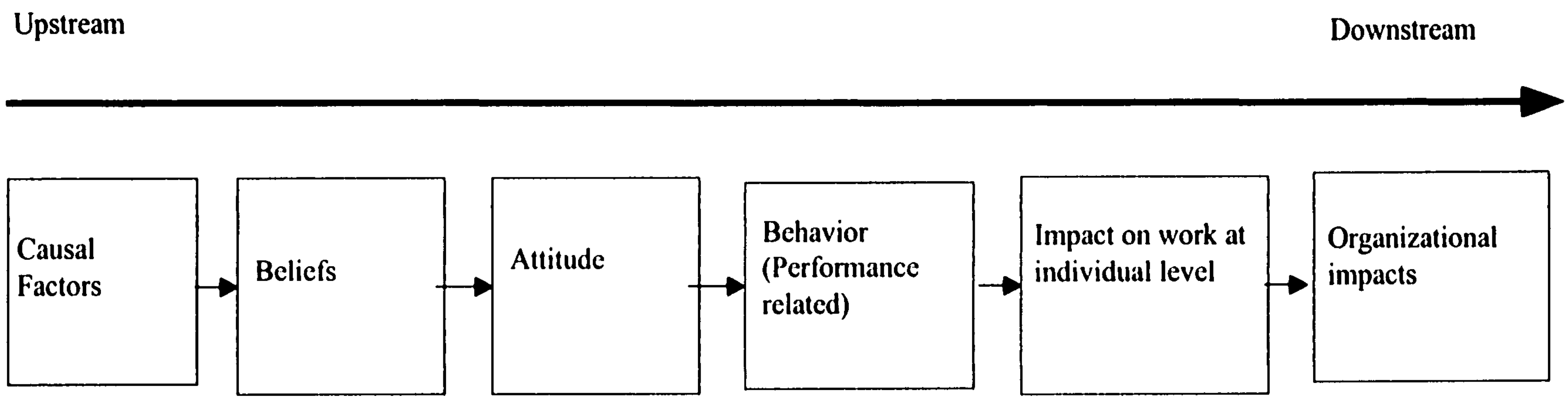
2.2. Continuous Improvement (CI)

Continuous improvement refers to the on-going activities of an individual to pursue incremental and innovative improvements of one's work processes, products, and services (Anderson, Rungtusanatham, & Schroeder, 1994; Deming, 1986; Imai, 1986). It has become an imperative for firms in seeking to raise productivity, boost quality, and enhance competitive advantage (Keating, Oliva, Repenning, Rockart, & Sterman, 1999; Choi & Liker, 1995). CI assumes that routines and standard operating procedures have to be continuously modified to fit the changing environment. Deming (1982; 1986) illustrates how individuals or working groups in a firm can continuously reduce the variation and increase the quality in its processes, products, and services through endless repetitions of plan-do-check-act cycles.

The concept of CI is related to learning curve (Bailey, 1989; Abernathy & Wayne, 1974), progress function, and experience curve. Progress function refers to the phenomenon that a firm can continuously improve its input-output productivity ratios as a consequence of a growing stock of knowledge (Dutton, Thomas, & Butler, 1984; Conway & Schultz, 1959). While some scholars use learning curve, progress function, and experience curve interchangeably, Dutton and Thomas (1984) distinguish the concepts by the type of improvement and unit of analysis. Learning curves are used most commonly to describe labor learning at the level of an individual employee or a production process, such as an assembly line. Progress functions describe changes in materials inputs, process or product technologies, or managerial technologies from the level of a process to the level of a firm. Experience curves, though sometimes used at a firm level, are often used to describe progress at an industry level.

Similar to CI, these three curves focus on incremental changes over time. Different from CI where improvements are focused on methods and processes (Imai, 1986) through both learning-by-planning and learning-by-doing, the three curves emphasize the skill enhancement through learning-by-doing (Yelle, 1979; Sahal, 1979; Conway & Schultz, 1959).

Figure 2.2. The System-to-Value Chain



Source: Doll & Torkzadeh (1991; 1998)

2.2.1. Continuous Improvement (CI) in Manufacturing Work

Continuous improvement in traditional manufacturing work normally assumes the constancy of the tool (e.g., machine equipment or application software) used for work (Shingo & Robinson, 1988; Imai, 1986). Introducing new equipment is viewed as an innovation and thus goes beyond many researchers' scope. The premise for continuous improvement is that the operations of a machine do not vary (Gharajedaghi & Ackoff, 1984). Therefore, improvement activities concentrate on the improvement of working processes and methods. For example, a simple CI program may be labeling all tools and putting them in labeled categories. By having the procedure of managing the tools in order, individual workers may learn how to use the tools effectively.

Continuous improvement captures both learning-by-doing and learning-by-planning effects. By consistently experimenting, a worker can enhance his/her skills, thus improving the work performance. This improvement is viewed as individual learning curve caused by learning-by-doing (Zangwill & Kantor, 1998; Hackman & Wageman, 1995; Ghemawat, 1985; Mazur & Hastie, 1978).

2.2.2. Continuous Improvement (CI) in Computer-Mediated Work

As manufacturing firms adopt more computer-mediated (i.e., IT-based) technologies such as CIM technologies for product design, product engineering, and manufacturing, the nature of the work becomes more intellectually oriented (Doll & Vonderembse, 1991; Zuboff, 1988). When the nature of the work becomes intellectually intensive due to the wide acceptance of IT-based applications, observed physical behaviors are less indicative of how well individual end-users use the applications

(Weick, 1990). For effective use of CIM, users involve more mental activities than physical movements. Their mental models (Zuboff, 1982) – people's internal pictures of how the world works (Senge, 1990) – are continuously revised and changed as the technology improvement and learning processes go on. The mental models affect how people behave/operate in a specific environment (e.g., use of CIM technology) (Kim, 1993).

Individual learning curve describes the situation where the time to complete a task decreases as the number of repetitions of the work increases (see chart a in Figure 2.3). Applying the concept to IT situation, one can use the curve to describe the situation where the utilization of IT becomes more effective as an individual spends a longer time (i.e., hours) using the technology (see chart b in Figure 2.3). However, learning or continuous improvement in computer-mediated work involves the improvement activities on the working process, an individual's expertise, and information technology (i.e., CIM).

These improvement efforts accelerate the individual learning by shifting the individual's learning curve to a new level (see the dashed curve on chart b of Figure 2.3). In traditional manufacturing work, changing or modifying the functions of a machine usually goes beyond an operator's responsibilities and abilities. But a CIM user has to serve both as "an operator" and as a designer of the computer software package. Improving the functionality of the software package provides another opportunity to observe the shifting effects between learning curves.

2.3. Computer-Integrated Manufacturing (CIM)

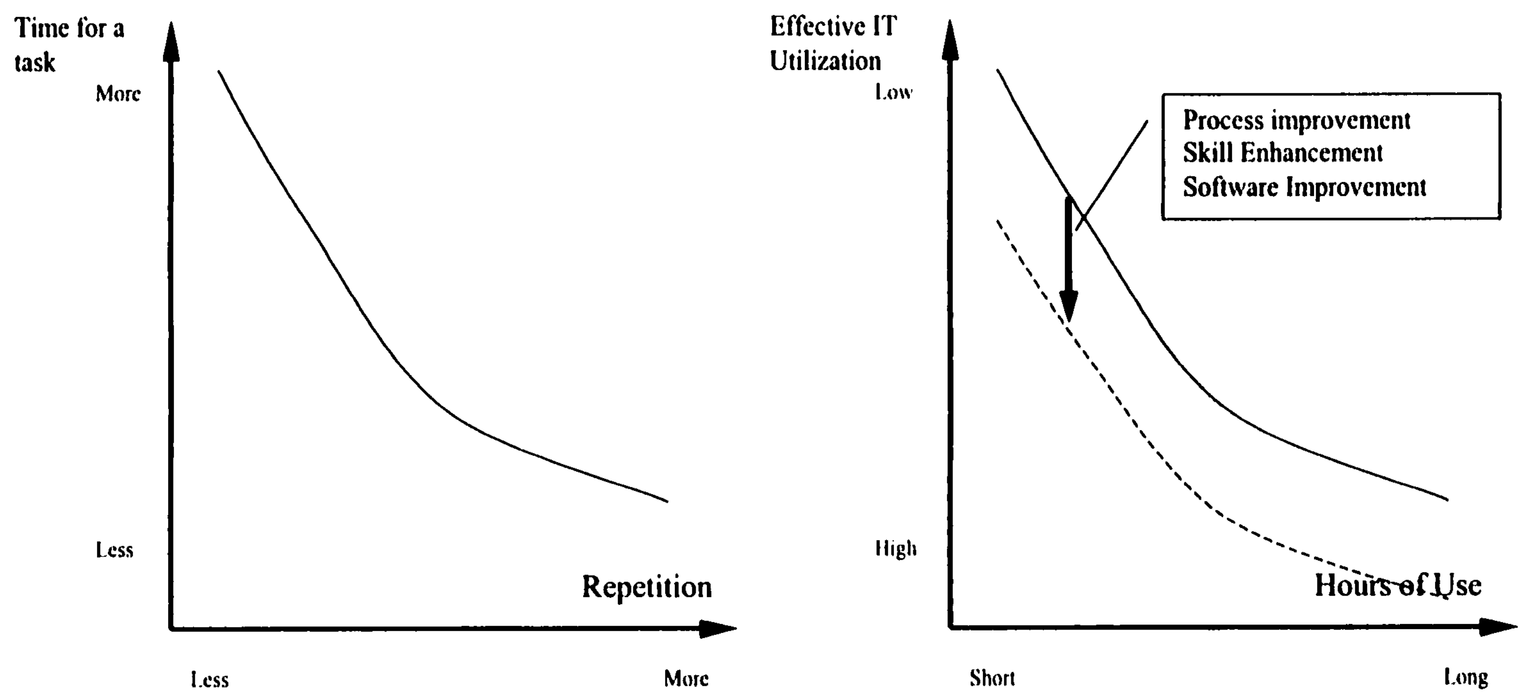
Computer-integrated manufacturing (CIM) is the application of information technology to manufacturing processes that include product design, product engineering, production planning, and manufacturing (Hannam, 1997; Veeramani, Bernardo, Chen, & Gupta, 1995; Doll & Vonderembse, 1987; Harrington, 1973). The wide acceptance of the technology is evident from the extent to which computer-aided design (CAD) systems, computer-aided manufacturing (CAM) systems, computer-aided engineering (CAE) systems, computer numerically controlled (CNC) machines, flexible manufacturing systems (FMS), cellular manufacturing (CM) systems, group technology (GT), computer-aided process planning (CAPP), automated materials handling and automated guided vehicles (AGVS), automated storage and retrieval (AS/RS), robotics, just-in-time (JIT), manufacturing resource planning (MRP II), simulation, and enterprise resource planning (ERP) are being used in industry.

In the environment of rapid market change, increasing complexity, and declining possibilities to achieve economies of scale, many manufacturing firms have adopted CIM technologies as a means to achieve competitive advantage. For example, some intelligent CAD/CAM systems are capable of evaluating CAD models of a part or a product from a variety of perspectives such as manufacturability and cost and automatically generating process plans for manufacturing the product (Veeramani et al., 1995). By performing various analyses such as design-for-assembly, design-for-manufacturability, and design-for-reliability on the CAD model, the software can help firms address a number of downstream issues at the design stage and make necessary modifications to the product design to minimize potential problems. This early detection of the downstream problems

Figure 2.3. An Individual Learning Curve

a. Typical Learning Curve

b. IT Learning Curve



increases the quality of the product and reduces the product development life cycle, thus enabling the firms to respond quickly to market changes.

In another case, flexible manufacturing systems (FMSs) enable the firms to quickly and easily change to produce different products with the same equipment. When integrated with CAD systems, the FMS can increase opportunities to achieve economies of scope (Doll & Vonderembse, 1987; Goldhar & Jelinek, 1985).

2.3.1. CIM Adoption and Implementation

Similar to the adoption of IT in office work, many CIM adopters are perplexed with the IT productivity paradox – they put large investment in the technologies but receive less benefit gains (Ragowski, 1998; Willcocks & Lester, 1996; Gupta, 1994; Jaikumar, 1986). CIM literature addresses the productivity paradox from investment justification and CIM implementation perspectives. Researchers on investment justification stream believe that the paradox comes from the nature of the benefits from CIM. The benefits directly offered by CIM are intangible and difficult to quantify. Thus, the researchers focus their studies on developing readily accessible and acceptable techniques for appraising the benefits of CIM (Slagmulder, Bruggeman, & van Wassenhove, 1995; Small & Chen, 1995; Parsaei & Wilhelm, 1989; Kaplan, 1986).

Researchers on CIM implementation suggest that the paradox comes from the ways that the technology has been implemented. CIM is a computer-mediated technology, and its implementation differs from that of traditional machine technology. Those researchers speculate that many CIM implementation strategies are limited in scope and focus on specific areas and functions within the firms (Veeramani et al., 1995;

Chen & Small, 1994). Thus, they concentrate their studies on identifying appropriate methodologies for a successful implementation of the technology (Gupta, 1996; Shirinzadeh, 1996; Rowlinson, Procter, & Hassard, 1994; Doll & Vonderembse, 1987; Jaikumar, 1986; Boer, Hill, & Krabbendam, 1990).

Doll and Vonderembse (1987) propose a content-oriented conceptual framework that integrates the variables such as environmental threats and opportunities, CIM capabilities, information systems development strategies, and related marketing, manufacturing, and organizational design to investigate how to achieve competitive advantage through CIM. The framework provides a solid foundation for further investigating how individual CIM users learn and make effective use of the technology and how CIM impacts the users' work.

2.3.2. Post-Implementation CIM Learning

Individual users of CIM applications are key players in post-implementation for manufacturing firms to achieve competitive advantage through CIM technology. Their effective use of the technology is a prerequisite for the effective and proper management of the CIM innovation. Zuboff (1982) suggests that information technology (e.g., CIM) cannot be treated as a simple extension of the traditional machine technology, the individual users of the computer-mediated technology need to continuously improve their on-the-job skills to master the technology and seize the opportunities. Effective utilization of IT depends upon the knowledge and authority that the engineers or specialists have in the service of complex tasks (Weick, 1990; Doll & Vonderembse, 1987). It requires individual users' commitment and learning (Doll & Vonderembse, 1991; Kaplan, 1986; Zuboff, 1982).

While the insights are created from IT in general, they are applicable to CIM context and can be organized in a model to guide the CIM research. The implied relationships between an individual's knowledge and authority on the usage of the technology, continuous improvement efforts on the job, technology utilization, and its impact have implications for CIM managers.

2.4. Information Technology Learning in a CIM Context

IT learning in CIM context is a complex phenomenon that reflects the combination and interaction of post-implementation IT learning, continuous improvement (CI) in computer-mediated work, and post-implementation CIM learning (i.e., block 1 in Figure 2.1). Different research streams may approach the phenomenon differently.

For post-implementation IT learning, end-user computing literature focuses on the outcome measures of IT learning such as effective IT utilization and impact on work (Doll & Torkzadeh, 1998; Torkzadeh & Doll, 1999). For a successful implementation of information technology, the literature also identifies some motivational antecedents like prior experience, perceived enjoyment, and support (Igbaria, Guimaraes, & Davis, 1995; Igbaria et al., 1996).

For computer-mediated work, CI literature emphasizes on the observable learning behaviors (i.e. continuous improvement efforts) of each plan-do-check-act (PDCA) cycle and investigates how these efforts help use information technology effectively. The literature also suggests the importance of a learning environment (i.e., antecedents) like management support, self-managing working groups, and goal attainment.

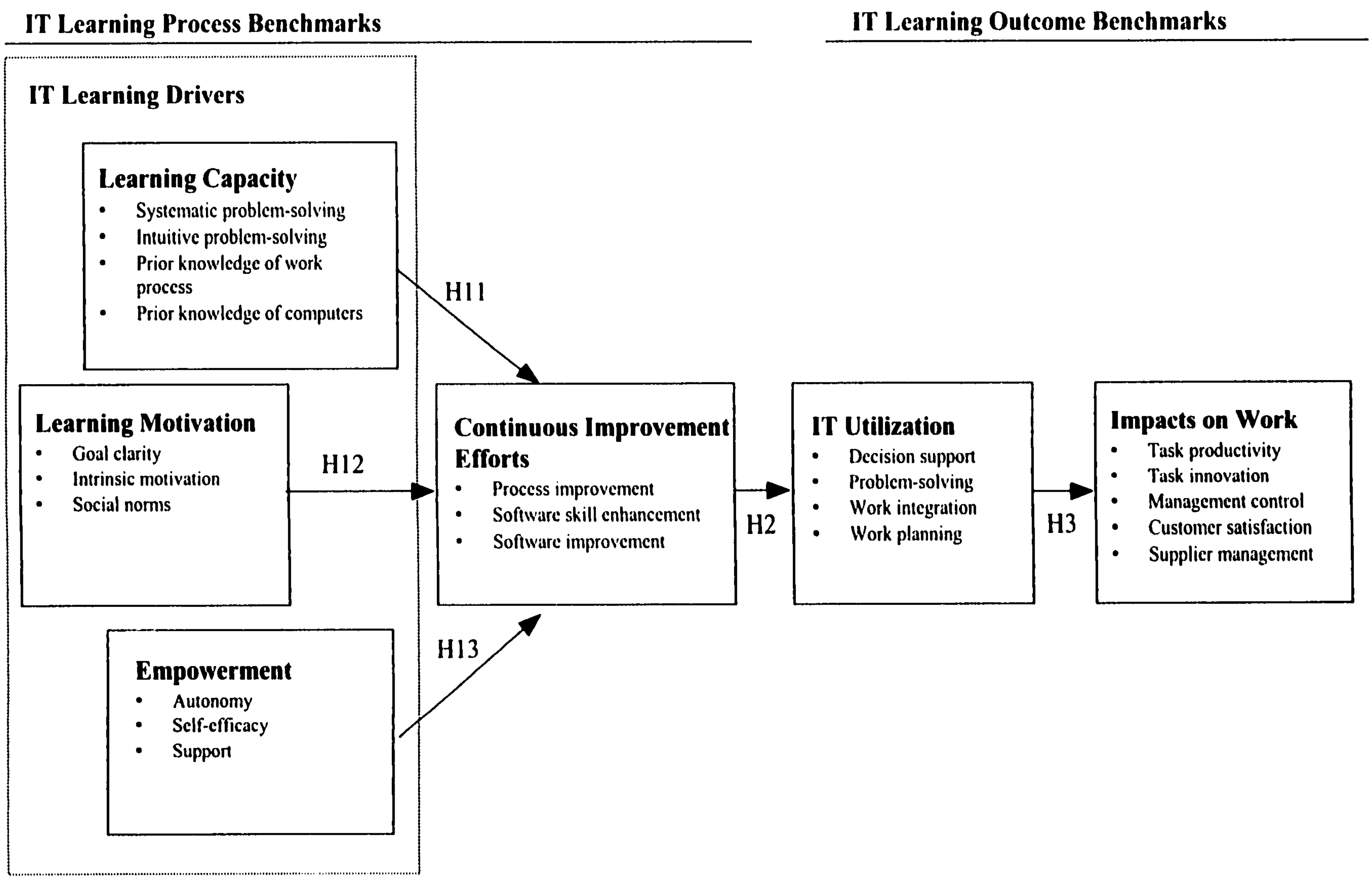
Learning CIM in post-implementation is a mutual adaptation process where an individual user continuously uses and modifies the technology. Like CI literature, CIM literature indicates the importance of building a conducive working environment to facilitate the implementation of the technology.

This research views IT learning in a CIM context as a complex phenomenon and approaches it by integrating the elements from different research streams and organizing them along a cause-effect chain that includes antecedents, behaviors, and outcomes. The antecedents, behaviors, and outcomes are conceptualized as learning drivers, continuous improvement efforts, and effective IT utilization and impact on work respectively. The research model to be presented next describes each component and their relationships in detail.

2.5. Research Model

An IT learning model is proposed to investigate the effective use and impact of IT in a CIM context (see Figure 2.4). The focus of the model is the overlap of end-user computing, continuous improvement, and CIM (see block 1 in Figure 2.1). First, the model hypothesizes that the IT (i.e., CIM) utilization generates impact on an individual's work. Doll and Torkzadeh (1991; 1998) describe a similar link between effective use (i.e., performance-related behavior) and IT's impact on an individual's work in the system-to-value chain. The impact refers to the influence of IT on the perceived performance of the individual. Without using the technology, an individual cannot

Figure 2.4. IT Learning Model in a CIM Context



describe how it shapes the nature of one's work and how it impacts on one's task performance.

EUC literature agrees that research is incomplete if the research identifies the determinants of IT acceptance or usage but ignores the consequence of the acceptance or usage (Torkzadeh & Doll, 1999; Joshi & Lauer, 1998; Igbaria & Tan, 1997; Ryker & Nath, 1995). Firms can deploy IT more effectively if they understand how the acceptance or usage of IT creates measurable values for the firms. While different empirical studies indicate that IT has effects on the nature of office work, job satisfaction (Ryder & Nath, 1995; Millman & Hartwick, 1987), and the quality of social and work life of the office worker (Joshi & Lauer, 1998; Coates, 1991), Igbaria and Tan (1997) have empirically examined the direct relationship between IT usage and its impact on individuals. They find that IT usage is positively related to individual impact.

Second, the model views that the effective IT utilization is caused by the individual user's continuous improvement efforts. This is different from the system-to-value chain and TAM, where effective IT utilization is viewed as directly caused by the user's attitudes to IT. In general, to be successful in the rapidly changing environment, a firm must learn how to adapt to it (Argyris, 1991). It must constantly build and refresh its individual areas of expertise and get its ever-changing mix of disciplines to work together in an ever-changing way (Leonard-Barton, Bowen, Clark, Holloway, & Wheelwright, 1994).

When the insight is applied to CIM context, it suggests that an engineer (i.e., end-user) has to constantly learn and refresh one's knowledge on a CIM application if the engineer wants to make effective use of the CIM technology. In fact, manufacturing tasks are changing everyday due to the demanding requirements of customers; and CIM software packages are improving constantly. In this situation, Seeley and Targett (1999) find that if a user cannot keep up with the advances of the process technology and the IT technology, then he/she suffers a severe skill loss. Similarly, Dreyfus and Dreyfus (1986) have observed that many end-users may develop their expertise to a level close to an expert, but then for some reason they do not make full use of that expertise and unfortunately regress to being a beginner.

CI literature also indicates that performance gains depend on the learning and continuous improvement efforts of an individual (Anderson, Rungtusanatham, & Schroeder, 1994; Spencer, 1994). While no empirical supports are available for the link, both the observations in IT literature and the theories in learning and continuous improvement indicate that the effective utilization of information technology (i.e., CIM) depends on the continuous improvement efforts (i.e., process improvement, skill enhancement, and software enhancement) of individual users.

Third, the model posits that the drivers for the continuous improvement efforts are learning capacity, learning motivation, and empowerment. Cognitive style (e.g., problem-solving style) is widely recognized as an important determinant of individual learning behavior (e.g., continuous improvement efforts) (Edmondson, 1999; Sadler-Smith & Badger, 1998). The style may be thought of as an individual's capacity of organizing and processing information. Streufert and Nogami (1992) speculate on why some people continuously perform on a high level even when transferred between jobs or tasks, whereas others (of equal levels of intelligence, experience, and training) who perform satisfactorily in one job setting fail to perform well when transferred to a different setting.

They suggest that one reason for the perplexing difference in performance may be the individual's inherent way of organizing and processing information, that is, his or her cognitive style.

Motivation is another well-accepted determinant that leads to learning and enhanced performance (Pintrich & Schunk, 1996). It is critical for sustain actions such as continuous improvement. Senge (1990) uses a "creative tension" concept to address the idea of how to generate the energy for continuous improvement (i.e., generative learning). The energy normally comes with vision and an understanding of the current situation. In CI literature, goal setting and empowerment/autonomy are viewed as key factors that facilitate continuous improvement efforts (Hackman & Wageman, 1995; Spencer, 1994; Deming, 1986). With a clear goal, empowered employees in CI project teams can search opportunities that the team members believe worth improving. The teams then follow PDCA cycle to verify or modify the methods or approaches to conduct the work.

Although the anecdotes, stories, and examples of the relationship between learning drivers and continuous improvement efforts are abundant in education, learning, and CI literatures, empirical studies of the relationship are limited. While alternative conceptualizations of learning drivers may exist, the IT learning model conceptualizes that the learning drivers include learning capacity, learning motivation, and empowerment. This classification is consistent with that of the antecedents for enhancing a user's propensity to innovate in IT (Nambisan, Agarwal, & Tanniru, 1999).

Nambisan, Agarwal, and Tanniru (1999) posit that technology cognizance, intention to explore, and ability to explore are three key antecedents to enhance user innovation in IT. Technology cognizance refers to a user's knowledge about information technology. It is similar to learning capacity at an individual level in that both concepts deal with a user's existing knowledge and expertise of a technology or an application. Intention to explore is a user's purpose and motivation to innovate based on the perceived business-related benefits to be derived from the IT deployment. The essence of both intention to explore and learning motivation is the same, that is, the motivation to make any changes believed to bring positive results. Ability to explore refers to a user's perceived competence in marshaling the cognitive and physical resources required for technology exploration. In the individual learning context, empowerment is used instead to convey the same idea as ability to explore. Empowerment refers to a user's perceived autonomy, self-efficacy, and support for continuous improvement efforts.

While technology cognizance, intention to explore, and ability to explore are the key antecedents to enhance user innovation in IT, it is plausible to hypothesize that learning capacity, learning motivation, and empowerment are major drivers of an individual's continuous improvement efforts.

Overall, the IT learning model is based on the system-to-value chain and TRA that are widely accepted and tested in end-user computing context. However, the model adapts continuous improvement concept from CI literature to end-user CIM usage context. The model identifies three specific learning antecedents (i.e., learning capacity, learning motivation, and empowerment) that drive the continuous improvement behaviors. It integrates IT learning antecedents and IT's impact on work, providing a comprehensive view of how to learn and make effective use of IT. Sections 2.5.1 thru 2.5.4 review each variable in the model and section 2.6 posits the hypotheses derived.

2.5.1. IT Learning Drivers

Literature on organizational learning, CI, organization effectiveness, psychology, and education has provided abundant motivational factors, learning facilitators, or antecedents that increase learning effectiveness (e.g., Goodman & Darr, 1998; Pisano, 1994; Woodman & Schoenfeldt, 1990). This research summarizes and re-conceptualizes them as learning drivers that include learning capacity, learning motivation, and empowerment. When an engineer learns or improves a CIM software package, the engineer requires a basic learning capacity such as problem-solving skills or background information about the package. However, the engineer has to be motivated to learn or to improve the package. Improvement means to change current situation, and it demands an individual's efforts. Expectancy theory asserts that an individual (i.e., the engineer) will not behave unless the person believes that the outcomes have positive value for him/her (Nadler & Lawler, 1983). In other words, motivation is required to make any changes. With the learning capacity and motivation, the engineer still needs authority such as resources or autonomy to make the change. In short, the engineer needs empowerment.

Organizational learning literature provides support for the re-conceptualization of the learning drivers. At an organizational level, Levitt and March (1988) suggest that learning is routine-based, history-dependent, and target-oriented. The term routine includes the forms, rules, procedures, conventions, strategies, and technologies around which a firm is constructed and through which it operates. Routines provide the firm with tools to learn because the firm can follow the routines to implement certain continuous improvement programs. The history relates to a firm's business experience cumulated through its operation. Target refers to the difference between the outcomes a firm observes and the aspirations the firm has had for those outcomes. This difference motivates the firm to continuously improve and learn. When applied to an individual setting, history, target, and routine correspond to learning capacity, learning motivation, and empowerment proposed in the research model.

In MIS literature, Nambisan, Agarwal, and Tanniru (1999) have identified three antecedents of the IT innovation: technology cognizance, intention to explore a technology, and ability to explore. As discussed above, technology cognizance, intention to explore, and ability to explore are the similar concepts of capacity, motivation, and empowerment at an individual level. Igbaria (1990) and Igbaria et al. (1996) find that computer experience, skills, perceived fun/enjoyment, social pressure, computer anxiety, and organizational support are motivational factors for system use. These factors can be classified into learning capacity, learning motivation, and empowerment. While the factors are found to enhance the IT system use, they may affect system use through the continuous improvement efforts.

In CI literature, cross-functional team, customer focus, and self-managed project team are reported as key elements for a successful implementation of CI programs (Anderson et al., 1994; Spencer, 1994). The practice of establishing cross-functional teams focuses on the marshaling of multi-facet skills and expertise needed for the CI programs because in most cases single function skills cannot satisfy the demanding customer requirements. The essence of the customer focus is to understand customer requirements, thus establishing a clear goal for the CI programs. The purpose of practicing self-managed project team is to empower the team to identify and implement the CI programs. The factors that advocate the practices are capacity (i.e., skills), motivation, and empowerment respectively. In other words, a successful CI program depends on capacity (i.e., cross-functional skills), motivation, and empowerment.

2.5.1.1. Learning Capacity

Learning capacity is defined as an individual's ability to acquire external knowledge, assimilate it, and apply it to work (see Table 2.2.1). While termed differently as intelligence, cognitive ability, cognitive style (Sadler-Smith & Badger, 1998), thinking style (Tullett, 1996), or competence (Ulrich, 1998), it represents an individual's inherent or preferred way of acquiring, organizing, and processing information.

The learning capacity has been found to be related to one's prior knowledge (Ulrich, 1998; Bower & Hilgard, 1981) and problem-solving styles (Tullett, 1996; Scott & Bruce, 1994; Jabri, 1991; Pirolli & Anderson, 1985; Lindsay & Norman, 1977; Ellis, 1965). For example, Ulrich (1998) suggests that competence can be viewed as the knowledge, skills, or ability within a time frame. In MIS literature, computer experience (Igbaria, 1990), skills (Igbaria et al., 1996), and prior performance (Compeau & Higgins, 1995[a]) are proposed and empirically supported as antecedents of an effective computer usage.

Cohen and Levinthal (1990) use absorptive capacity to describe a similar concept: innovative capability in an organizational context. It refers to the acquisition of information and the ability to exploit it. An organization's absorptive capacity depends on the absorptive capacities of its individual members. It is developed cumulatively; and it relates to the relevant prior knowledge and problem-solving skills. In a study of inter-organizational learning, Lane and Lubatkin (1998) find that a firm's absorptive capacity

Table 2.2.1. Dimensions of Learning Capacity and Related Literature

Label	Definition	Related Literature
Learning Capacity	An individual's ability to acquire external knowledge, assimilate it, and apply it to work.	Cohen & Levinthal, 1990; Boynton, Zmud, & Jacobs, 1994; Kim, 1998; Lane & Lubatkin, 1998
Systematic problem solving	An individual's ability to solve a problem using established methods or procedures.	Cohen & Levinthal, 1990; Scott & Bruce, 1994; Jabri, 1991; Ahmed, Loh, & Zairi, 1999
Intuitive problem solving	An individual's ability to solve a problem overlapping separate domains of knowledge simultaneously.	Cohen & Levinthal, 1990; Scott & Bruce, 1994; Jabri, 1991; Ahmed, Loh, & Zairi, 1999
Prior knowledge of work process	An individual's understanding of the overall work process.	Cohen & Levinthal, 1990; Igbaria & Iivari, 1995; Igbaria, Parasuraman, & Baroudi, 1996; Nambisan, Agarwal, & Tanniru, 1999
Prior knowledge of computers	An individual's overall understanding of computer technologies.	Cohen & Levinthal, 1990; Igbaria & Iivari, 1995; Igbaria, Parasuraman, & Baroudi, 1996; Nambisan, Agarwal, & Tanniru, 1999

depends on the similarity of the two firms' knowledge bases, organizational structures and policies, and dominant logics. A firm's dominant logic refers to the preference that the firm runs business. The concept is similar to the problem-solving skills at an individual level.

Problem solving can be categorized into systematic problem solving and intuitive problem solving (Scott & Bruce, 1994). Systematic problem solving refers to the individual's ability to solve a problem using established methods or procedures. It is also referred to as associative thinking, which is based on habits or a set of routines that can be expressed in words or by symbols (Jabri, 1991). Intuitive problem solving refers to the individual's ability to solve a problem by overlapping separate domains of knowledge simultaneously. The concept is also termed as bisociative thinking, which occurs when two types of thoughts are combined, resulting in a non-habitual thought that is only made known by judgment, decision, or action (Jabri, 1991).

The above discussions suggest two important elements of learning capacity: prior knowledge and problem-solving skills. In CIM context, an engineer has to have the knowledge on both the manufacturing process (e.g., metal forming) and computers (e.g., CAE software package) in order to use the software for the work effectively. Learning capacity is thus assessed from four aspects: systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers. Systematic problem solving refers to an individual's ability to solve a problem using established methods or procedures. Intuitive problem solving refers to an individual's ability to solve a problem overlapping separate domains of knowledge simultaneously. Prior knowledge of work process represents an individual's understanding of the overall work process.

Table 2.2.2. Dimensions of Learning Motivation and Related Literature

Label	Definition	Related Literature
Learning Motivation	An individual's objective and the motive to use an application.	Frank, 1935; Lewin, Demara, Festinger, & Sears, 1944; March & Simon, 1958; Cyert & March, 1963; Wilsted & Hand, 1974; Payne, Laughhunn, & Rrum, 1980; Mezias, 1988; Doll & Torkzadeh, 1989; Lant & Mezias, 1990; 1992; Lant, 1992
Goal clarity	The clarity of the objectives for using an application.	March & Simon, 1958; Barki & Hartwick, 1989; Senge, 1990; Thomas & Velthouse, 1990; Lant & Mezias, 1990; 1992; Lant, 1992; Spreitzer, 1995
Intrinsic motivation	An individual's inherent motive for using an application.	Gill, 1996; Igbaria, Parasuraman, & Baroudi, 1996; Ahmed, Loh, & Zairi, 1999; Venkatesh, 1999
Social norms	An individual's understanding of the objectives and expectations set up and communicated by management for how to use a software package for the process.	Fishbein & Azjen, 1975; Robey, 1979; Stata, 1989; Igbaria, Parasuraman, & Baroudi, 1996; Shein, 1996; Ahmed, Loh, & Zairi, 1999; Barnard, 1999

Prior knowledge of computers represents an individual's overall understanding of computer technologies. Table 2.2.1 summarizes the definition and related literature for each dimension of learning capacity.

2.5.1.2. Learning Motivation

Learning motivation refers to an individual's objective and the motive to use an application (see Table 2.2.2). Individuals need incentives to direct their energies toward behaviors. Among many incentives like money and job enrichment, Latham and Locke (1991) find that goal setting is more effective than alternative methods. Goal setting operates directly by providing clear direction and then increasing effort and persistence toward achieving the goal. In learning literature, Senge (1990) argues that leadership in a learning organization needs to know how to build a creative tension, the difference between vision and current reality. With creative tension, the energy for change comes from the clear picture of vision and current reality and their gap.

Davis, Bagozzi, and Warshaw (1992) find that intrinsic and extrinsic motivations are key drivers of behavioral intention. Intrinsic motivation refers to the pleasure and inherent satisfaction derived from a specific activity (Vallerand, 1997). In MIS literature, Igbaria et al., (1996) use perceived enjoyment/fun to represent an intrinsic motivation for the use of computers. They argue that an individual's behavior (i.e., using computers) may be motivated by intrinsic psychological rewards. Gill (1996) finds that intrinsic motivation such as job variety and arousal motivates the usage of expert systems.

Extrinsic motivation focuses on performing a behavior to achieve a specific goal (e.g., management expectations) (Deci & Ryan, 1987). Social norms, one form of extrinsic motivation, are viewed as a motivational factor that affects behaviors (e.g., computer usage/improvement). According to TRA (Theory of Reasoned Action) model, social norms are the normative beliefs about the appropriateness of the behavior in question (Fishbein & Ajzen, 1975). The social norms of an individual are from the beliefs and opinions of the persons who are important to him/her. In a CIM context, those persons can be supervisors, peers, and subordinates. Satisfying their expectations motivates the individual to improve his/her performance.

While many other motivation factors exist, goal clarity, intrinsic motivation, and social norms are considered as three most relevant aspects of learning motivation in CIM context. Goal clarity refers to the clarity of the objectives for using an application. Intrinsic motivation refers to an individual's inherent motive for using an application. Social norms here represent an individual's understanding of the objectives and expectations set up and communicated by management for how to use a software package for the process. Table 2.2.2 summarizes the definitions and literature supports for goal clarity, intrinsic motivation, and social norms.

Engineers need a clear goal for their work. However, goal alone is not sufficient to lead the engineers to perform. They need to be motivated both internally and externally. This conceptualization is consistent with that of Igbaria et al. (1996). When investigating computer usage, Igbaria et al. (1996) identify perceived usefulness, perceived enjoyment, and social pressure as major motivational elements. While perceived usefulness is different from goal clarity, the two concepts are related in that both emphasize on the expectancy/outcome. Perceived enjoyment and social pressure share the same concepts with intrinsic motivation and social norms respectively.

2.5.1.3. Empowerment

Empowerment refers to an individual's cognitive, authoritative, and resource readiness to use an application (see Table 2.2.3). It is a construct used to explain organizational effectiveness (Spreitzer, 1995; 1996; Bowen & Lawer, 1995; Conger & Kanungo, 1988). In the management and social influence literature, empowerment means power granting or authority delegating. Delegation, participation, involvement, and resource sharing are central to empowerment (Burke, 1986; Pfeffer, 1981; Pettigrew, 1972; Likert, 1961).

In psychology literature, empowerment derives from the concepts of power and control. Power and control are motivational and/or expectancy belief-states that are internal to individuals (Conger & Kanungo, 1988). They are intrinsic needs for self-determination (Thomas & Velthouse, 1990; Deci, 1975) or beliefs in personal self-efficacy (Bandura, 1986). Empowerment thus means to enable or motivate through enhancing personal efficacy.

Psychological empowerment, termed as intrinsic task motivation (Thomas & Velthouse, 1990), is assessed through competence, self-determination, meaning, and impact (Spreitzer, 1995; 1996). Competence refers to self-efficacy specific to work – a belief in one's capability to perform work activities with skill. Compeau and Higgins (1995[a]) identify that self-efficacy perceptions influence decisions about what behaviors to undertake, the effort exerted and persistence in attempting those behaviors, the emotional responses of the individual performing the behaviors, and the actual performance attainments of the individual with respect to the behavior.

Table 2.2.3. Dimensions of Empowerment and Related Literature

Label	Definition	Related Literature
Empowerment	An individual's cognitive, authoritative, and resource readiness to use an application.	Locke & Schweiger, 1979; Conger & Kanungo, 1988; Doll & Torkzadeh, 1989; Thomas & Velthouse, 1990; Hayes, 1994; Spreitzer, 1995; 1996
Autonomy	An individual's perception of having choices in initiating and regulating the application usage.	Spreitzer, 1995; 1996
Self-efficacy	An individual's belief in his/her ability to skillfully use this software for the process.	Robey, 1979; Compeau & Higgins, 1995[a]; [b]; Igbaria & Iivari, 1995; Compeau, Higgins, & Huff, 1999
Support	Whether an individual has the necessary resources to use the application.	Igbaria & Iivari, 1995; Igbaria, Parasuraman, & Baroudi, 1996; Ahmed, Loh, & Zairi, 1999

Self-determination is a sense of choice in initiating and regulating actions. It reflects autonomy over the initiation and continuation of work behavior and processes; making decisions about work methods, pace, and efforts are examples. Meaning refers to a fit between the requirements of a work role and a person's beliefs, values, and behaviors. The concept concerns the value of the task goal, judged in relation to the individual's own standards. MIS literature uses perceived usefulness to capture this dimension (Davis, 1989).

Impact is the degree to which a person influences strategic, administrative, or operating outcomes at work. The concept is the converse of learned helplessness and implies the perceived relationship between the person and his/her working environment.

In continuous improvement (CI) literature, empowerment means to enhance employee authority to act (Hayes, 1994). In learning literature, empowerment is captured in terms of top management commitment or support (Garvin, 1993; Senge, 1990). If an employee or a project gets support from top management, then the employee or the team members of the project team feels certain psychological empowerment.

In MIS literature, Igbaria et el. (1995) and Igbaria et el. (1996) identify support as an important antecedent to computer usage and find empirical evidence for this relationship. The support means the extent to which an end-user has the necessary resources to use computer (Igbaria, Parasuraman, & Baroudi, 1996; Igbaria & Iivari, 1995). It can be in the forms of information, resources, and spiritual encouragement. In some situations, it can be the availability of within-function or cross-function training. It can also be the time to interact or collaborate with team members or the members from other group or department of the organization.

This research uses autonomy, self-efficacy, and support to capture major factors of empowerment in CIM learning and usage environment. Autonomy measures an individual's perception of having choices in initiating and regulating the application usage. Self-efficacy evaluates an individual's belief in one's ability to skillfully use the software for the process. Support measures whether an individual has the necessary resources to use the application (see Table 2.2.3).

As in Spreitzer (1995; 1996) and Thomas and Velthouse (1990), autonomy and self-efficacy are used to measure an individual's empowerment. Different from their studies, impact is replaced with support to capture the readiness of resources necessary for the effective use of CIM applications. Unlike their studies, meaning is not included to measure empowerment. The concept is modified as goal clarity under learning motivation. Table 2.2.3 provides the definition and the literature support for the three aspects.

2.5.2. Continuous Improvement Efforts

Continuous improvement (CI) is an array of powerful techniques that has produced substantial improvements in numerous companies and organizations (Zangwill & Kantor, 1998). In a manufacturing setting, quality and productivity are improved in three ways: through innovation in design of a product or service, through innovation in process, and through improvement of existing processes (Deming, 1994). Each improvement includes many micro plan-do-check-act (PDCA) cycles. As a firm or a person completes one PDCA cycle, learning happens.

Learning can be categorized as autonomous learning and induced learning (Li & Rajagopalan, 1998; Dutton & Thomas, 1984; Levy, 1965). Autonomous learning is viewed as automatic improvements that result from sustained production over long periods while induced learning is referred as the conscious efforts made to increase the rate of output or to reduce costs in the production process. While autonomous learning occurs with the repetition of routine tasks, induced learning requires investment, induction, or resources made available that are not present in the current operating situation.

Using different terminologies, Adler and Clark (1991) explicitly classify learning in manufacturing into first-order learning and second-order learning. First-order learning, similar to the concept of autonomous learning, is the result of repetition and the associated development of expertise through practice. It happens autonomously, independent of direct managerial action. Second-order learning, close to the concept of induced learning, is the improvements resulted from changing the process design, training employees, or modifying the product design. Unlike first-order learning, second-order learning happens as a result of direct managerial action. The learning from continuous improvement efforts belongs to induced learning or second-order learning. In most cases, the continuous improvement programs deal with process improvement, product improvement, and employee training (i.e., knowledge enhancement).

Learning can be measured in different ways. In manufacturing setting, cost or production are frequently used to measure the learning effects (Zangwill & Kantor, 1998; Levy, 1965; Conway & Schultz, 1959). Zangwill and Kantor (1998) develop a way to measure the continuous improvement along the learning curve. The idea is illustrated in the following example. Assuming that management implements, by following PDCA learning cycle, a strategy to decrease the costs. In order to examine whether or not the strategy is successful, they can subtract the total cost of making an item at the end of the current period from the total cost at the end of the previous period. Thus learning is measured by the cost difference between two consecutive learning cycles.

In CIM utilization context, the learning effects are not easy to quantify. In this case, the learning is observed through individuals' continuous improvement efforts. For each PDCA cycle, the research focuses on the A (i.e. Act) stage of a PDCA cycle. If an individual takes actions to improve his/her working processes, to learn more features of the software packages, or to make changes to the software packages, then the person learns. The more actions (i.e., continuous improvement behaviors) the person takes, the more he/she learns.

The continuous improvement efforts of the CIM users are largely cognitive in nature and involve much more mental activities than that of traditional machine technology. The mental activities involve the understanding of both the technology and the task for which the technology is used (Weick, 1990). In other words, end-users of the CIM need to have the knowledge of both "why" (i.e., planning) and "how to" (i.e., implementing) to use the technology. The former involves what functions provided by the technology can be used for tasks and the latter concerns how to use the functions for designated tasks. Doll (1994) summarizes these efforts as the technology enhancement and the individual's skill improvement.

Continuous improvement efforts are conceptualized as the extent to which an individual enhances one's skills and knowledge on the CIM software and the work process, and improves the software and the work process to better fit the task requirements (see Table 2.3). The efforts include process improvement, skill enhancement, and software improvement. Process improvement measures the extent to which an individual strives to understand and/or improve the work process to better fit the task requirements. Skill enhancement measures the extent to which an individual strives to enhance one's skills and knowledge on how the software should be used for the process. Software improvement examines the extent to which an individual strives to improve the software to better fit the process requirements. This classification is evidenced from Deming (1994) and Adler and Clark (1991). Table 2.3 describes the definition and the literature support for each of the continuous improvement efforts.

2.5.3. Information Technology (IT) Utilization

IT utilization refers the extent to which an individual uses IT for his/her work (see Table 2.4). In particular, it represents the ways or the patterns that engineers use CIM applications for their work. Usage has long been investigated in MIS literature as an important measure of information technology's acceptance (Davis, 1989; Ives & Olson, 1984) and success (Igbaria et al., 1996). In the system-to-value chain of system success (Doll & Torkzadeh, 1991), information system-use has been proposed as both a success measure of the upstream IT innovation research and as a complex causal agent that predicts the downstream impact of IT. Despite the importance of technology utilization, no widely agreed measurement is available. Extensive literature review has shown that the diverse measures of IT utilization can be categorized into the amount of use (e.g., time, frequency, extensive) and the extent of use (e.g., level, pattern) (Doll & Torkzadeh,

Table 2.3. Dimensions of Continuous Improvement Efforts and Related Literature

Label	Definition	Related Literature
Continuous Improvement Efforts	The extent to which an individual enhances one's skills and knowledge on the CIM software and the work process and improves the software and the work process to better fit the task requirements.	Mazur & Hastie, 1978; Sahal, 1979; Deming, 1982; Ghemawat, 1985; Hackman & Wageman, 1995; Choi, 1995; Zangwill & Kantor, 1998
Process improvement	The extent to which an individual strives to understand and/or improve the work process to better fit the task requirements.	Deming, 1982; Tyre & Orlikowski, 1993; Doll, 1994; Li & Rajagopalan, 1998; Hatch & Mowery, 1998; Zangwill & Kantor, 1998; Ahmed, Loh, & Zairi, 1999
Skill enhancement	The extent to which an individual strives to enhance one's skills and knowledge on how the software should be used for the process.	Tyre & Orlikowski, 1993; Doll, 1994; Leonard-Barton, Bowen, Clark, Holloway, & Wheelwright, 1994; Bolk, van Elswijk, Melis, & van Praag, 1997; Baba & Nobeoka, 1998
Software improvement	The extent to which an individual strives to improve the software to better fit the process requirements.	Tyre & Orlikowski, 1993; Doll, 1994; Bolk, van Elswijk, Melis, & van Praag, 1997; Baba & Nobeoka, 1998

1998).

Focusing on the amount and frequency of use, many lab studies and field studies operationalize IT utilization as the frequency and hours of different uses of computers (Euema, 1985; Benbasat, Dexter, & Masulis, 1981), the number of system features used (Green & Hughes, 1986), the number of messages sent or received on an average day (Straub, Limayem, & Karahanna-Evaristo, 1995), number of minutes, sessions, and functions used (Ginzberg, 1981), percentage of total work time spent using computers and average weekly hours of usage (Howard & Mendelow, 1991), hours of usage and number of different types of applications used (Lee, 1986), minutes of job-related PC use per day, and the diversity of software packages (Thompson, Higgins, & Howell, 1991).

When investigating the consequences of IT acceptance, Igbaria and Tan (1997) examine how many business tasks are performed by individuals who use computers in their work. The tasks include making decisions, planning, budgeting, writing reports, scheduling meeting, and communicating with others.

The amount or the frequency of system use is good for the adoption or acceptance stage of the system innovation. However, after systems have become operational, end-users (i.e., engineers) continuously learn and use the system to accomplish different tasks. In the post-implementation context, the total hours of usage may be the same or increased, but for the same task, less hours are desired. The goal of learning and using the system is to do work in less time while utilizing the information system more effectively to perform more functions (Doll & Torkzadeh, 1998).

An alternative measure focuses on how the system is used, that is, the extent to which the system is used. The measurement also reflects the level of skills or expertise of individual users. For example, Igbaria, Pavri, and Huff (1989) measure the level of sophistication of IT use. Cooper and Zmud (1989) use the levels of diffusion in marketing strategy, manufacturing method, production complexity, and inventory item dependence aspects to measure the successful adoption of MRP systems. Moore and Benbasat (1991) measure the levels of IT adoption and diffusion from voluntariness, relative advantage, compatibility, image, ease of use, result demonstrability, visibility, and trialability perspectives. Seeley and Targett (1999) identify patterns (steady state, declining, born again, and growing) that senior executives use computers.

Doll and Torkzadeh (1995; 1998) propose a multidimensional concept of system-use (i.e., a taxonomy of performance-related behaviors) that recognizes the organizational functions for which IT is utilized in the post-implementation context. Based on Hirschhorn and Farduhar's (1985) model, they develop an instrument to measure different IT usage patterns: decision rationalization, problem solving, vertical integration, horizontal integration, and customer service. The results of the empirical study suggest a three-dimension construct: decision support, work integration, and customer service. Decision support includes problem solving and decision rationalization while work integration includes vertical integration and horizontal integration.

This research emphasizes on the post-implementation use of CIM applications. For this reason, effective utilization is used as a measure of system success. The choice is consistent with Doll and Torkzadeh's (1995) suggestion. After a CIM application has been installed and has become operational, how the application is used for the individual's work determines the social and economic impact of IT on work (Doll & Torkzadeh, 1998). For example, an end-user can use a CIM application mainly for problem solving, decision rationalization, work integration, and work planning (Braverman, 1974; Hirschhorn, 1984; Hirschhorn & Farduhar, 1985; Zuboff, 1988; Weick, 1990; Doll & Torkzadeh, 1998).

Information technology utilization is measured by decision support, problem solving, work integration, and work planning. Decision support represents the extent to which an application is used to improve the decision making process or to explain the reasons for decisions. Problem solving measures the extent to which an application is used to analyze cause and effect relationship (i.e., to make sense out of data). Work integration refers to the extent to which an application is used to coordinate work activities with others in one's work group. Work planning assesses the extent to which an application is used to plan one's own work and monitor performance. Table 2.4 describes the definition and supporting literature for each aspect.

This classification is consistent with Doll and Torkzadeh's (1998) study. However, unlike their research, this research does not include customer dimension. Rather, the customer dimension is captured in the impact variable.

2.5.4. Impact on Work

Impact refers to the influences that an information technology (IT) exerts on individual work and/or organizational performance (see Table 2.5). At the industrial level, Segars and Grover (1994) have examined the industrial level competitive advantage of IT. At the organizational level, for example, MIS researchers have studied the IT impacts on organizational strategy (Mahmood, 1991), on time utilization (Sulek & Marucheck, 1992), on middle managers (Millman & Hartwick, 1987; Pinsonneault &

Kraemer, 1993), and on competitive advantage, including efficiency, functionality, threat, preemptiveness, and synergy (Sethi & King, 1994).

At the individual level, Joshi and Lauer (1998) employ equity – implementation model as a framework to identify and analyze the impacts of CAD implementation on part designers' work environment. Ryker and Nath (1995) have empirically tested the IT's impacts on five core job dimensions (i.e., skill variety, identity, significance, autonomy, and feedback) and found a positive relationship between information systems and identity, significance, autonomy, and feedback. Igbaria and Tan (1997) measure how IT impacts individuals on decision-making quality, performance, productivity, and effectiveness. Torkzadeh and Doll (1999) have identified four ways that IT impacts on individual work: task productivity, task innovation, management control, and customer satisfaction.

Suppliers have become an integral part in product development team (Heckman, 1999; Fleischer & Liker, 1997; Kamath & Liker, 1994; Vonderembse &Tracey, 1999). They provide the information of sub-components, parts material, and parts supply necessary for the product designing, engineering, and manufacturing. Heckman (1999) investigates how to manage IT-suppliers relationship and finds that many firms are moving toward formal relationship through collaboration and communication. Better understanding of the suppliers' product information, material information, and schedule information can help engineers communicate their design requirements and cooperate with suppliers better.

This research views IT's impact on individual work from job performance perspective rather than from psychological perspective. It investigates how IT helps

Table 2.4. Dimensions of Information Technology Utilization and Related Literature

Label	Definition	Related Literature
Information Technology Utilization	The extent to which an individual uses IT technology for one's work.	Doll & Torkzadeh, 1998; Weick, 1990; Zuboff, 1988; Delone, 1988; Hirschhorn & Farduhar, 1985; Melone, 1990; Robey, 1979; Seeley and Targett, 1997; 1999
Decision support	The extent to which an application is used to improve the decision making process or explain the reasons for decisions.	Doll & Torkzadeh, 1998; Weick, 1990; Zuboff, 1988; Delone, 1988; Hirschhorn & Farduhar, 1985; Melone, 1990; Robey, 1979
Problem-solving	The extent to which an application is used to analyze cause and effect relationship (i.e., to make sense out of data).	Doll & Torkzadeh, 1998; Weick, 1990; Zuboff, 1988; Delone, 1988; Hirschhorn & Farduhar, 1985; Melone, 1990; Robey, 1979
Work integration	The extent to which an application is used to coordinate work activities with others in one's work group.	Doll & Torkzadeh, 1998; Delone, 1988; Hirschhorn & Farduhar, 1985; Melone, 1990; Robey, 1979
Work planning	The extent to which an application is used to plan one's own work and monitor performance.	Doll & Torkzadeh, 1998; Delone, 1988; Hirschhorn & Farduhar, 1985; Melone, 1990; Robey, 1979

individuals increase task productivity, task innovation, management control, customer satisfaction, and supplier management. Task productivity refers to the extent to which an application improves the user's output per unit of time. Task innovation examines the extent to which an application helps the user create and try out new ideas in their work. Management control measures the extent to which the application helps to regulate work processes and performance. Customer satisfaction evaluates the extent to which an application helps the user create value for the firm's internal or external customers. Supplier management assesses the extent to which an application helps the user coordinate the work with firm's suppliers. The definition and the literature support of each dimension are listed in Table 2.5

2.6. Hypotheses Development

In order to empirically examine the links specified in the research model, a set of hypotheses are developed in following sections.

2.6.1. The Link between Learning Drivers and CI Efforts

Continuous improvement efforts are conscious activities of an individual aimed to improve task performance. While opportunities to develop better methods always exist, a commitment to continuous improvement ensures that the person will never stop learning about the work (Hackman & Wageman, 1995). For sustained CI efforts, Keating et al. (1999) view that commitment is necessary because improvement activities are less structured and less easily monitored than throughput time. Based on Shiba, Graham, and Walden's (1993) and Schaffer and Thomson's (1992) work, two types of commitment are

Table 2.5. Dimensions of IT Impact on Individual Work and Related Literature

Label	Definition	Related Literature
Impact on Work	The extent to which an application influences an individual work.	Torkzadeh & Doll, 1999; Weick, 1990; Zuboff, 1988; Danziger & Kraemer, 1986; Braverman, 1974; Hirschheim & Farduhar, 1985; Kraemer & Danziger, 1990; Sulek & Marucheck; 1992; Li & Ye, 1999; Joshi & Lauer, 1998; Igbaria & Tan, 1997; Ryker & Nath, 1995
Task productivity	The extent to which an application improves the user's output per unit of time.	Torkzadeh & Doll, 1999; Zuboff, 1988; Braverman, 1974; Hirschheim & Farduhar, 1985; Kraemer & Danziger, 1990; Sulek & Marucheck; 1992
Task innovation	The extent to which an application helps the user create and try out new ideas in their work.	Torkzadeh & Doll, 1999; Davis, 1989; Larson & Fielden, 1985; Long, 1993; Hirschheim & Farduhar, 1985; Kraemer & Danziger, 1990
Management control	The extent to which the application helps to regulate work processes and performance.	Torkzadeh & Doll, 1999; Zuboff, 1988; Braverman, 1974; Hirschhorn, 1981; Kraemer & Danziger, 1990
Customer satisfaction	The extent to which an application helps the user create value for the firm's internal or external customers.	Torkzadeh & Doll, 1999; Hirschhorn, 1981; Kraemer & Danziger, 1990
Supplier management	The extent to which an application helps the user coordinate the work with firm's suppliers.	Heckman, 1999; Liker, 1998; Krause, Handfield, & Scannell, 1998

distinguished: managerial push and employee pull. Managerial push refers to the efforts to promote improvement effort or mandate participation. In contrast, employee pull represents the improvement efforts that come from the individual's understanding of the benefits from the improvement. The efforts are independent of management attitudes and support. They find that employee pull is essential to sustained improvement efforts.

Employee pull is similar to individual IT learning drivers, which include learning capacity, learning motivation, and empowerment. For the commitment to be effective, knowledge and skills are necessary (Ulrich, 1998; Hackman & Wageman, 1995). Thus the research proposes the following hypothesis:

H11: The score of an individual's learning capability is positively associated with the score of the individual's continuous improvement efforts.

The user's motivation influences the likelihood of enduring adoption within the organization (Gill, 1996). The motivation differs in different situations. For example, Hackman and Wageman (1995) argue that the effectiveness of a continuous improvement team depends on the clear direction from its performance strategy. Senge (1990) uses the creative vision concept to indicate that endured behaviors for changing come from the motivation generated from the creative vision. Therefore, following hypothesis is derived for an empirical test:

H12: The score of an individual's learning motivation is positively associated with the score of the individual's continuous improvement efforts.

Empowerment sometimes means involvement because involvement enhances empowerment. Some organizations create self-managing teams to perform the regular work of the enterprise, thereby expanding the involvement of organization members (Hackman & Wageman, 1995). As more people participate in all kinds of regular works, more collective efforts are derived. The collective efforts in turn help continuous improvement teams to achieve team effectiveness or team learning.

Bandura (1977) contends that people get involved in activities and behave assuredly when they judge themselves capable of handling situations that would otherwise be intimidating. In other words, the more an individual involves in activities such as decision-making, the more powerful the person feels. In MIS area, Doll and Torkzadeh (1989) find that greater involvement leads to higher end-user satisfaction through value attainment. As people feel that they are more valuable, they feel empowered. Empowerment affects both initiation and persistence of the person's task behavior (Conger & Kanungo, 1988). Argyris (1991) has identified that when people have the right attitudes and commitment, learning automatically follows. While people cannot assure that the continuous improvement behaviors happen automatically, empowerment can help initiate and even maintain continuous improvement efforts. Following hypothesis is derived:

H13: The score of the empowerment that an individual feels is positively associated with the score of the individual's continuous improvement efforts.

2.6.1.1. The Link between Learning Capacity and CI Efforts

In project management literature, thinking style and thinking ability make important contribution to the manner and effectiveness with which managers guide their work (Tullett, 1996). When solving problems, the thinking style determines the actions a person is likely to take.

In learning literature, Argyris (1977) views learning as single-loop and double-loop learning. Single-loop learning refers to the process in which errors are tracked down and corrected within the existing set of rules and norms. Double-loop learning represents the changes in the fundamental rules and norms underlying action and behavior. He has found that highly skilled professionals are frequently very good at single-loop learning. But the effective double-loop learning is not simply a function of how people feel. It is determined by the cognitive rules or reasoning they use to design and implement their actions.

In CI literature, scientific methods and statistical analysis provide teams with trustworthy data to use in their decision-making. Several techniques can be used to help quality teams use their collective knowledge effectively in identifying and analyzing opportunities to improve quality (Hackman & Wageman, 1995). All the methods and techniques can be viewed as problem-solving styles at an individual level.

Scott and Bruce (1994) hypothesize and find a positive relationship between intuitive problem solving and innovative behavior and a negative relation between systematic problem solving and innovative behavior. While innovative behaviors are similar to continuous improvement efforts in that both concepts represent improvement behaviors, they differ in magnitude. Continuous improvement signifies small improvements made in the status quo as a result of ongoing efforts. Innovation involves a drastic improvement in the status quo as a result of a large investment in new technology and/or equipment (Imai, 1986). While systematic problem solving is less effective for innovation, where intuitive problem solving may be more effective, both will be effective for continuous improvement activities. Continuous improvement efforts include process improvement, skill enhancement, and software improvement. The study assumes that learning drivers will affect all of them in similar patterns. Thus, the study hypothesizes:

H11-1: The score of an individual's systematic problem solving is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

H11-2: The score of an individual's intuitive problem solving is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

Research in diverse fields has identified that learning and improvement are affected by domain-relevant skills, such as expertise, technical skills, and talent (Amabile, 1988; Shalley & Oldham, 1985). Psychologists have found that prior knowledge enhances learning by the development of the knowledge base (Bower & Hilgard, 1981; Lindsay & Norman, 1977). The knowledge base is enhanced when associative learning (i.e., systematic problem solving) establishes linkages with existing concepts and then puts the new knowledge back to the knowledge base. Learning literature also suggests that prior experience or knowledge on one task can influence and improve performance on subsequent tasks, for example, continuous improvement efforts (Estes, 1970; Ellis, 1965).

In CI literature, one assumption on the CI theory is that once employees are equipped with the knowledge (i.e., tools and training) that is necessary for quality improvement, they will take initiatives to improve the quality of work (Hackman & Wageman, 1995). In MIS literature, Igbaria et al. (1996) also have found that skills influence user's behaviors such as continuous improvement and computer usage. In organizational IT usage setting, Boynton, Zmud, and Jacobs (1994) use managerial IT knowledge as a surrogate of absorptive capacity. Their findings suggest that a higher level of a firm's absorptive capacity (i.e., knowledge) directly and positively influences the firm's extent of IT usage.

In summary, continuous improvement or learning efforts need knowledge. In CIM utilization setting, the knowledge means the expertise, experience, and skills on both computers and the working process. The prior knowledge is obtained through the end-user's direct working experience, within function training, and cross-functions training. However, the knowledge of computers differs from that of manufacturing processes. They are different disciplines; and mastering and using them may demand different cognitive skills. While both types of knowledge may have inseparable effects on continuous improvement efforts, the study develops two hypotheses for further examination:

H11-3: The score of an individual's knowledge of the process is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

H11-4: The score of an individual's knowledge of computers is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

2.6.1.2. The Link between Learning Motivation and CI Efforts

Goal setting is proposed to operate directly by providing direction, and then increasing effort and persistence toward achieving the goal (Frink & Ferris, 1998; Earley & Shalley, 1991; Locke & Latham, 1990). Frank (1935) uses the aspiration level (i.e., the future performance) to refer to a goal. He explicitly links one's aspiration level to the person's action to reach that goal. A proper aspiration level leads to the behavioral outcomes that are consistent with rationality (Lewin, Dembo, Festinger, & Sears, 1944). In learning literature, this is referred to as adaptive learning (Lant, 1992; Lant & Mezias, 1990; 1992; Cyert & March, 1963; March & Simon, 1958). It is widely used to observe an individual's goal-striving behaviors occurring in the course of a specific activity such as using CIM applications.

Continuous improvement is a goal-directed behavior. To achieve high quality, it is essential to know what customers want and to provide products or services that meet their requirement (Ishikawa, 1985). A clear goal provides an end-user with clear requirement, thus reduces misunderstanding. With the clear goal, the user can plan the work better, allocate energy properly, and initiate improvement efforts earlier if necessary. Therefore, following hypothesis is developed:

H12-1: The score of the goal clarity of an individual is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

Intrinsic motivation is a key driver of learning and creativity (Amabile, 1988; Shalley & Oldham, 1985). The concept refers to playfulness when used in computer game setting (Venkatesh, 1999). With high intrinsic motivation, people enjoy the pleasure and inherent satisfaction derived from using a CIM application (Venkatesh, 1999; Vallerand, 1997; Igbaria, Parasuraman, & Baroudi, 1996). Ishikawa (1985) uses an analogy to describe the phenomenon: saying that people like to work due to their intrinsic motivation is just like saying people enjoy climbing a mountain just because it is there.

Activities initiated through intrinsic motivation last much longer than those through external incentives. Senge (1990) contends that many people find themselves motivated to change only when their problems are bad enough to cause them to change. This works for a while, but the change process runs out of steam as soon as the problems driving the change become less pressing. With the intrinsic motivation, the energy for change comes from the vision, from what the people want to create, juxtaposed with current reality, and thus will last longer. Management should always create and maintain this tension.

Learning motivation may come from intrinsic psychological rewards (Igbaria et al., 1996). Individuals who experience immediate pleasure and joy from using a microcomputer and perceive any activity involving use of it as inherently enjoyable, apart from any anticipated performance consequences, are likely to use it more extensively than others (Webster, 1992; 1993).

The study hypothesizes that intrinsic motivation plays similar role in enforcing continuous improvement efforts. Thus, following hypothesis is developed:

H12-2: The score of an individual's intrinsic motivation is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

The social norms reflect the end-user's normative beliefs of using a CIM application (Igbaria, Parasuraman, & Baroudi, 1996; Fishbein & Ajzen, 1975). It is an important source of human motivation due to social approval and public recognition. In other words, it represents the energy that comes from cooperating with others on a shared task and the incentive provided by recognition from others (Deming, 1986; Ishikawa, 1985).

In an empirical study, Burnside (1990) has found that productivity (number of ideas for improvement) is higher when evaluation is expected. Igbaria et al. (1996) conceptualize social norms as social pressure in their study and find empirical evidence that supports the positive relation between social pressure and computer usage.

Argyris (1991) has observed that getting people to learn is largely a matter of motivation. An individual invests more efforts on learning and improvement when the person perceives higher group and organizational expectations or norms. Following hypothesis is thus derived:

H12-3: The score of an individual's social norms is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

2.6.1.3. The Link between Empowerment and CI Efforts

Burnside (1990) argues that in order to be creative, individuals need freedom to take risks, to play with ideas, and to expand the range of considerations and material from which solutions may emerge. Motivation is strengthened when performers have considerable autonomy in determining the means by which it is accomplished (Hackman & Oldham, 1976).

Autonomy describes an end-user's sense of having choice in initiating and regulating the CIM application usage (Spreitzer, 1995; Deci, Connell, & Ryan, 1989). The concept derives from the constructs of power and control. It provides the individuals with the freedom described above. Bass (1985) hypothesizes that a person's choice is positively associated with his/her innovative behavior. Amabile (1988) indicates that having freedom to decide what to do and how to do one's work enhances the individual's capability for creative behavior. Conceptualized as self-determination, autonomy has been found to be positively related to innovative behaviors (Spreitzer, de Janasz, & Quinn, 1999; Spreitzer, 1995).

All the discussions support the notion that autonomy leads to innovative behavior although different terms are used for autonomy. Thus this study hypothesizes:

H13-1: The score of an individual's autonomy is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

Self-efficacy defines an end-user's belief in one's capability to use the CIM application with skills (Compeau & Higgins, 1995[a]; [b]; Spreitzer, 1995; Bandura, 1986). Zaleznik (1977) and Hunt (1991) suggest that a high level of self-efficacy is a prerequisite for embracing the inherent risk of making continuous improvement. Conceptualized as competence, self-efficacy has been found to lead to more innovation due to positive expectations of success (Spreitzer, de Janasz, & Quinn, 1999; Spreitzer, 1995; Locke, Frederick, Lee, & Bobko, 1984).

In learning literature, team efficacy is developed based on Bandura's (1982) work on the role of self-efficacy in enhancing individual performance. Edmondson (1999) hypothesizes and finds empirical support for the positive relation between team efficacy and team learning behaviors. In MIS literature, Davis (1989) uses perceived ease of use as the variation of self-efficacy in IT setting and finds positive relation between self-efficacy and the acceptance of information systems. Studies conducted by Compeau, Higgins, and Huff (1999) and Igbaria and Iivari (1995) also support this positive relationship.

While learning behaviors, innovation, and computer acceptance are not the same as continuous improvement, all of them deal with making changes for status quo. Following hypothesis is thus derived:

H13-2: The score of an individual's self-efficacy is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

Support is normally related to working climate and organizational culture. From an individual's perspective, support is a cognitive interpretation of his/her working environment (James, James, & Ashe, 1990). They represent signals the individual receives concerning management efforts in assisting the individual completing works. Scott and Bruce (1994) have observed a positive relationship between supportive climate and innovative behaviors. Igbaria et al. (1995) and Igbaria et al. (1996) have also found empirical evidence between support and computer usage. These findings lead to following hypothesis:

H13-3: The score of the support to an individual is positively associated with the score of the individual's efforts for process improvement, skills enhancement, and software improvement.

2.6.2. The Link between CI Efforts and IT Utilization

Continuous improvement and learning are intricately linked (Ahmed, Loh, & Zairi, 1999). Learning has been proposed as a key element in the process of implementing CIM technology. Dreyfus and Dreyfus (1986) note that effective IT utilization demands the continuous update of the knowledge and expertise in the process and software.

CIM is a computer-mediated technology (Jaikumar, 1986; Zuboff, 1982). It is open to several interpretations, subject to misunderstandings, complex, and recondite in the course of usage or implementation (Weick, 1990). A contingency perspective (Markus & Robey, 1988) has to be adopted to realize the full potential of CIM applications. Contingency theory suggests that the outcomes of an IT implementation depend on the on-going interaction between the technology and the people who are using it. This implies that CIM using process is actually ongoing structuring and sense making process, that is, a learning process. In the process, the continuous interactions of the users with CIM technology create more skills and knowledge on the process and the CIM software. The more skills and knowledge the users obtain, the greater extent to which the software can be used in different tasks (Locke & Schweiger, 1979; Doll & Torkzadeh, 1998). Following hypothesis is thus derived from the discussions:

H2: The score of an individual's continuous improvement efforts is positively associated with the score of CIM technology utilization.

While the hypothesis assumes the overall effects of continuous improvement efforts on CIM technology utilization, different CI efforts may influence the IT utilization differently. Process improvement focuses on the information of the working process. Skill enhancement concerns the knowledge base in an individual or engineer's brain. Software improvement concentrates on the effective and efficient of working tools. The improvement in different types may influence the utilization to different extent. Three hypotheses are thus developed for individual CI efforts:

H2-1: The score of an individual's process improvement efforts is positively associated with the score of CIM technology utilization.

H2-2: The score of an individual's skills enhancement efforts is positively associated with the score of CIM technology utilization.

H2-3: The score of an individual's software improvement efforts is positively associated with the score of CIM technology utilization.

2.6.3. The Link between IT Utilization and Impact on Work

In the system-to-value chain, the IT impact on individual work is a direct consequence of computer usage. It is also a major factor determining IT impacts on organizations (Torkzadeh & Doll, 1999). The linkage between IT utilization and IT impact has been well discussed in the studies such as Doll and Torkzadeh (1991), Doll and Torkzadeh (1998), and Torkzadeh and Doll (1999). Danziger (1985) supports the link through his findings that the impacts of computing are highly dependent upon the context of use. Empirical studies in the field have also supported the linkage (Li & Ye, 1999; Joshi & Lauer, 1998; Igbaria & Tan, 1997; Ryker & Nath, 1995). Therefore, this study develops the following hypothesis:

H3. The score of an individual's CIM technology utilization is positively associated with the score of CIM impact on the individual work.

Chapter 3: Research Methods

A cross-sectional survey design is employed to empirically test the hypotheses derived from the IT learning model. The word "cross-sectional" has two meanings in this context. First, the survey will involve as many manufacturing firms as possible; and second, and more important, the survey will examine as many CIM applications as possible. The target respondents are those who use CIM applications regularly for their work. The unit of analysis focuses on an individual level.

An experimental research design would be appropriate to test the casual relationships in the model. However, the studies in CIM, continuous improvement, and end-user computing have suggested the causal linkages from learning drivers to continuous improvement behaviors, effective use of IT, and the IT impact on work. Thus, this research focuses on examining the significance of the relationships.

Measures of the constructs have to be developed to test the hypotheses. An effective process has to be followed for developing robust measures (Churchill, 1979; Nunnally, 1978). The process used in this study is based on generally accepted psychometric principles. The process includes specifying the domain of the constructs, generating measurement items for each construct, collecting initial data and purifying the items, collecting large-scale data and assessing the reliability and validity of the instrument, and finally developing norms.

3.1. Measurement Instruments

An effective instrument should cover the content domain of the construct (Nunnally, 1978). A measure has content validity if the subjects and/or researchers agree that the measurement instrument includes items that cover important aspects of the variable being measured. Thus, content validity depends on how well the researchers create measurement items to cover the content domain of the variable (Nunnally, 1978). The items that measure a construct should converge with each other while the items of one construct should be discriminated from the measurement items of other constructs. Each construct should have a reliability score of 0.80 or above, and the instrument should be short and easy to use. To increase the usefulness of the instrument for basic researches, the instrument should be applicable across industries and/or CIM applications. To achieve these goals, item generation has to be grounded in theory and/or suggestions from practitioners.

This research develops measurement instruments for learning drivers and continuous improvement efforts. The instruments developed in the study are for learning capacity, learning motivation, empowerment, process improvement, skill enhancement, and software improvement. To measure each construct, a literature review is conducted to ensure that a comprehensive list of items is generated. Reviewed studies on the related subjects include, but not limited to, Igbaria, Parasuraman, and Baroudi (1996), Spreitzer (1995; 1996), Compeau and Higgins (1995[b]), Igbaria and Iivari (1995), Doll (1994), Hayes (1994), Scott and Bruce (1994), Lant (1992), Jabri (1991), Nambisan, Agarwal, and Tanniru (1999), Schaubroeck and Fink (1998), Cohen and Levinthal (1990), Senge (1990), Barki and Hartwick (1989), Deming (1982), Mazur and Hastie (1978), and

Fishbein and Azjen (1975). These writings provide a rich description of what continuous improvement and/or learning behaviors people have in a work context and what factors drive those learning behaviors. Illustrations and examples in the literature are used to generate measures for the constructs.

The measurement instruments for IT utilization and IT's impact on individual's work are adapted from Doll and Torkzadeh's (1998) and Torkzadeh and Doll's (1999) work respectively. Overall, the questionnaire for the pilot study includes 162 items as shown in Tables 3.1.1 thru 3.1.6.

3.1.1. Measures for Learning Capacity

Learning capacity refers to an individual's ability to acquire external knowledge, assimilate it, and apply it to work. It is measured by systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers. Items for systematic problem solving and intuitive problem solving are generated from the studies of Scott and Bruce (1994) and Jabri (1991). Items for prior knowledge of work process and prior knowledge of computers are generated from the studies of Igbaria, Parasuraman, and Baroudi (1996), Igbaria and Iivari (1995), Moor and Benbasat (1991), Goh and Richards (1997), and Cohen and Levinthal (1990). Based on the definitions specified earlier and the literature reviewed, thirty-eight items (see Table 3.1.1) are developed for the four aspects of learning capacity (i.e., system problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers). A five-point Likert type scale is used where 1= To none or a little extent, 2= To some extent, 3= To a moderate extent, 4= To a great extent, and 5= To a very great extent.

Table 3.1.1. Measurement Items of Learning Capacity Used in the Pilot Study (38 items)

Label	Item Description
	Systematic Problem-Solving (10 items)
SYS1	When using the software for this task/process, I adhere to the commonly established rules of my area of work.
SYS2	When using the software for this task/process, I adhere to the well-known techniques, methods, and procedures of my area of work.
SYS3	When using the software for this task/process, I adhere to the standards of my area of work.
SYS4	When using the software for this task/process, I follow well-established ways and generally accepted methods for solving problems.
SYS5	When using the software for this task/process, I accept the usual and generally proven methods of solutions.
SYS6	When using the software for this task/process, I pay strict regard to the sequence of steps needed for the completion of a job.
SYS7	When using the software for this task/process, I am strict on the production of results, as and when required.
SYS8	When using the software for this task/process, I am methodical and consistent in the way I tackle problems.
SYS9	When using the software for this task/process, I am precise and exact about production of results and reports.
SYS10	When using the software for this task/process, I am aware beforehand of the sequence of steps required in solving problems.
	Intuitive Problem-Solving (9 items)
INT1	When using the software for this task/process, I tackle a problem, particularly if it takes me into areas I don't know much about.
INT2	When using the software for this task/process, I search for novel approaches not required at the time.
INT3	When using the software for this task/process, I struggle to make connections between apparently unrelated ideas.
INT4	When using the software for this task/process, I spend time tracing relationships between disparate areas of work.
INT5	When using the software for this task/process, I make unusual connections about ideas even if they are trivial.
INT6	When using the software for this task/process, I use more than one concept, method, or solution.
INT7	When using the software for this task/process, I deal with a maze of ideas which may, or may not, lead to somewhere.
INT8	When using the software for this task/process, I link ideas that stem from more than one area of investigation.

Label	Item Description
INT9	When using the software for this task/process, I am full of what appears to be novel methods of solving problem.
	Prior Knowledge of Work Process and Computers (19 items)
TSK1	I have used different software packages for this task/process.
TSK2	I have rotated several positions.
TSK3	I have general knowledge of this task/process for which I am using the software.
TSK4	I have field knowledge of this task/process for which I am using the software.
TSK5	I have knowledge about how to design this task/process.
TSK6	I have expertise on this task/process.
TSK7	I have knowledge of the cause and effect relationships in this task/process.
TSK8	I have a theoretical understanding of this task/process.
TSK9	I have an understanding of what the output of this application should look like.
TSK10	I have a conceptual understanding of how the computer can be used to help me with this task/process.
CIS1	I have used different types of software packages, e.g., spreadsheet, word processing.
CIS2	I have used programming languages for information system development.
CIS3	I have implemented computer information systems.
CIS4	I have participated in cross-function training courses.
CIS5	I have experience in non-technical analysis, e.g., feasibility studies.
CIS6	I have experience in designing computer information systems.
CIS7	I have hands-on experience of how to use the software for my job assignments.
CIS8	I have knowledge about how to design the computer software for this task/process.
CIS9	I have knowledge of the database/input data required by this application.

3.1.2. Measures for Learning Motivation

Learning motivation refers to an individual's objectives, beliefs, and norms of using a CIM application. It includes goal clarity, intrinsic motivation, and social norms. The measurement indicators of goal clarity are generated from the researches of Barki and Hartwick (1989), Senge (1990), Thomas and Velthouse (1990), Lant and Mezias (1990; 1992), Lant (1992), and Spreitzer(1995). The items for intrinsic motivation are adapted from Igbaria et al. (1995). The items for social norms are developed from the studies of Fishbein and Azjen (1975), Robey (1979), Stata (1989), Igbaria, Parasuraman, and Baroudi (1996), Shein (1996), Ahmed, Loh, and Zairi (1999), and Barnard (1999).

Table 3.1.2. Measurement Items of Learning Motivation Used in the Pilot Study (24 items)

Label	Item Description
	Goal Clarity (12 items)
GLS1	Using the software for this task/process is important to me.
GLS2	I foresee what I am going to achieve when using software for this task/process.
GLS3	I foresee what benefits can be achieved by the use of the software for this task/process.
GLS4	I foresee the overall picture of how this task/process fits in the whole project.
GLS5	I foresee the overall picture of how this task/process fits into other tasks/processes.
GLS6	The objective in using software for this task/process makes sense to me.
GLS7	The goal of using the software for this task/process is meaningful to me.
GLS8	The goal that will be achieved through using the software for this task/process is important to the company's success.
GLS9	The objective of using the software for this task/process is clear to me.
GLS10	The goal that will be achieved through using the software for this task/process is clear to me.
GLS11	I have a clear goal in mind when using the software for this task/process.
GLS12	I can achieve my goal by using the software for this task/process.
	Intrinsic Motivation (3 items)
ITM1	Using the software for this task/process is enjoyable.
ITM2	Using the software for this task/process is pleasurable.
ITM3	Using the software for this task/process fosters enjoyment.
	Social Norms (9 items)
SNM1	I foresee what my colleagues expect of me when using software for this task/process.
SNM2	I foresee what important people expect of me when using the software package for this task/process.
SNM3	The people I work with expect me to use this application effectively.
SNM4	The people I work with expect me to improve this application.
SNM5	The people I work with expect me to master this application.
SNM6	The people I work with expect me to use the computer to improve my work process.
SNM7	Management has set up a clear vision of using the software for this task/process.
SNM8	Management has established a clear objective for using the software for this task/process.
SNM9	My supervisor has set up a clear goal for using the software for this task/process.

A total of twenty-four (24) items are generated to measure goal clarity, intrinsic motivation, and social norms of learning motivation (see Table 3.1.2). Different from that of learning capacity, a five-point Likert type scale used is 1= Strongly disagree, 2= Disagree, 3= Neutral, 4= Agree, and 5= Strongly agree.

3.1.3. Measures for Empowerment

Empowerment refers to an individual's authoritative, cognitive, and resource readiness of using a CIM application. It is measured from autonomy, self-efficacy, and support perspectives. The items that measure autonomy are based on Spreitzer's (1995; 1996) work. The items that measure self-efficacy are drawn on the studies of Spreitzer (1995), Compeau and Higgins (1995[b]), Gist and Mitchell (1992), and Igbaria et al. (1995). The measurement items of the support scale are developed from the studies of Scott and Bruce (1994), Igbaria et al. (1995), and Igbaria et al. (1996). These studies provide in-depth descriptions and illustrations for empowerment. Some of them also suggest measurement scales. In this case, items or parts of them are adapted to IT learning setting, where appropriate.

Twenty-eight items are thus generated to measure autonomy, self-efficacy, and support of empowerment (see Table 3.1.3). Same as that of learning motivation but different from that of learning capacity, a five-point Likert type scale is used where 1= Strongly disagree, 2= Disagree, 3= Neutral, 4= Agree, and 5= Strongly agree.

3.1.4. Measures for CI Efforts

Continuous improvement efforts refer to the extent to which an individual strives to enhance one's skills and knowledge of how the software should be used, to understand the work process, and to improve the software and/or the work process to better fit the task requirements. Items for measuring the construct are generated through reviewing the continuous improvement and learning literature (e.g., Hatch & Mowery, 1998; Li & Rajagopalan, 1998; Zangwill & Kantor, 1998; Anderson et al, 1995; Hackman &

Wageman, 1995; Doll, 1994; Leonard-Barton, Bowen, Clark, Holloway, & Wheelwright, 1994; Imai, 1986; Mazur & Hastie, 1978). Doll (1994) develops measurement scales for software improvement and skill enhancement, which are revised and adapted to this study.

Table 3.1.3. Measurement Items of Empowerment Used in the Pilot Study (28 items)

Label	Item Description
	Autonomy (4 items)
AUT1	I can decide on my own how to use the software for this task/process.
AUT2	I have considerable opportunity for independence in how I use the software for this task/process.
AUT3	I have considerable opportunity for freedom in how I use the software for this task/process.
AUT4	I have significant autonomy in determining how I use this application.
	Self-Efficacy (13 items)
SEF1	I am confident about my ability to use the software for this task/process.
SEF2	I am self-assured about my capabilities of using the software to perform my work.
SEF3	I have mastered the skills necessary for using this application.
SEF4	I could complete the job using this application if I only had the software manuals for reference.
SEF5	I could complete the job using this application if I just had the built-in help facility for assistance.
SEF6	I could complete the job using this application if I had enough time to complete the job for which the application was provided.
SEF7	I could complete the job using this application if I had used similar applications before this one to do the same job.
SEF8	I could complete the job using this application if I had seen someone else using it before trying it myself.
SEF9	I could complete the job using this application if I had never used an application like it before.
SEF10	I could complete the job using this application if someone showed me how to do it first.
SEF11	I could complete the job using this application if someone else had helped me get started.
SEF12	I could complete the job using this application if I could call someone for help if I got stuck.
SEF13	I could complete the job using this application if there was no one around to tell me what to do as I go.
	Support (11 items)
SPT1	Cross training on other jobs is available to me.

Label	Item Description
SPT2	Software training is available to me.
SPT3	Training for this task/process is available to me.
SPT4	Technical training opportunities are available to me.
SPT5	I am well supported in using the software for this task/process.
SPT6	I have the necessary help to become familiar with this application.
SPT7	I have the necessary resources to get acquainted with this application.
SPT8	When I had difficulty in using the software for this task/process, I can exchange information with others who know how to better use this application.
SPT9	When I had difficulty in using the software for this task/process, I can talk to other people who are more knowledgeable.
SPT10	When I had difficulty in using the software for this task/process, I can consult with our Help Desk.
SPT11	When I had difficulty in using the software for this task/process, I can discuss with others who know how to make better use of this application.

Twenty-five items are developed to measure the process improvement, skill enhancement, and software improvement efforts when an engineer uses CIM applications (see Table 3.1.4). Same as that of learning capacity, a five-point Likert type scale is used where 1= To none or a little extent, 2= To some extent, 3= To a moderate extent, 4= To a great extent, and 5= To a very great extent.

3.1.5. Measures for IT Utilization

Information technology utilization refers to the extent to which an individual uses IT for one's work. Previous research in IT utilization is reviewed (e.g., Seeley & Targett, 1999; Doll & Torkzadeh, 1998; Igbaria et al., 1995; Igbaria et al., 1996; Moor & Benbasat, 1991; Davis, 1989; Melone, 1990; Weick, 1990; Zuboff, 1988; Delone, 1988; Hirschhorn, 1984; Robey, 1979). Of which, Doll and Torkzadeh (1998) develop scales measuring the similar constructs as those proposed in the IT learning model. All the relevant items are kept or adapted to the current research. The measurement scale of the four aspects of IT utilization (i.e., decision support, problem solving, work integration, and work planning) includes thirty items (see Table 3.1.5). A five-point Likert type scale used here is 1=Not at all, 2= A little, 3=Moderately, 4=Much, and 5=A great deal.

Table 3.1.4. Measurement Items of Continuous Improvement Efforts Used in the Pilot Study (25 items)

Label	Item Description
	Process Learning (5 items)
PRL1	I train on-the-job to use the task/process more effectively.
PRL2	I spend time on-the-job learning how to perform this task/process more efficiently.
PRL3	I spend time on-the-job learning how to improve this task/process.
PRL4	I spend time on-the-job learning how to perform this task/process more effectively.
PRL5	I spend time on-the-job learning how to apply this task/process to different projects.
	Process Improvement (7 items)
PRC1	When necessary, I change the way this task/process works.
PRC2	I make changes in this task/process that make it easier to use.
PRC3	I make changes in this task/process that make it more useful.
PRC4	I make changes in this task/process that make it applicable to different tasks.
PRC5	I make changes in this task/process that improve my productivity.
PRC6	I make changes in this task/process that improve the quality of my work.
PRC7	I make changes in this task/process that give me greater control over my work.
	Software Learning (6 items)
SKL1	I spend time on-the-job learning how to use the software for this task/process more efficiently.
SKL2	I spend time on-the-job learning how to use additional features of the software.
SKL3	I spend time on-the-job learning how to use the software for different tasks/processes.
SKL4	I spend significant time on-the-job learning how to make full use of the software.
SKL5	I spend time learning more about how to use the software for the task/process.
SKL6	I train on-the-job to use the software more effectively.
	Software Improvement (7 items)
SFT1	I make changes in the software that make it easier to use.
SFT2	I make changes in the software that make it more useful.
SFT3	I make changes in the software that make it applicable to different tasks/processes.
SFT4	I make changes in the software that improve my productivity.
SFT5	I make changes in the software that improve the quality of my work.
SFT6	I make changes in the software that give me greater control over my work.
SFT7	When necessary, I change the way the software works.

Table 3.1.5. Measurement Items of Information Technology Utilization Used in the Pilot Study (30 items)

Label	Item Description
	Decision Support (8 items)
DSP1	I use software for this task/process to help me explain my decisions.
DSP2	I use software for this task/process to help me justify my decisions.
DSP3	I use software for this task/process to help me make explicit the reasons for my decisions.
DSP4	I use software for this task/process to rationalize my decisions.
DSP5	I use software for this task/process to control or shape the decision process.
DSP6	I use software for this task/process to improve the effectiveness of the decision process.
DSP7	I use software for this task/process to improve the efficiency of the decision process.
DSP8	I use software for this task/process to make the decision process more rational.
	Problem Solving (6 items)
PSE1	I use software for this task/process to help me think through problems.
PSE2	I use software for this task/process to make sense out of data.
PSE3	I use software for this task/process to make sure the data matches my analysis of problems.
PSE4	I use software for this task/process to analyze why problems occur.
PSE5	I use software for this task/process to decide how to best approach a problem.
PSE6	I use software for this task/process to check my thinking against the data.
	Vertical Integration (4 items)
WIV1	I use software for this task/process to communicate with people who report to me.
WIV2	I use software for this task/process to communicate with people I report to.
WIV3	I use software for this task/process to exchange information with people who report to me.
WIV4	I use software for this task/process to keep my supervisor informed.
	Horizontal Integration (8 items)
WIH1	I use software for this task/process to communicate with other people in my work group.
WIH2	I use software for this task/process to communicate with people in other work groups/departments.
WIH3	I use software for this task/process to coordinate activities with others in my work group.
WIH4	I use software for this task/process to coordinate activities with people in other work groups/departments.
WIH5	I use software for this task/process to exchange information with people in my work group.
WIH6	I use software for this task/process to exchange information with people in other work groups/departments.
WIH7	I use software for this task/process to keep people in other work groups/departments informed.
WIH8	My work group and I use the software for this task/process to coordinate our activities.
	Work Planning (4 items)

Label	Item Description
WPL1	I use software for this task/process to help me manage my work.
WPL2	I use software for this task/process to get feedback on job performance.
WPL3	I use software for this task/process to monitor my own performance.
WPL4	I use software for this task/process to plan my work.

3.1.6. Measures for Impact on Work

IT's impact on individual work measures the extent to which an IT application influences an individual's work. After previous studies about IT impact are reviewed (e.g., Li & Ye, 1999; Heckman, 1999; Torkzadeh & Doll, 1999; Joshi & Lauer, 1998; Krause, Handfield, & Scannell, 1998; Kamath & Liker, 1994; Igbaria & Tan, 1997; Ryker & Nath, 1995; Kraemer & Danziger, 1990; Weick, 1990), this study uses Torkzadeh and Doll's (1999) measurement instruments of the impact scale to measure task productivity, task innovation, management control, and customer satisfaction.

The measurement items for supplier management are generated based on the work of Torkzadeh and Doll (1999), Heckman (1999), Fleischer and Liker (1997), and Kamath and Liker (1994). Seventeen (17) items are developed to measure the five aspects of IT's impact on work (i.e., task productivity, task innovation, management control, customer satisfaction, and supplier management) (see Table 3.1.6). Same as that of IT utilization, a five-point Likert type scale is used where 1=Not at all, 2= A little, 3=Moderate, 4=Much, and 5=A great deal.

3.2. Data Analysis Methods

The data analysis focuses on the purification, unidimensionality, reliability, brevity, and simplicity of the factor structure of the measurement items. First, as suggested by Churchill (1979), the study purifies the items, that is, eliminates 'garbage items'. Next, an exploratory factor analysis is conducted to identify items that are not factorially pure (Weiss, 1970).

Table 3.1.6. Measurement Items of Impact on Work Used in the Pilot Study (17 items)

Label	Item Description
	Task Productivity (3 items)
TKP1	This application increases my productivity.
TKP2	This application saves me time.
TKP3	This application allows me to accomplish more work than would otherwise be possible.
	Task Innovation (3 items)
TKI1	This application helps me come up with new ideas.
TKI2	This application helps me create new ideas.
TKI3	This application helps me try out innovative ideas.
	Management Control (3 items)
MGC1	This application helps management control the work process.
MGC2	This application helps management control performance.
MGC3	This application improves management control.
	Customer Satisfaction (3 items)
CST1	This application helps me meet customer needs.
CST2	This application improves customer satisfaction.
CST3	This application improves customer service.
	Supplier Management (5 items)
SPL1	This application helps me provide a clear vision for suppliers.
SPL2	This application improves the coordination with suppliers.
SPL3	This application helps me meet supplier needs.
SPL4	This application improves the cooperation with suppliers.
SPL5	This application improves the communication with suppliers.

3.2.1. Purifying Items for the Scales (using SPSS)

The measurement items have to be purified before a factor analysis is conducted (i.e., to eliminate garbage items). The need to purify the items/indicators of a construct is described by Churchill (1979). He contends that when a factor analysis is done before purification, more dimensions tend to be produced than can be conceptually identified, thus confounding the interpretation of the factor analysis.

Items are eliminated if their corrected-item total correlation (i.e., the correlation of an item with the sum of the other items in its category) is less than 0.50. The domain-sampling model suggests that all items, if they belong to the domain of a concept, have an equal amount of common core (Churchill, 1979). If all items of a measure are drawn from the domain of a single construct, responses to those items should be highly inter-correlated. The corrected-item total correlation (CITC) provides a measure for this purpose.

The purification process begins with a CITC analysis. For each scale, the hypothesized items are pooled together to test the reliability of each item. CITC is used to decide whether or not to keep an item. If the corrected item-total correlation is less than .50, then the item is removed from the scale. The process is repeated till all corrected item-total correlations are greater than .50. However, in the process of eliminating the items, the scale's reliability should increase. Otherwise, the item should be kept and the process should stop.

3.2.2. Checking the Factorial Structure for Each Construct (using SPSS)

The purified items hypothesized to measure a variable (e.g., learning motivation) are then analyzed to examine the factorial structure of the variable. DeVellis (1991) provides three reasons for using factor analysis. One of the primary functions of a factor analysis is to help an investigator determine how many latent variables underlie a set of items. A second purpose, which follows from the first, is to provide a means of explaining variation among relatively many original measurement items using relatively few newly created variables (i.e., factors). This amounts to condensing information so that variation can be accounted for by using a smaller number of variables. A third purpose is to define the substantive content or meaning of the factors (i.e., latent variables) that account for the variation among a larger set of items. This is accomplished by identifying groups of items that covary with one another and appear to define meanings that underlie latent variables. If anticipated item groupings are identified prior to factoring, a factor analytic solution that is consistent with these groupings provides some evidence of factorial validity (Comrey, 1988).

The items in each scale of a variable are assumed to be the indicators of the same scale. If the factor analysis reveals more than one factor, theory has to be employed to determine whether or not to eliminate the additional factor or conclude that the construct is more complex than the originally anticipated (Weiss, 1970). Items that are not factorially pure (item-factor loading on more than one factor at 0.40 or above) or items that have item-factor loadings below 0.60 are considered as candidates for elimination.

The number of factors to extract in this research is based on Kaiser's Eigen values that should be equal to or greater than 1 (e.g., Nunnally, 1978). This rule suggests that only factors that explain more variance than the average amount explained by one of the original items be retained. The logic behind Kaiser's method is that if the worst factor explains more variance than an original item, then one is achieving some degree of condensation, that is, the ability to explain variation with a set of factors smaller than the original number of items (DeVellis, 1991). Varimax rotation (i.e., direct oblimin rotation in SPSS) is used for factor rotation. For simplification purpose, if the value of an item-factor loading is less than 0.30, then the value will not be listed.

To achieve a stable factor structure, the ratio of respondents to items is suggested to be at least between 5 and 10 (Tinsley & Tinsley, 1987). Comrey (1988) contends that a sample size of 200 is adequate in most cases of ordinary factor analysis that involves no more than 40 items.

The reliability of all scales is examined using Cronbach's (1951) alpha along with computations of average variance extracted. Average variance extracted (Fornell & Larcker, 1981) is similar to the LISREL measure of composite reliability, but differs in that the standardized loadings are squared before they are summed. Average variance extracted measures the amount of variance for the specified indicators accounted for by a latent construct/scale. Higher values of variance extracted occur when the indicators are truly representative of the latent construct. The variance-extracted indicator is a complementary measure of the construct reliability. Guidelines suggest that the value of variance extracted should exceed 0.50 for a construct (Bagozzi & Yi, 1988). In general, reliabilities above 0.80 indicate that the scale performs well (Nunnally, 1978).

3.2.3. Checking the Model-Data Fit for the Scales (using LISREL)

A measurement model using items purified through steps 1 and 2 is specified in LISREL to examine the unidimensionality and the correlated error terms of the scale. A non-significant p-value indicates that the measurement model fits the data well. Otherwise, Root Mean Square Error of Approximation (RMSEA), Non-Normed Fit Index (NNFI), and Comparative Fit Index (CFI) are used to check the model-data fit. If the

RMSEA of the model is greater than 1.0, then the modification index is used to find out the correlated error terms. One of the items should be removed from the model if the error terms are correlated. The item(s) with better theory support will be kept. The process will be repeated till the RMSEA goes below 1.0.

A model with the values of NNFI and CFI equal to or greater than .90 is considered as good. A model with the NNFI and CFI equal to or greater than .80 but less than .90 is considered as satisfactory.

3.2.4. The Discriminant Validity Test (using LISREL)

Next, a Chi-square test described by Bagozzi and Phillips (1982) is used to assess the discriminant validity between pairs of constructs/scales. Using LISREL, models of pairs of latent constructs and their indicators are run with the correlation between the latent constructs fixed at 1.0 and also with the correlation between the latent constructs free to assume any value. The difference in chi-square values for the fixed and free solutions indicates whether a unidimensional rather than a two-dimensional model accounts for the intercorrelations among the observed items in each pair. The Chi-square difference equal to or greater than 3.84 for one degree of freedom indicates discriminant validity between the scales.

3.2.5. The Predictive Power of the Scales (using SPSS)

The predictive power of the scales is evidenced by the correlations between the scales. A stepwise linear regression method is used to check the predictive power of the scales. All variables to the left of the focus variable are entered as independent variables for a regression equation (see Figure 2.4). For example, when the scale of process improvement is designated as a dependent variable, all scales to its left (i.e., all the scales of learning capacity, learning motivation, and empowerment) are specified as independent variables. When 'problem solving' is chosen as a dependent variable, scales of learning drivers and continuous improvement efforts are entered as independent variables.

3.3. The Pilot Study

The purposes of a pilot study are to collect the initial data, to purify the measurement items, to verify the factorial structure of the measurement scales, to examine the model-data fit of each measurement scale, and to investigate the predictive power of the scales. The pilot study provides an opportunity to refine the instruments before proceeding with a large-scale study.

An evaluation of the instruments before the large-scale study is helpful in several ways. First, it provides a final opportunity to remove "bugs" from the scales. Second, it provides a vehicle to assess the preliminary reliability and validity of the scales. It should be noted, however, that such assessments are based on a small sample at hand.

During the pilot study, first, the items are reviewed and modified through a series of activities that use industry and academic experts. Where any expert/practitioner suggests that the domain of a construct be more adequately covered, the researcher modifies the items and/or generates additional items to capture the phenomena. Second, a test is conducted to establish the construct validity and to further enhance the content validity, readability, and brevity of the refined items. An item is a candidate to be deleted if 1). its content validity is below 0.70 (Gatewood & Field, 1994); 2). it loads above 0.40 on any other factors; or 3). its item-factor loading is 0.20 less than the highest item-factor loading of an item measuring the same construct (Babbie, 1998).

A sample of about fifty is drawn from potential respondents to conduct a preliminary reliability analysis of each scale and discriminant analysis between scales by using SPSS and LISREL. Even though Harris and Schaubroeck (1990) suggest a minimum sample size of 100 when using LISREL for data analysis, they recommend a sample size of at least 200. However, sample sizes of 67 or less for cross-validating applications are widely observed in business settings (Doll, Hendrickson, & Deng, 1998). For example, Adams, Nelson, and Todd (1992) use a sample size of 54 to cross-validate graphics applications.

The respondents of the pilot study are engineers or specialists who use CIM applications for their daily work at manufacturing firms. The CIM applications can be any of the computer software packages used for manufacturing tasks such as CAD, CAE, CAM, CAPP, AGVS, AS/RS, JIT, MRP II, CNC, and robotics.

3.3.1. The Data Collection Process

The data are collected from the manufacturing technology center of an automotive company where a variety of manufacturing applications are in use. During the initial contact with the company, the researcher introduces the purpose, the scope, and the implications of the study. After the company agrees to cooperate, the researcher asks the company to identify the potential respondents, the software packages they are using, and the process/task they are using the software for. Four people are initially chosen to answer the questionnaire and are asked for the opinions of the fitness of the questions. Some modifications have been made based on their suggestions.

Table 3.2. Responses Classified by Application in the Pilot Study

Application	Case	Percentage
Advanced Material Handling & Logistics	1	2.2
Body Construction/CAE/Intelligent Control	1	2.2
C3P Technology	3	6.5
CAD	1	2.2
CAD/DFA	1	2.2
CNC	1	2.2
Control Technologies and Automation/Intelligent Control	1	2.2
DOE/SPC	1	2.2
Environmental Technology	1	2.2
Ergonomics	1	2.2
Ergonomics Analysis	1	2.2
Graphics Software	1	2.2
Heating Treating/CAD/CAM	1	2.2
Knowledge-Based Engineering	2	4.3
Machine Process Improvement/CAE/FEA	1	2.2
Machining/ Intelligent Control	1	2.2
Machining Performance Optimization/FEA	1	2.2
Material Planning & Logistics	2	4.3
Material Planning & Packaging Engineering	2	4.3
Material Planning & Packaging Engineering/Simulation	1	2.2
Metal Coating/Intelligent Control/CNC	2	4.3
Modeling/Simulation	1	2.2
Office System Support and Planning/CAE	1	2.2
Quality and Reliability	1	2.2
Robotics	1	2.2
Sealing	1	2.2
System Modeling/Optimization	1	2.2
System Modeling/Simulation	9	19.6
Vehicle Assembly/DFA/DFM	2	4.3
Vision, Sensing, & Identification	1	2.2
Welding and Mechanical Fasteners/CAE	1	2.2
Total	**46**	**100.0**

The cover page of the questionnaire is then customized with a specific software package and a process used by a specific person (see Appendix 1). Then the questionnaire with the cover page is distributed to the corresponding person through the contact person in the company. The respondents are asked to remove the cover page when they return the completed questionnaire to remain anonymous. A note from the management is attached to show the endorsement of the company. With this endorsement, the respondent rate is expected to increase.

3.3.2. The Sample of the Pilot Study

A total of two hundred and twenty five (225) questionnaires are sent out. Fifteen (15) people have left the company or are unreachable. For the remaining two hundred and ten (210) people, forty-nine (49) respond. Three responses miss many questions and thus are not included for data analysis. This leads to forty-six (46) usable responses, representing a twenty two percent (22%) of response rate.

Table 3.3. Responses Classified by Gender in the Pilot Study

Gender	Cases	Percentage
Female	6	13.0
Male	36	78.3
Missing	4	8.7
Total	**46**	**100.0**

Table 3.4. Responses Classified by Position in the Pilot Study

Position	Cases	Percentage
Top management	0	0.0
Middle level management	9	19.6
First level supervisor	6	13.0
Professional employee without supervisory responsibility	24	52.2
Other (e.g.. operating personnel)	4	8.7
Missing	3	6.5
Total	**46**	**100.0**

The sample is appropriate for this study since all the respondents are knowledge workers who use information technology for their work intensively. The applications cover the majority of the CIM applications discussed before (see Table 3.2). Tables 3.3 and 3.4 illustrate the demographics of the sample by gender and position in the firm. The information reflects the situation of an average research center in manufacturing firms.

3.3.3. The Results of the Pilot Study

The measurement items for each dimension are purified through SPSS. Items with CITC less than 0.50 are removed from further analysis. The remained items are then analyzed with LISREL to check the items with correlated error terms. If the error term of an item is correlated with that of another item, one of them should be removed.

After each scale has been purified, the scales (e.g., autonomy, self-efficacy, and support) of a variable (e.g., empowerment) are pooled together to check the factorial structure of the variable. Normally, Eigen value (>1) is used to extract factors. In the case where the number of extracted factors is not the same as the number suggested in theory, factor number is used to extract factors. Varimax (i.e., direct oblimin in SPSS) rotation is used for factor rotation. The results are interpreted with caution at this stage since the ratio of respondents to items is relatively low for certain scales such as the prior knowledge. Several items have significant cross loadings. Tables 3.5.1 thru 3.5.6 show the results of the factor analysis for each variable. Each table includes pattern matrix and component correlation matrix.

Four factors are obtained for learning capacity dimension (see Table 3.5.1). Systematic problem-solving style and intuitive problem-solving style are remained as hypothesized. The prior knowledge scale is split into prior knowledge of work process and prior knowledge of computers, indicating that engineers view the two types of knowledge differently.

Table 3.5.1. Structural Analysis of Learning Capacity during the Pilot Study

Pattern Matrix

	Component			
	1	2	3	4
TSK8	0.828			
TSK3	0.795			
TSK9	0.773			
TSK6	0.762			
TSK1	0.732			
TSK5	0.711			
TSK10	0.692			
INT2		0.922		
INT4		0.874		
INT5		0.863		
INT7		0.823		
INT8		0.707		
INT3		0.699		
SYS3			0.919	
SYS1			0.916	
SYS4			0.868	
SYS2			0.764	
CIS3				-0.932
CIS2				-0.874
CIS6				-0.873

Component Correlation Matrix

Component	1	2	3	4
1. Prior Knowledge of Work Process	1			
2. Intuitive Problem Solving	0.192	1		
3. Systematic Problem Solving	0.250	4.929E-03	1	
4. Prior knowledge of Computers	-0.352	-0.233	-0.116	1

Table 3.5.2. Structural Analysis of Learning Motivation during the Pilot Study

Pattern Matrix

	Component		
	1	2	3
GLS4	0.936		
GLS11	0.862		
GLS12	0.857		
GLS5	0.775		
GLS9	0.728		
SNM8		0.966	
SNM7		0.900	
SNM9		0.774	
ITM3			0.994
ITM2			0.928
ITM1			0.813

Component Correlation Matrix

Component	1	2	3
1. Goal Clarity	1		
2. Social Norms	0.304	1	
3. Intrinsic Motivation	0.405	0.230	1

Table 3.5.3. Structural Analysis of Empowerment during the Pilot Study

Pattern Matrix

	Component		
	1	2	3
SPT9	0.921		
SPT11	0.877		
SPT8	0.825		
SPT5	0.707		
SEF7		0.886	
SEF8		0.834	
SEF5		0.823	
SEF6		0.786	
AUT4			0.935
AUT3			0.922
AUT2			0.881
SEF2	0.327		0.650

Component Correlation Matrix

Component	1	2	3
1. Support	1		
2. Self-Efficacy	0.355	1	
3. Autonomy	0.331	9.716E-02	1

Three factors are obtained as hypothesized for learning motivation (see Table 3.5.2). They are goal clarity, intrinsic motivation, and social norms. Three factors are obtained for empowerment dimension as hypothesized: autonomy, self-efficacy, and support (see Table 3.5.3). Item SEF2 of self-efficacy is loaded (0.650) on autonomy and is cross-loaded (0.327) on supports. The item is thus reworded for the large-scale study.

Table 3.5.4. Structural Analysis of Continuous Improvement Efforts during the Pilot Study

Pattern Matrix

	Component		
	1	2	3
SFT4	1.008		
SFT5	1.001		
SFT6	0.982		
SFT1	0.932		
SFT3	0.866		
SFT7	0.702		
SKL4		0.897	
SKL5		0.868	
SKL1		0.738	
SKL6		0.643	-0.385
PRC2			-0.975
PRC6			-0.873
PRC3			-0.792
PRL3			-0.775

Component Correlation Matrix

Component	1	2	3
1. Software Improvement	1		
2. Skill Enhancement	0.261	1	
3. Process Improvement	-0.528	-0.510	1

For continuous improvement efforts, three factors are derived: software improvement, skill enhancement, and process improvement (see Table 3.5.4). Originally hypothesized process learning scale is merged with the process improvement scale. This may reflect the fact that engineers don't separate process learning from process improvement. Item SKL6 of skill enhancement is cross-loaded (-0.385) on process improvement. Since the loading is less than 0.40, the item is kept for the large-scale study.

Table 3.5.5. Structural Analysis of Information Technology Utilization during the Pilot Study

Pattern Matrix

	Component	
	1	2
DSP5	0.997	
DSP6	0.890	
DSP7	0.825	
PSE5	0.656	
PSE1		0.958
PSE2		0.748
DSP2		0.704
PSE4		0.646

Component Correlation Matrix

Component	1	2
1. Decision Support	1	
2. Problem Solving	0.612	1

Pattern Matrix

	Component	
	1	2
WIH2	1.021	
WIH7	0.808	
WIV2	0.794	
WIH5	0.730	
WIH1	0.716	
WIV1	0.681	
WPL4		-0.928
WPL3		-0.924
WIH8		-0.839
WPL1		-0.805

Component Correlation Matrix

Component	1	2
1. Work Integration	1	
2. Work Planning	-0.567	1

For information technology utilization dimension, items are analyzed separately for a better factorial structure (see Table 3.5.5). Overall, four factors are derived: decision support, problem solving, work integration, and work planning. Item PSE5 of problem solving is loaded on decision support rather than on problem solving as originally hypothesized and item DSP2 of decision support is loaded on problem solving rather than on decision support. This may indicate that engineers don't distinguish the decision support and problem solving activities in their work.

Table 3.5.6. Structural Analysis of Impact on Work during the Pilot Study

Pattern Matrix

	Component				
	1	2	3	4	5
SPL5	0.968				
SPL4	0.892				
SPL3	0.825				
CST3	0.549				0.473
MGC2		0.956			
MGC3		0.934			
MGC1		0.928			
TKI2			0.969		
TKI3			0.826		
TKI1		0.324	0.690		
TKP2				0.958	
TKP1				0.849	
TKP3				0.827	
CST2					0.805
CST1				0.315	0.735

Component Correlation Matrix

Component	1	2	3	4	5
1. Supplier Management	1				
2. Management Control	0.312	1			
3. Task Innovation	0.255	0.415	1		
4. Task Productivity	0.451	0.215	0.425	1	
5. Customer Satisfaction	0.424	0.283	0.110	0.249	1

Item WIH8 of work integration is loaded on work planning rather than on horizontal integration. The item reads as "My work group and I use the software for this task/process to coordinate our activities." It is possible that individual engineers view coordination with group as a work planning activity. It may also indicate that horizontal integration and working planning are the same or closely related concepts to the engineers. The items are thus kept for the large-scale study for further investigation.

For Impact on work, five factors are obtained (see Table 3.5.6). Based on the content of measurement items, they represent supplier management, management control, task innovation, task productivity, and customer satisfaction. These scales are consistent with the hypothesized scales. Item TKI1 of task innovation is cross-loaded (0.324) on management control and item CST1 of customer satisfaction is cross-loaded (0.315) on task productivity. Since the cross loadings are less than 0.40, they are kept for the large-scale study.

The exception is item CST3 of customer satisfaction, which is cross-loaded (0.549) on supplier management. The item reads as "This application improves customer service." The cross loading suggests that engineers view supplier management and customer service as similar concepts. Two new items are thus generated for customer satisfaction in the large-scale study.

Tables 3.6.1 thru 3.6.6 show the measurement items suggested from the pilot study. The first column is the label of each item; the second column reports the corrected item-total correlation (CITC), and the third column describes each item. At the top of each group (scale) is the label of the scale with the reliability in parenthesis.

Table 3.6.1. Measurement Items of Learning Capacity Suggested from the Pilot Study (total 20 items)

Label	CITC	Item Description
		Systematic Problem-Solving (alpha = .9164)
SYS1	.8650	When using the software for this task/process, I adhere to the commonly established rules of my area of work.
SYS2	.8166	When using the software for this task/process, I adhere to the well-known techniques, methods, and procedures of my area of work.
SYS3	.8466	When using the software for this task/process, I adhere to the standards of my area of work.
SYS4	.7385	When using the software for this task/process, I follow well-established ways and generally accepted methods for solving problems.
		Intuitive Problem-Solving (alpha = .9057)
INT2	.7973	When using the software for this task/process, I search for novel approaches not required at the time.
INT3	.6134	When using the software for this task/process, I struggle to make connections between apparently unrelated ideas.
INT4	.8238	When using the software for this task/process, I spend time tracing relationships between disparate areas of work.
INT5	.7742	When using the software for this task/process, I make unusual connections about ideas even if they are trivial.
INT7	.7585	When using the software for this task/process, I deal with a maze of ideas which may, or may not, lead to somewhere.
INT8	.6862	When using the software for this task/process, I link ideas that stem from more than one area of investigation.
		Prior Knowledge of Work Process (alpha = .8760)
TSK1	.5960	I have used different software packages for this task/process.
TSK3	.6487	I have general knowledge of this task/process for which I am using the software.
TSK5	.6495	I have knowledge about how to design this task/process.
TSK6	.6215	I have expertise on this task/process.
TSK8	.7516	I have a theoretical understanding of this task/process.
TSK9	.7123	I have an understanding of what the output of this application should look like.
TSK10	.6900	I have a conceptual understanding of how the computer can be used to help me with this task/process.
		Prior Knowledge of Computers (alpha = .9039)
CIS2	.7701	I have used programming languages for information system development.
CIS3	.8443	I have implemented computer information systems.
CIS6	.8232	I have experience in designing computer information systems.

For learning capacity, the original 38 items are purified through a reliability test and a factorial structure examination. Twenty (20) items are remained to measure four factors (see Table 3.6.1). The CITC values range from 0.5960 (TSK1) to 0.8650 (SYS1). The values of reliability range from 0.8760 for prior knowledge of work process to 0.9164 for systematic problem-solving style.

Table 3.6.2. Measurement Items of Learning Motivation Suggested from the Pilot Study (total 11 items)

Label	CITC	Item Description
		Goal Clarity (alpha = .9023)
GLS4	.8151	I foresee the overall picture of how this task/process fits in the whole project.
GLS5	.7329	I foresee the overall picture of how this task/process fits into other tasks/processes.
GLS9	.7212	The objective of using the software for this task/process is clear to me.
GLS11	.8285	I have a clear goal in mind when using the software for this task/process.
GLS12	.7104	I can achieve my goal by using the software for this task/process.
		Intrinsic Motivation (alpha = .9223)
ITM1	.8070	Using the software for this task/process is enjoyable.
ITM2	.8860	Using the software for this task/process is pleasurable.
ITM3	.8387	Using the software for this task/process fosters enjoyment.
		Social Norms (alpha = .8753)
SNM7	.8100	Management has set up a clear vision of using the software for this task/process.
SNM8	.8083	Management has established a clear objective for using the software for this task/process.
SNM9	.6689	My supervisor has set up a clear goal for using the software for this task/process.

The CITC values of learning motivation range from 0.6689 (SNM9) to 0.8860 (ITM2). The values of reliability range from 0.8753 for social norms to 0.9223 for intrinsic motivation (see Table 3.6.2). For empowerment, the CITC values range from 0.6182 (SEF8) to 0.8719 (AUT3). The values of reliability range from 0.8460 for self-efficacy to 0.8954 for autonomy (see Table 3.6.3).

Table 3.6.3. Measurement Items of Empowerment Suggested from the Pilot Study (total 12 items)

Label	CITC	Item Description
		Autonomy (alpha = .8954)
SEF2	.6440	I am self-assured about my capabilities of using the software to perform my work.
AUT2	.7853	I have considerable opportunity for independence in how I use the software for this task/process.
AUT3	.8719	I have considerable opportunity for freedom in how I use the software for this task/process.
AUT4	.7849	I have significant autonomy in determining how I use this application.
		Self-Efficacy (alpha = .8460)
SEF5	.6737	I could complete the job using this application if I just had the built-in help facility for assistance.
SEF6	.6876	I could complete the job using this application if I hadenough time to complete the job for which the application was provided.
SEF7	.7553	I could complete the job using this application if I had used similar applications before this one to do the same job.
SEF8	.6182	I could complete the job using this application if I had seen someone else using it before trying it myself.
		Support (alpha = .8767)
SPT5	.6307	I am well-supported in using the software for this task/process.
SPT8	.7447	When I had difficulty in using the software for this task/process, I can exchange information with others who know how to better use this application.
SPT9	.8137	When I had difficulty in using the software for this task/process, I can talk to other people who are more knowledgeable.
SPT11	.7965	When I had difficulty in using the software for this task/process, I can discuss with others who know how to make better use of this application.

The CITC values of continuous improvement efforts range from 0.6351 (SKL1) to 0.9693 (SFT4). The values of reliability range from 0.8627 for skill enhancement to 0.9732 for software improvement (see Table 3.6.4).

For information technology utilization, the CITC values range from 0.6188 (PSE1) to 0.9101 (WPL4). The values of reliability range from 0.8625 for problem solving to 0.9162 for work planning (see Table 3.6.5). For CIM impact on work, the CITC values range from 0.6793 (CST3) to 0.9329 (MGC3). The values of reliability range from 0.8264 for customer satisfaction to 0.9570 for management control (see Table 3.6.6).

Table 3.6.4. Measurement Items of Continuous Improvement Efforts Suggested from the Pilot Study (total 14 items)

Label	CITC	Item Description
		Process Improvement (alpha = .9233)
PRL3	.7984	I spend time on-the-job learning how to improve this task/process.
PRC2	.8733	I make changes in this task/process that make it easier to use.
PRC3	.8094	I make changes in this task/process that make it more useful.
PRC6	.8122	I make changes in this task/process that improve the quality of my work.
		Skill Enhancement (alpha = .8627)
SKL1	.6351	I spend time on-the-job learning how to use the software for this task/process more efficiently.
SKL4	.6673	I spend significant time on-the-job learning how to make full use of the software.
SKL5	.7916	I spend time learning more about how to use the software for the task/process.
SKL6	.7578	I train on-the-job to use the software more effectively.
		Software Improvement (alpha = .9732)
SFT1	.8948	I make changes in the software that make it easier to use.
SFT3	.9110	I make changes in the software that make it applicable to different tasks/processes.
SFT4	.9673	I make changes in the software that improve my productivity.
SFT5	.9640	I make changes in the software that improve the quality of my work.
SFT6	.9524	I make changes in the software that give me greater control over my work.
SFT7	.7865	When necessary, I change the way the software works.

Overall, the high CITC values (ranging from 0.5960 to 0.9693) and the high reliability (ranging from 0.8264 to 0.9732) indicate that the measurement items of each scale are appropriate for a large-scale study.

Table 3.7 shows the data-model fit index of each measurement scale. For each scale, the table reports the Chi-square (normal theory weighted least squares), degree of freedom, p-value, RMSEA (Root Mean Square Error of Approximation), NNFI (Non-

Normed Fit Index), CFI (Comparative Fit Index), and the number of items. The Chi-square values range from 0 to 17.22. The degrees of freedom range from 0 to 14. All p-values are non-significant (from 0.1059 to 1). The values of RMSEA are low (less than 0.073) except for the self-efficacy scale, which has RMSEA value of 0.166. Since the p-value is not significant, this high RMSEA value of the scale is not a concern. All NNFI and CFI values are above 0.90, which is excellent for data-model fit. The number of items for each scale ranges from 3 to 7.

Table 3.6.5. Measurement Items of Information Technology Utilization Suggested from the Pilot Study (total 18 items)

Label	CITC	Item Description
		Decision Support (alpha = .9064)
DSP5	.7090	I use software for this task/process to control or shape the decision process.
DSP6	.8362	I use software for this task/process to improve the effectiveness of the decision process.
DSP7	.8982	I use software for this task/process to improve the efficiency of the decision process.
PSE5	.7260	I use software for this task/process to decide how to best approach a problem.
		Problem Solving (alpha = .8625)
DSP2	.7050	I use software for this task/process to help me justify my decisions.
PSE1	.6188	I use software for this task/process to help me think through problems.
PSE2	.7753	I use software for this task/process to make sense out of data.
PSE4	.7489	I use software for this task/process to analyze why problems occur.
		Work Integration (alpha = .9118)
WIH1	.7550	I use software for this task/process to communicate with other people in my work group.
WIV1	.6782	I use software for this task/process to communicate with people who report to me.
WIV2	.8283	I use software for this task/process to communicate with people I report to.
WIH2	.7781	I use software for this task/process to communicate with people in other work groups/departments.
WIH5	.7478	I use software for this task/process to exchange information with people in my work group.
WIH7	.7632	I use software for this task/process to keep people in other work groups/departments informed.
		Work Planning (alpha = .9162)

Label	CITC	Item Description
WPL1	.6918	I use software for this task/process to help me manage my work.
WPL3	.8106	I use software for this task/process to monitor my own performance.
WPL4	.9101	I use software for this task/process to plan my work.
WIH8	.8297	My work group and I use the software for this task/process to coordinate our activities.

Table 3.6.6. Measurement Items of Impact on Work Suggested from the Pilot Study (total 15 items)

Label	CITC	Item Description
		Task Productivity (alpha = .9126)
TKP1	.8503	This application increases my productivity.
TKP2	.8679	This application saves me time.
TKP3	.7601	This application allows me to accomplish more work than would otherwise be possible.
		Task Innovation (alpha = .8962)
TKI1	.7868	This application helps me come up with new ideas.
TKI2	.8378	This application helps me create new ideas.
TKI3	.7639	This application helps me try out innovative ideas.
		Management Control (alpha = .9570)
MGC1	.8825	This application helps management control the work process.
MGC2	.9207	This application helps management control performance.
MGC3	.9329	This application improves management control.
		Customer Satisfaction (alpha = .8264)
CST1	.6851	This application helps me meet customer needs.
CST2	.7175	This application improves customer satisfaction.
CST3	.6793	This application improves customer service.
		Supplier Management (alpha = .9288)
SPL3	.8092	This application helps me meet supplier needs.
SPL4	.9108	This application improves the cooperation with suppliers.
SPL5	.8519	This application improves the communication with suppliers.

Table 3.8 reports the reliability and the discriminant validity of each scale. The numbers in the cells on diagonal are the reliability of the scale. The reliability ranges from .85 for self-efficacy to .97 for software improvement, indicating that each scale is reliable. The numbers in the cells off diagonal are the correlation coefficient between the corresponding scales. The values range from -.071 for work planning with prior

knowledge of computers to .727 for problem solving with process improvement. One asterisk (*) associated with the number indicates that the correlation is significant at 0.05 levels while two asterisks (**) associated with the number indicate that the correlation is significant at 0.01 levels. The numbers in parenthesis are the Chi-square difference with one degree of freedom for the corresponding scales. The Chi-square differences are from 27 for problem solving with process improvement to 251 for work integration with software improvement. The numbers indicate discriminant validity for all scales.

Table 3.8 also reports the mean and standard deviation of each scale as shown at the bottom of the table. It reports the number of items generated from literatures, the number of items suggested by the pilot study, of those suggested items the number of reworded items, the number of items added for the large-scale study, and the total number of items used for the large-scale study.

Table 3.9 illustrates the predictive power of each scale and the R-square of each criterion. The criteria are listed on the right-hand side of the table. The R-squares of the criteria range from 0.287 for task productivity to 0.675 for process improvement, suggesting that at least 28.7 percent of the variance is explained for each criterion. For each row, the cells with shaded area indicate that they are not included as predictors. The numbers in the cells indicate that the corresponding scales are entered into the equation to predict the corresponding criterion and the values in the cell is the standard beta coefficient of the regression analysis. Most of the beta coefficients are positive and range from 0.322 to 0.619. Systematic problem solving style has a negative coefficient (-0.228) with process improvement, indicating that the engineers with strong systematic problem-solving style conduct less process improvement. Prior knowledge of computers has a

Table 3.7. The Data-Model Fit Index of the Scales for the Pilot Study

		Chi-square	Degree of freedom	p-value	RMSEA	NNFI	CFI	# of Items
Information Technology Utilization	Decision support	2.43	2	.2961	0.069	0.99	1.00	4
	Problem solving	1.54	2	.4625	0.000	1.01	1.00	4
	Work integration	9.14	9	.4240	0.020	0.99	0.99	6
	Work planning	0.23	2	.8924	0.000	1.04	1.00	4
Continuous Improvement Efforts	Process improvement	2.09	2	.3522	0.032	1.00	1.00	4
	Skill enhancement	1.27	2	.5288	0.000	1.03	1.00	4
	Software improvement	9.22	9	.4169	0.024	1.00	1.00	6
Learning Capacity	System-problem solving	2.36	2	.3075	0.063	0.99	1.00	4
	Intuitive-problem solving	4.52	9	.8737	0.000	1.05	1.00	6
	Prior knowledge of work process	17.22	14	.2245	0.073	0.97	.98	7
	Prior knowledge of computers	0	0	1	0			3
Learning Motiva-tion	Goal clarity	5.57	2	.3503	0.050	0.98	.99	5
	Intrinsic motivation	0	0	1	0			3
	Social norms	0	0	1	0			3
Empower-ment	Autonomy	1.94	2	.3795	0.000	1.00	1.00	4
	Self-efficacy	4.49	2	.1059	0.166	0.90	0.97	4
	Support	0.90	2	.6386	0.000	1.03	1.00	4

Table 3.8. The Reliability and the Discriminant Validity of the Scales for the Pilot Study

		Systematic problem solving	Intuitive problem solving	Prior knowledge of computers	Prior knowledge of work process	Goal clarity	Social norms	Intrinsic motivation	Autonomy	Self-efficacy	Support	Process improvement	Skill enhancement	Software improvement	Decision support	Problem solving	Work integration	Work planning
Learning Capacity	Systematic problem solving	.92																
	Intuitive problem solving	.076 (134)	.91															
	Prior knowledge of computers	.282 (82)	.256 (77)	.90														
	Prior knowledge of work process	.339* (152)	.255 (228)	.430** (64)	.88													
Learning Motivation	Goal clarity	.268 (145)	.311* (182)	.486** (70)	.657** (48)	.90												
	Social norms	.317* (56)	.335* (63)	.428** (51)	.261 (51)	.362* (63)	.88											
	Intrinsic motivation	.163 (84)	.321* (66)	.478** (69)	.407** (74)	.466** (80)	.278 (62)	.92										
Empowerment	Autonomy	.344* (116)	.399** (97)	.377* (64)	.364* (101)	.448** (104)	.265 (57)	.213 (82)	.90									
	Self-efficacy	.115 (82)	.540** (43)	.183 (90)	.288 (77)	.273 (79)	.345* (68)	.111 (78)	.149 (85)	.85								
	Support	.523** (88)	.123 (101)	.372* (75)	.345* (96)	.484** (96)	.485** (46)	.201 (82)	.443** (102)	.411** (59)	.88							
Continuous Improvement Efforts	Process improvement	.141 (135)	.432** (131)	.398** (64)	.560** (115)	.549** (111)	.412** (50)	.450** (74)	.549** (95)	.519** (55)	.396** (112)	.92						
	Skill enhancement	.402** (87)	.317* (78)	.429** (81)	.551** (59)	.540** (64)	.452** (52)	.201 (89)	.599** (66)	.335* (78)	.451** (79)	.670** (41)	.86					
	Software improvement	.051 (121)	.265 (245)	.390** (78)	.448** (191)	.397** (135)	.330* (48)	.275 (75)	.208 (118)	.519** (66)	.222 (101)	.602** (91)	.358* (79)	.97				
Information Technology Utilization	Decision support	.292* (157)	.159 (120)	.472** (71)	.513** (112)	.528** (138)	.469** (57)	.225 (86)	.320* (108)	.316* (78)	.525** (87)	.584** (94)	.574** (82)	.595** (107)	.91			
	Problem solving	.366* (86)	.284 (86)	.424** (75)	.635** (42)	.662** (41)	.354* (58)	.374* (79)	.528** (84)	.416** (68)	.567** (64)	.727** (27)	.559** (56)	.547** (63)	.712** (42)	.86		
	Work integration	.212 (145)	.229 (241)	.375* (74)	.423** (198)	.458** (172)	.573** (45)	.208 (82)	.528** (90)	.371* (69)	.479** (90)	.638** (81)	.470** (83)	.464** (251)	.711* (78)	.611** (53)	.91	
	Work planning	.092 (138)	.090 (121)	-.071 (70)	.352* (95)	.206 (157)	.318* (48)	.107 (72)	.283 (105)	.278 (76)	.315* (103)	.463** (111)	.353* (72)	.424** (105)	.606** (80)	.460** (70)	.621** (101)	.92
Mean		13.9	18.1	6.2	25.9	20.2	9.8	10.2	16.1	13.0	15.6	13.6	13.0	15.3	13.1	14.2	18.9	10.5
Standard Deviation		3.0	5.3	3.5	5.2	2.4	2.4	2.6	3.1	3.4	3.1	3.9	3.3	8.0	4.1	3.9	5.9	4.5
# of Initial Items		10	9	4	15	12	9	3	7	10	11	12	6	7	4	10	13	4
# of Items Recommended		4	6	3	7	5	3	3	4	4	4	4	4	6	4	4	6	4
# of reworded items		1							1	4			2		1		2	1
# of New Items		2		3			3	3	3	3	2	2	2	1	2		2	
Total items for large scale study		**6**	**6**	**6**	**7**	**5**	**6**	**6**	**7**	**7**	**6**	**6**	**6**	**7**	**6**	**4**	**8**	**4**

The reliability of scale Intrinsic Motivation is .92

The correlation between scale Support and scale Autonomy is .443, which is at .01 significant level.
The two scales have discriminant validity because the Chi-square difference with one degree of freedom difference is 102.

Table 3.9. The Predictive Power of the Scales and the R-Square of the Criteria for the Pilot Study

Systematic problem solving	Intuitive problem solving	Prior knowledge of work process	Prior knowledge of computers	Goal clarity	Intrinsic motivation	Social norms	Autonomy	Self-efficacy	Supports	Process improvement	Skill enhancement	Software improvement	Problem solving	Decision support	Work integration	Work planning	Criteria	R-Square
														0.536			Task productivity	0.287
													0.557				Task innovation	0.310
													0.558				Management control	0.311
															0.559		Customer satisfaction	0.312
															0.562		Supplier management	0.316
									0.378			0.505					Decision support	0.521
				0.382						0.514							Problem solving	0.628
						0.401				0.496							Work integration	0.565
			-0.377							0.619							Work planning	0.330
-0.228		0.383					0.506	0.322									Process improvement	0.675
		0.356					0.480										Skill enhancement	0.484
		0.324						0.452									Software improvement	0.395

negative beta coefficient (-0.377) with work planning, suggesting that the more prior knowledge of computers an engineer has, the less likely the engineer will use the software package for work planning.

The measurement instruments are evaluated based on the results of the pilot study before the large-scale study. Some scales are re-conceptualized, new items are added, and/or existing items are modified, wherever appropriate. If the remaining items of a scale are less than six, new items will be developed for the large-scale study. All items are coded with a five-digit prefix for identification purposes. The first two-digit represents the variable and the last three-digit represents the scale of that variable. For example, all items measuring the impact on work variable have a prefix of IP. Items measuring task productivity have a prefix of IP followed by a prefix of TKP and a successive number designator (i.e., IPTKP1, IPTKP2, and IPTKP3). These codes are shown later in the large-scale data analysis section.

After the pilot study, a total of 128 items are recommended for the large-scale study (see Tables 3.10.1 thru 3.10.6). For each scale, the first column shows the labels used in the pilot study (e.g., TKP1, TKP2, etc.). The second column indicates the status of the item. A space means that the item is from the pilot study; an "R" indicates that the item is reworded based on the results of the pilot study; and an "A" represents that the item is newly generated for the large-scale study. The third column shows the labels used for the large-scale study (e.g., IPTKP1, IPTKP2, etc.). The fourth column is the description of each item.

In the revised measurement instrument, prior knowledge of the learning capacity scale is split into prior knowledge of work process and prior knowledge of computers.

Process learning and process improvement of the continuous improvement efforts scale are merged into process improvement. The vertical integration and horizontal integration scales of information technology utilization are merged into work integration; decision rationalization is renamed as decision support to reflect the content of the retained items.

Table 3.10.1. Measurement Scales of Learning Capacity Used in the Large-Scale Study (25 items)

PLabel	S	LLabel	Item Description
			Systematic Problem-Solving (6 items)
			When using the software for this process, I
SYS1		LCSYS1	adhere to the commonly established rules of my area of work.
SYS2		LCSYS2	adhere to the well-known techniques, methods, and procedures of my area of work.
SYS3		LCSYS3	adhere to the standards of my area of work.
SYS4	R	LCSYS4	follow well-established ways for solving problems.
	A	LCSYS5	follow generally accepted methods for solving problems.
	A	LCSYS6	accept the usual proven methods of solution.
			Intuitive Problem-Solving (6 items)
			When using the software for this process, I
INT2		LCINT1	search for novel approaches not required at the time.
INT3		LCINT2	struggle to make connections between apparently unrelated ideas.
INT4		LCINT3	spend time tracing relationships between disparate areas of work.
INT5		LCINT4	make unusual connections about ideas even if they are trivial.
INT7		LCINT5	deal with a maze of ideas which may, or may not, lead to somewhere.
INT8		LCINT6	link ideas that stem from more than one area of investigation.
			Prior Knowledge of Work Process (7 items)
TSK1		LCTSK1	I have used different software packages for this process.
TSK3		LCTSK2	I have general knowledge of this process for which I am using the software.
TSK5		LCTSK3	I have knowledge about how to design this process.
TSK6		LCTSK4	I have expertise on this process.
TSK8		LCTSK5	I have a theoretical understanding of this process.
TSK9		LCTSK6	I have an understanding of what the output of this application should look like.
TSK10		LCTSK7	I have a conceptual understanding of how the computer can be used to help me with this process.
			Prior Knowledge of Computers (6 items)
CIS2		LCCIS1	I have used programming languages for information system

PLabel	S	LLabel	Item Description
			development.
CIS3		LCCIS2	I have implemented computer information systems.
CIS6		LCCIS3	I have experience in designing computer information systems.
	A	LCCIS4	I have knowledge of computer database software.
	A	LCCIS5	I have implemented a database application.

Table 3.10.2. Measurement Scales of Learning Motivation Used in the Large-Scale Study (17 items)

PLabel	S	LLabel	Item Description
			Goal Clarity (5 items)
GLS4		LMGLS1	I foresee the overall picture of how this process fits in the whole project.
GLS5		LMGLS2	I foresee the overall picture of how this process fits into other processes.
GLS9		LMGLS3	The objective of using the software for this process is clear to me.
GLS11		LMGLS4	I have a clear goal in mind when using the software for this process.
GLS12		LMGLS5	I can achieve my goal by using the software for this process.
			Intrinsic Motivation (6 items)
ITM1		LMITM1	Using the software for this process is enjoyable.
ITM2		LMITM2	Using the software for this process is pleasurable.
ITM3		LMITM3	Using the software for this process fosters enjoyment.
	A	LMITM4	Using computers is fun.
	A	LMITM5	Working with computers is satisfying.
	A	LMITM6	Computers make my work more enjoyable.
			Social Norms (6 items)
SNM7		LMSNM1	Management has set up a clear vision of using the software for this process.
SNM8		LMSNM2	Management has established a clear objective for using the software for this process.
	A	LMSNM3	I understand the management's expectations of me for using the software for this process.
SNM9		LMSNM4	My supervisor has set up a clear goal for using the software for this process.
	A	LMSNM5	My supervisor has given a clear direction for using the software for this process.
	A	LMSNM6	I understand my supervisor's expectations of me for using the software for this process.

Table 3.10.3. Measurement Scales of Empowerment Used in the Large-Scale Study (20 items)

PLabel	S	LLabel	Item Description
			Autonomy (7 items)
SEF2		EPAUT1	I am self-assured about my capabilities of using the software to perform my work.
AUT2		EPAUT2	I have considerable opportunity for independence in how I use the software for this process.
AUT3		EPAUT3	I have considerable opportunity for freedom in how I use the software for this process.
AUT4	R	EPAUT4	I have significant autonomy in determining how I use the software for this process.
	A	EPAUT5	I have influence in how this software is used in this process.
	A	EPAUT6	I have control over my work.
	A	EPAUT7	I have a say in how I use this software for this process.
			Self-Efficacy (7 items)
	A	EPSEF1	I am confident about my ability to use the software to complete my work.
	A	EPSEF2	I believe my capabilities of using the software for my work.
	A	EPSEF3	I have mastered the skills necessary for using this software for my work.
			I could complete the job using this software if
SEF5	R	EPSEF4	I just had the built-in help facility for assistance.
SEF6	R	EPSEF5	I had enough time to complete the job for which the application was provided.
SEF7	R	EPSEF6	I had used similar applications before this one to do the same job.
SEF8	R	EPSEF7	I had seen someone else using it before trying it myself.
			Support (6 items)
SPT5		EPSPT1	I am well-supported in using the software for this process.
	A	EPSPT2	I have had the necessary resources for using the software for this process.
			When I had difficulty in using the software for this process, I can
SPT8		EPSPT3	exchange information with others who know how to better use of the software for the process.
SPT9		EPSPT4	talk to other people who are more knowledgeable.
SPT11		EPSPT5	discuss with others who know how to make better use of the software for the process.
	A	EPSPT6	go to my supervisor for help.

Table 3.10.4. Measurement Scales of Continuous Improvement Efforts Used in the Large-Scale Study (19 items)

PLabel	S	LLabel	Item Description
			Process Improvement (6 items)
PRL3		CIPRC1	I spend time on-the-job learning how to improve this process.
PRC2		CIPRC2	I make changes in this process that make it easier to use.
PRC3		CIPRC3	I make changes in this process that make it more useful.
PRC6		CIPRC4	I make changes in this process that improve the quality of my work.
	A	CIPRC5	I change the way this process works.
	A	CIPRC6	I look for ways to improve this process.
			Skill Enhancement (6 items)
SKL1	R	CISKL1	I spend time on-the-job learning how to use the software more efficiently.
SKL4		CISKL2	I spend significant time on-the-job learning how to make full use of the software.
SKL5	R	CISKL3	I spend time learning more about how to use the software for my work.
SKL6		CISKL4	I train on-the-job to use the software more effectively.
	A	CISKL5	I spend time on-the-job learning how to use advanced functions of the software.
	A	CISKL6	I spend time on-the-job learning how to use additional features of the software.
			Software Improvement (7 items)
SFT7		CISFT1	When necessary, I change the way the software works.
SFT1		CISFT2	I make changes in the software that make it easier to use.
SFT3		CISFT3	I make changes in the software that make it applicable to different processes.
SFT4		CISFT4	I make changes in the software that improve my productivity.
SFT5		CISFT5	I make changes in the software that improve the quality of my work.
SFT6		CISFT6	I make changes in the software that give me greater control over my work.
	A	CISFT7	I make changes in the software that make it better fit to my work.

Table 3.10.5. Measurement Scales of Information Technology Utilization Used in the Large-Scale Study (25 items)

PLabel	S	LLabel	Item Description
			Decision Support (8 items)
DSP5	R	TUDPI1	I use this application to control the decision process.
	A	TUDPI2	I use this application to shape the decision process.
DSP6		TUDPI3	I use this application to improve the effectiveness of the decision process.
DSP7		TUDPI4	I use this application to improve the efficiency of the decision process.

PLabel	S	LLabel	Item Description
PSE5		TUDPI5	I use this application to decide how to best approach a problem.
	A	TUDPI6	I use this application to make the decision process better fit to my work.
	A	TUDPI7	I use this application to help me make explicit the reasons for my decisions.
	A	TUDPI8	I use this application to rationalize my decisions.
			Problem Solving (5 items)
DSP2		TUPSE1	I use this application to help me justify my decisions.
PSE1		TUPSE2	I use this application to help me think through problems.
PSE2		TUPSE3	I use this application to make sense out of data.
PSE4		TUPSE4	I use this application to analyze why problems occur.
	A	TUPSE5	I use this application to make sure the data match my analysis of problems.
			Work Integration (8 items)
WIH1		TUWIT1	I use this application to communicate with other people in my work group.
WIV1		TUWIT2	I use this application to communicate with people who report to me.
WIV2		TUWIT3	I use this application to communicate with people I report to.
WIH2	R	TUWIT4	I use this application to communicate with people in other work groups.
	A	TUWIT5	I use this application to communicate with people in other departments.
WIH5		TUWIT6	I use this application to exchange information with people in my work group.
WIH7	R	TUWIT7	I use this application to keep people in other departments informed.
	A	TUWIT8	I use this application to keep people in other work groups informed.
			Work Planning (4 items)
WPL1		TUWPL1	I use this application to help me manage my work.
WPL3		TUWPL2	I use this application to monitor my own performance.
WPL4		TUWPL3	I use this application to plan my work.
WIH8	R	TUWPL4	I use this application to coordinate my work with my work group.

Table 3.10.6. Measurement Scales of Impact on Work Used in the Large-Scale Study (22 items)

PLabel	S	LLabel	Item Description
			Task Productivity (3 items)
TKP1		IPTKP1	This application increases my productivity.
TKP2		IPTKP2	This application saves me time.
TKP3		IPTKP3	This application allows me to accomplish more work than would otherwise be possible.
			Task Innovation (3 items)

PLabel	S	LLabel	Item Description
TKI1		IPTKI1	This application helps me come up with new ideas.
TKI2		IPTKI2	This application helps me create new ideas.
TKI3		IPTKI3	This application helps me try out innovative ideas.
			Management Control (3 items)
MGC1		IPMGC1	This application helps management control the work process.
MGC2		IPMGC2	This application helps management control performance.
MGC3		IPMGC3	This application improves management control.
			Customer Satisfaction (6 items)
CST1		IPCST1	This application helps me meet customer needs.
CST2		IPCST2	This application improves customer satisfaction.
CST3		IPCST3	This application improves customer service.
	A	IPCST4	This application enhances communication with customers.
	A	IPCST5	This application allows me to get the feedback from customers.
	A	IPCST6	This application helps understand customers.
			Supplier Management (7 items)
SPL3		IPSPL1	This application helps me meet supplier needs.
SPL4		IPSPL2	This application improves the cooperation with suppliers.
SPL5		IPSPL3	This application improves the communication with suppliers.
	A	IPSPL4	This application helps suppliers meet our needs.
	A	IPSPL5	This application helps me communicate requirements to suppliers.
	A	IPSPL6	This application improves the effectiveness of our supplier alliances.
	A	IPSPL7	This application helps us manage our supplier chain.

3.4. The Large-Scale Study

A large-scale study is conducted to assess the performance of the instrument scales and the associations between learning drivers, continuous improvement efforts, IT utilization, and impact on work.

An introduction package is developed for the large-scale data collection. Several manufacturing and engineering service firms in mid-west area have been contacted. When a company agrees to participate, they are asked to identify the potential software packages, end-users, and the processes. Then, the questionnaires (see Appendix 2) are distributed through a contact person in the company or posted on the company's Intranet. Five organizations have participated in the study. The total end-users surveyed are 743.

Of the 217 returned questionnaires, two hundred and eight (208) are usable, representing a 28 percent responding rate. They answer more than two thirds of the questions.

The collected data are categorized to help the participating firms understand their current level of the end-users' learning drivers, continuous improvement efforts, CIM usage pattern, and perceived impact on their work in related to the overall performance of all participating firms. This benchmarking result could help the firms find out their strengths and weaknesses on each aspect in relation to other firms, and thus provide an opportunity for future improvement of their CIM use.

The structural path analysis will be conducted to investigate the relationships among the learning drivers, the continuous improvement efforts, the information technology utilization, and the impact of CIM on work. SPSS and LISREL are used to examine the reliability and validity of each construct (Bollen, 1989). Should any model include too many items that lead to a un- or uni-identified model, partial or full aggregated model will be used instead.

Chapter 4: The Results of the Large-Scale Study

Sample characteristics are reported in Tables 4.1.1 thru 4.1.2. Of all the software packages surveyed, forty-four (44) percent are CAE; twenty-five (25) percent are CAD; seventeen (17) percent are customer information system (CIS); six (6) percent are simulation; and eight (8) percent are others (see Table 4.1.1). Overall, seventy-five (75) percent are engineering or manufacturing-related software packages. Of all the working processes reported, seventy nine percent (79%) are engineering or manufacturing processes; seventeen percent (17%) are project management; and four percent (4%) are others (see Table 4.1.2).

The majority respondents are engineers who use information technology intensively for manufacturing work. Most of the software packages surveyed are used for manufacturing or engineering processes; and the processes are engineering or manufacturing related such as CAD, CAE, and manufacturing. The information indicates that the nature of the sample is appropriate for a CIM study.

4.1. Large Scale Measurement Results

The data from 208 responses are analyzed with several objectives in mind: purification, simplicity of a factor structure, reliability, brevity, convergent validity, discriminant validity, and predictive validity. The measurement items are purified before

Table 4.1.1. Software Packages in the Sample of the Large Scale Study

Category	# of Cases	Percent	Software	# of Cases	Percent
CAE	91	44	ANSA	34	16.3
			CAE	7	3.4
			CATIA	7	3.4
			FEMB	3	1.4
			HYMESH	27	13
			ICEM	2	1.0
			MSC	9	4.3
			Other CAE	2	1.0
CAD	52	25	AutoCAD	23	11.1
			Eagle Point 13	18	8.7
			Eagle Point 99	11	5.3
Simulation	13	6	Arena 3.2	1	0.5
			Arena V3.5	1	0.5
			AutoMod 8.7	1	0.5
			ProModel	1	0.5
			ProModel 4.1	1	0.5
			Quest 4.0R3	1	0.5
			Simul8	1	0.5
			Simul8 5	1	0.5
			Simul8 5034	1	0.5
			Simul8 5038	1	0.5
			Witness	2	1.0
			Witness 9.1	1	0.5
Customer IS	35	17	CIS/ Lotus Notes	35	16.8
Other	17	8	Access	1	0.5
			ACT	4	1.9
			Excel	3	1.4
			Excel/Word	1	0.5
			PeachTree	2	1.0
			Rootwell Software	1	0.5
			Spreadsheet	1	0.5
			Teradata	1	0.5
			Visual Studio	1	0.5
			Word	2	1.0
Total	208	100		208	100

a structural analysis is conducted. This is important especially when the instruments are revised after the pilot study. Including "garbage" items that do not have a common core in the data analysis will produce additional dimensions that may not be conceptually identified in the factor analysis (Churchill, 1979). The details of the method have been described in Chapter 3.

Table 4.1.2. Engineering Processes in the Sample of the Large Scale Study

Engineering Processes	# of Cases	Percent
CAD	53	25.5
General Finite Element Analysis	28	13.5
Durability Analysis	17	8.2
Impact Simulation	16	7.7
NVH/Acoustics	15	7.2
Computational Fluid Dynamics	8	3.8
Manufacturing	7	3.4
Cellular Manufacturing	2	1
Metal Forming	5	2.4
CAM	2	1
CAE	1	0.5
CAE, Robotics, Logistics	1	0.5
Logistics	2	1
AGVS, Logistics	1	0.5
Simulation	2	1
Engine Combustion	1	0.5
Material Handling and Defect Detection	1	0.5
Process Analysis and Verification	1	0.5
Other Engineering Process	1	0.5
Contact/ Project Management	35	16.8
Sales	4	1.9
Accounting	2	1
Services/ Business Processes	1	0.5
Company Internet	1	0.5
Data Warehouse	1	0.5
Total	208	100

Response rate is checked for each item and each respondent before data analysis. More than one-fourth (59 out of 217) of the responses have missed the measurement items LCCIS6 (a measurement item of learning capacity) and EPAUT1 (a measurement item of empowerment). These two items are thus excluded for further analysis. Respondents that have answered more than two-thirds (86 out of 128) of the questions are treated as usable. This leads to a total of 208 usable responses with 126 items for data analysis. Sections 4.1.1 thru 4.1.6 report the analysis results for each variable in the research model. Section 4.1.7 summarizes the results of the measurement instruments.

4.1.1. Learning Capacity

Table 4.2.1 provides initial results of SPSS for each scale of learning capacity. The alpha values for systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers are .8890, .7276, .8727, and .8720 respectively. The values indicate that each scale is reliable. The corrected item-total correlation (CITC) values for system problem solving, prior knowledge of work process, and prior knowledge of computers are high, ranging from .54 for LCTSK1 (a measurement item of prior knowledge of work process) to .78 for LCCIS3 (a measurement item of prior knowledge of computers). The measurement item LCINT2 of the intuitive problem-solving scale has a low CITC value of 0.25 and is thus excluded for further analysis. The CITC values for remaining measurement items of the intuitive problem-solving scale range from .47 for LCINT5 to .56 for LCINT3, suggesting a future improvement on this scale.

A LISREL measurement model is constructed for each scale with the hypothesized measurement items. Figure 4.1.1 shows the initial results of each scale of learning capacity. Two LISREL diagrams are presented for each scale. The one on the left reports the names of the measurement items, the construct/scale name, and the standardized solution of the measurement model. The one on the right shows the modification index of the measurement model. At the bottom of the both diagrams show the model's Chi-square value, degree of freedom (df), P-value, and RMSEA. If a model does not have any modification index, then the t-value of the model is reported. In this case, phrase *T-Value is used to indicate the situation.

Table 4.2.1. The Initial Reliability Analysis of Learning Capacity

Systematic Problem Solving (alpha=.8890; N=201)	
Measurement Items	Corrected Item-Total Correlation
LCSYS1	0.6544
LCSYS2	0.7354
LCSYS3	0.7521
LCSYS4	0.7599
LCSYS5	0.7565
LCSYS6	0.5853

Intuitive Problem Solving (alpha=.7276; N=199)	
Measurement Items	Corrected Item-Total Correlation
LCINT1	0.4311
LCINT2	**0.2459**
LCINT3	0.5912
LCINT4	0.5244
LCINT5	0.4977
LCINT6	0.4961
Revised Intuitive Problem Solving Measurement (alpha=.7503; N=200)	
Measurement Items	Corrected Item-Total Correlation
LCINT1	0.4786
LCINT3	0.5646
LCINT4	0.5102
LCINT5	0.4774
LCINT6	0.5476

Prior Knowledge of Work Process (alpha=.8727; N=191)	
Measurement Items	Corrected Item-Total Correlation
LCTSK1	0.5430
LCTSK2	0.7024
LCTSK3	0.5696
LCTSK4	0.7688
LCTSK5	0.6962
LCTSK6	0.6845
LCTSK7	0.6664

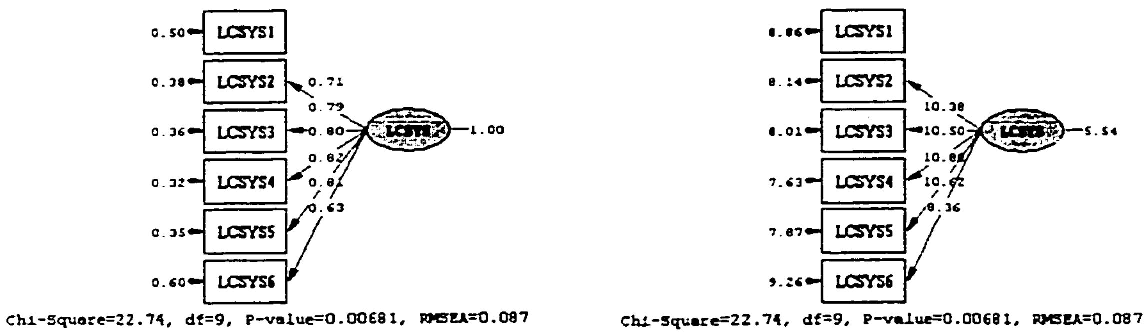
Prior Knowledge of Computers (alpha=.8720; N=197)

Measurement Items	Corrected Item-Total Correlation
LCCIS1	0.6949
LCCIS2	0.7151
LCCIS3	0.7880
LCCIS4	0.6291
LCCIS5	0.6772

Measurement models of systematic problem solving, prior knowledge of the process, and prior knowledge of computers do not show the modification index. The t-values of their measurement models are reported. However, measurement model of intuitive problem solving suggests a modification index. The error term of item LCINT5 is correlated with that of item LCINT6. The removal of one of the correlated items for the scale can improve the model's data-model fit index.

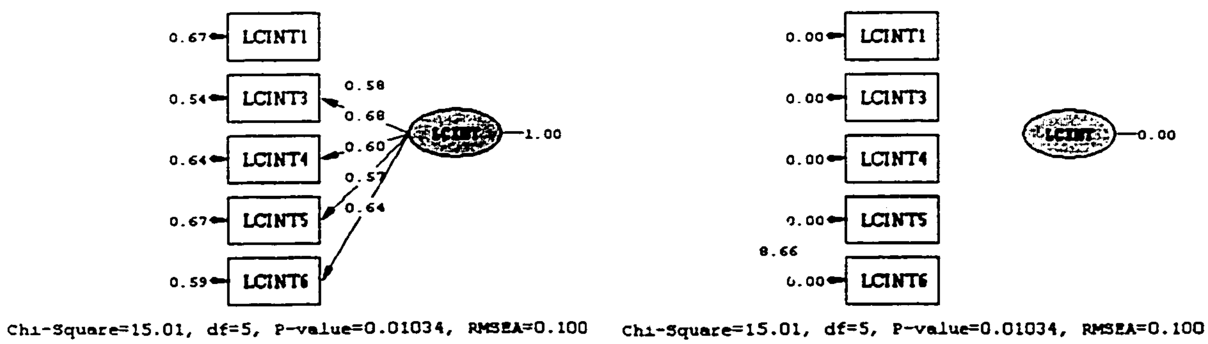
Figure 4.1.1 The Initial Measurement Results of Learning Capacity

Systematic Problem-Solving

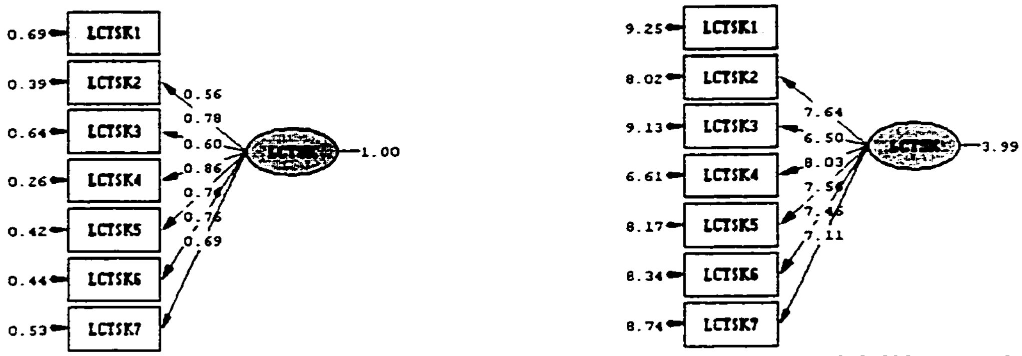


• T-Values

Intuitive Problem-Solving



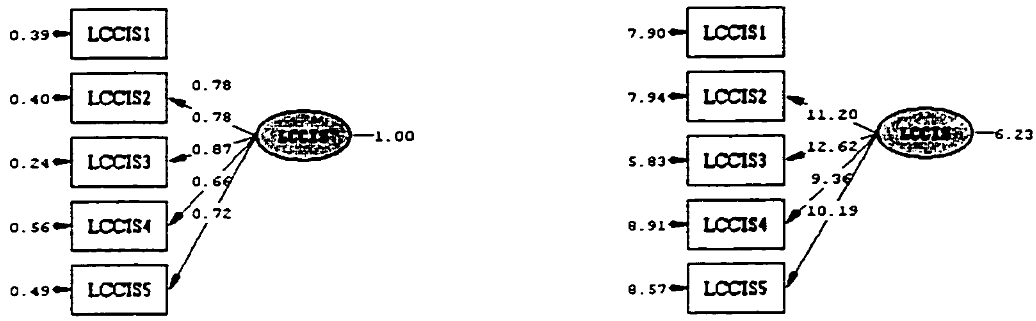
Prior Knowledge of Work Process



Chi-Square=24.46, df=14, P-value=0.04028, RMSEA=0.063 Chi-Square=24.46, df=14, P-value=0.04028, RMSEA=0.063

• T-Values

Prior Knowledge of Computers



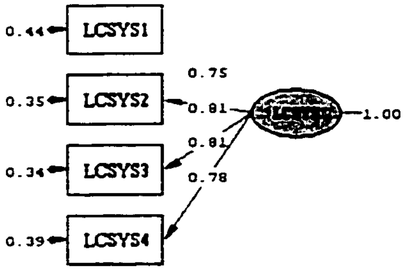
Chi-Square=13.21, df=5, P-value=0.02147, RMSEA=0.092 Chi-Square=13.21, df=5, P-value=0.02147, RMSEA=0.092

• T-Values

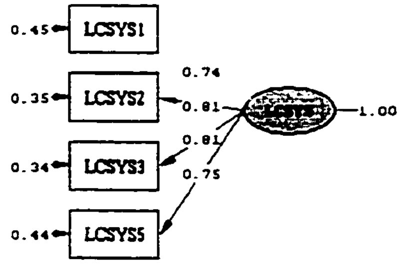
The removal of measurement items is based on following rules. First, the item with a high correlated error term will be removed from the model. Second, the item with a low item-factor loading will be removed from the model. Third, for any competing items, the item with better theory support will be kept in the model. The measurement model is regarded as satisfactory if its P-value is equal to or greater than 0.05 or its RMSEA index is less than 0.10. Competing models are kept as alternatives for further factorial analysis. Figure 4.1.2 shows the alternative measurement model(s) of each scale of learning capacity.

Figure 4.1.2. The Alternative Measurement Solutions for Learning Capacity

Systematic Problem-Solving Style

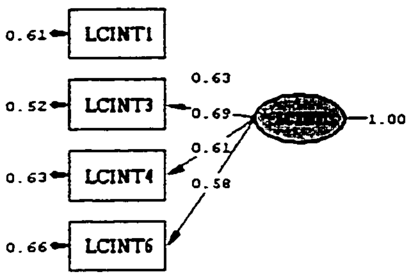


Chi-Square=0.85, df=2, P-value=0.65491, RMSEA=0.000

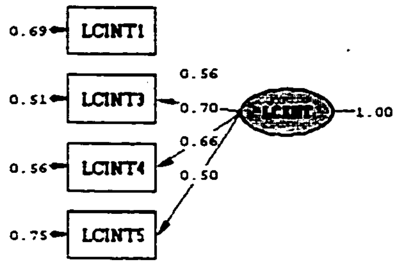


Chi-Square=1.19, df=2, P-value=0.55202, RMSEA=0.000

Intuitive Problem-Solving Style

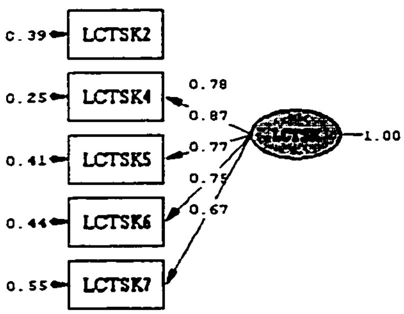


Chi-Square=2.55, df=2, P-value=0.27949, RMSEA=0.037

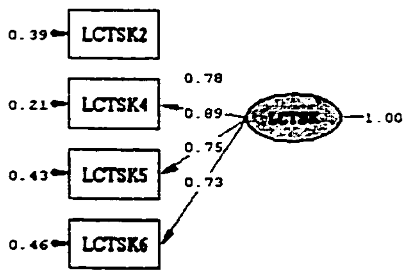


Chi-Square=1.94, df=2, P-value=0.37837, RMSEA=0.000

Prior Knowledge of Work Process

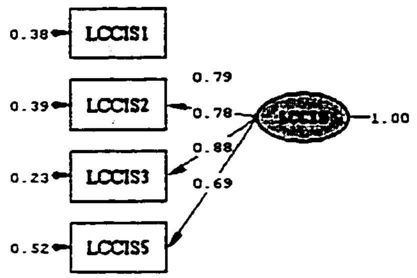


Chi-Square=9.98, df=5, P-value=0.07579, RMSEA=0.072

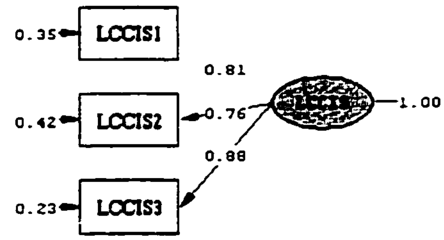


Chi-Square=3.92, df=2, P-value=0.14109, RMSEA=0.071

Prior Knowledge of Computers



Chi-Square=5.47, df=2, P-value=0.06473, RMSEA=0.094



Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

An exploratory factor analysis is conducted on the items suggested from data purification. The analysis uses principal components as the means of extraction and varimax as the method of rotation (Table 4.2.2). The ratio of respondents to items is 13, which satisfies the general guidelines. By specifying four factors, the factorial structure of the learning capacity shows that the Eigen values for the scales of systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers are 2.740, 1.040, 5.860, and 1.351 respectively. The cumulative variance explained by the four scales is sixty nine percent (69%).

Overall, the factor analysis provides a clean structure for learning capacity. All measurement items demonstrate good item-factor loadings. For simplicity, Table 4.2.2 shows only the values of item-factor loadings that are equal to or greater than 0.30. The results indicate that all items load well on their respective factor of learning capacity. No item has a cross loading greater than 0.30, suggesting that each item measures only the hypothesized factor, not the other factors.

Table 4.2.2. Factorial Analysis Results of Learning Capacity

Pattern Matrix

Items	Component			
	Prior Knowledge of Work Process	Systematic Problem-Solving	Prior Knowledge of Computers	Intuitive Problem-Solving
LCTSK6	0.864			
LCTSK4	0.820			
LCTSK5	0.814			
LCTSK2	0.725			
LCTSK7	0.679			
LCSYS1		-0.886		
LCSYS3		-0.826		
LCSYS2		-0.810		
LCSYS4		-0.670		
LCCIS3			0.870	
LCCIS2			0.836	
LCCIS5			0.824	
LCCIS1			0.795	
LCINT5				0.788
LCINT3				0.709
LCINT4				0.664

Component Correlation Matrix

Component	Prior Knowledge of Work Process	Systematic Problem-Solving	Prior Knowledge of Computers	Intuitive Problem-Solving
Prior Knowledge of Work Process	1			
Systematic Problem-Solving	-0.439	1		
Prior Knowledge of Computers	0.379	-8.85E-02	1	
Intuitive Problem-Solving	0.320	-5.13E-02	0.356	1

Eigen Value	5.860	2.740	1.351	1.040
% of Variance	36.623	17.122	8.445	6.500
Total Variance Explained: 69%				

All the five measurement items of systematic problem solving load on a single factor (i.e., column 2 in Table 4.2.2) and the item-factor loadings are greater than 0.67. The three items of intuitive problem solving load together with item-factor loadings greater than 0.66 (see column 3 in Table 4.2.2). All measurement items of prior knowledge of work process also load together with the item-factor loadings above 0.67 (see column 1 in Table 4.2.2). The four items of prior knowledge of computers load on a single factor and all loadings are greater than 0.79 (see column 4 in Table 4.2.2). Overall, the factor pattern matrix is simple; all of the items load high on their respective factors and low on others.

Table 4.2.3. Measurement Scales of Learning Capacity Recommended for Future Studies (16 items)

Label	Item Description	CITC
	Systematic Problem-Solving (No of Cases = 203; No of Items = 4; Alpha = .8670)	
	When using the software for this process, I	
LCSYS1	adhere to the commonly established rules of my area of work...............	0.6833
LCSYS2	adhere to the well-known techniques, methods, and procedures of my area of work..	0.7375
LCSYS3	adhere to the standards of my area of work.................................	0.7403
LCSYS4	follow well-established ways for solving problems..........................	0.7150
	Intuitive Problem-Solving (No of Cases = 202; No of Items = 3; Alpha = .6599)	
	When using the software for this process, I	
LCINT3	spend time tracing relationships between disparate areas of work........	0.4990
LCINT4	make unusual connections about ideas even if they are trivial..............	0.4851
LCINT5	deal with a maze of ideas which may, or may not, lead to somewhere......	0.4306
	Prior Knowledge of Work Process (No of Cases = 200; No of Items = 5; Alpha = .8744)	
LCTSK2	I have general knowledge of this process for which I am using the software	0.7120
LCTSK4	I have expertise on this process..	0.7778
LCTSK5	I have a theoretical understanding of this process..............................	0.7183
LCTSK6	I have an understanding of what the output of this application should look like..	0.6897
LCTSK7	I have a conceptual understanding of how the computer can be used to help me with this process...	0.6292
	Prior Knowledge of Computers (No of Cases = 198; No of Items = 4; Alpha = .8614)	
LCCIS1	I have used programming languages for information system development...	0.6965
LCCIS2	I have implemented computer information systems............................	0.7236
LCCIS3	I have experience in designing computer information systems................	0.7846
LCCIS5	I have implemented a database application....................................	0.6410

Cronbach's alpha is then calculated for all factors (see Table 4.2.3). The systematic problem-solving scale (LCSYS) has four items and a reliability alpha of 0.87. The intuitive problem-solving scale (LCINT) has three items and a relative low reliability alpha of 0.66. The prior knowledge of work process scale (LCTSK) has an alpha of 0.87 for five items. The prior knowledge of computers scale (LCCIS) with four items has an alpha of 0.86. Overall, the reliabilities for the scales systematic problem solving, prior knowledge of work process, and prior knowledge of computers are high (greater than 0.80).

Section 1 in Table 4.3 shows the data-model fit index for each scale of learning capacity. The chi-square values for the systematic problem solving, prior knowledge of work process, and prior knowledge of computers are 0.85, 9.98, and 5.47 respectively. The p-values are non-significant (> .06). The values of RMSEA, ECVI, NNFI, and CFI indicate that they have an excellent data-model fit. The intuitive problem solving scale is saturated. The chi-square is one and the degree of freedom is zero. Other information is not available. This is true for all saturated model.

LISREL methodology is employed to test the discriminant validity between pairs of constructs in the four-factor solution (Bagozzi & Phillips, 1982). Six models showing pairs of latent variables and their observable variables are run: (1) with the correlation between the latent variables fixed at 1.0 and (2) with the correlation between the latent variables free to assume any value. The difference in chi-square values for the fixed and free solutions indicates whether a uni-dimensional model will be sufficient to account for the inter-correlations among the observed variables in each pair. The difference between the chi-square values (one degree of freedom) for the fixed and free solutions for the six

Table 4.3. The Data-Model Fit Index of the Scales

		Chi-square	Degree of freedom	p-value	RMSEA	ECVI	NNFI	CFI	# of Items
1 Learning Capacity	Systematic-Problem Solving	0.85	2	.6549	0.000	0.090	1.00	1.00	4
	Intuitive-Problem Solving	0	0	1	0				3
	Prior Knowledge of Work Process	9.98	5	.0758	0.072	0.16	0.98	.99	5
	Prior Knowledge of Computers	5.47	2	.0647	0.094	0.11	0.99	0.99	4
2 Learning Motivation	Goal Clarity	5.68	2	.0584	0.096	0.11	0.96	.99	4
	Intrinsic Motivation	2.58	2	.2757	0.038	0.092	0.99	1.00	4
	Social Norms	5.42	2	.0666	.092	0.11	0.98	0.99	4
3 Empowerment	Autonomy	0	0	1	0				3
	Self-Efficacy	0	0	1	0				3
	Support	0	0	1	0				3
4 Continuous Improvement Efforts	Process Improvement	9.77	5	.0822	0.069	0.15	0.99	0.99	5
	Skill Enhancement	2.30	5	.8065	0.000	0.12	1.00	1.00	5
	Software Improvement	1.00	2	.6051	0.000	0.090	1.00	1.00	4
5 IT Utilization	Decision Support	2.58	2	.2753	0.039	0.099	1.00	1.00	4
	Work Integration	3.09	2	.2138	0.053	0.100	0.99	1.00	4
	Work Planning	0	0	1	0				3
6 Impacts on Work	Task Productivity	0	0	1	0				3
	Task Innovation	0	0	1	0				3
	Management Control	0	0	1	0				3
	Customer Satisfaction	0	0	1	0				3
	Supplier Management	3.50	2	.1740	0.063	0.10	0.99	1.00	4

(6) pairs are listed in section 1 of Table 4.4.

Due to the multiple comparisons, the alpha value is adjusted (alpha is divided by the number of comparisons). For six (6) comparisons, the chi-square value for any pair must be equal to or greater than approximately 6.9611 for a significant level at 0.05 and 9.8809 for a significant level at 0.01 (Cohen & Cohen, 1983: 167). The smallest chi-square difference of all pairs is 45, which is the value for prior knowledge of computers with intuitive problem solving. The results suggest that the scales of learning capability have discriminant validity.

For the remaining variables, only the results will be reported without repeating the methodology.

The descriptive statistics and the correlations between the factors are reported in section 1 of Table 4.4. The correlations are derived from SPSS output. It is noticeable that the correlations for four out of six pairs are significant at 0.01 (> .419). The systematic problem-solving scale has a non-significant correlation with the intuitive problem-solving scale (.121) and the prior knowledge of computers scale (.135). Considering the discriminant validity tests, however, the results suggest that all the scales are distinct, although some of them are highly correlated.

All four scales of learning capability are able to predict continuous improvement, information technology utilization, and impact scales to a certain degree (see section 1 of Table 4.5). Overall, learning capacity has a strong predictive power for the continuous improvement variable but a relatively weak explanation power for the information technology utilization and impact variables. All four scales of learning capacity explain the scales of continuous improvement to some extent. The systematic problem-solving

Table 4.4. The Reliability and the Discriminant Validity of the Scales

		Impact on Work					IT Utilization			CI Efforts			Learning Capacity				Learning Motivation			Empowerment		
		IPTKP	IPTKI	IPMGC	IPCST	IPSPL	TUDSE	TUWIT	TUWPL	CIPRC	CISKL	CISFT	LCSYS	LCINT	LCCIS	LCTSK	LMGLS	LMITM	LMSNM	EPAUT	EPSEF	EPSPT
Impact on Work	IPTKP	0.9076			Section 6																	
		202																				
	IPTKI	.641(**)	0.8994																			
		222.93	202																			
	IPMGC	.376(**)	.557(**)	0.8912																		
		268.89	241.93	197																		
	IPCST	.681(**)	.677(**)	.617(**)	0.8612																	
		119.7	125.09	119.71	199																	
	IPSPL	.452(**)	.707(**)	.724(**)	.622(**)	0.9262																
		327.64	166.31	117.3	156.83	192																
IT Utilization	TUDSE	.550(**)	.715(**)	.471(**)	.583(**)	.584(**)	0.9127	Section 5														
		301.21	161.76	266.57	179.9	473.69	203															
	TUWIT	.203(**)	.369(**)	.577(**)	.304(**)	.492(**)	.500(**)	0.9223														
		329.69	305.73	222.24	227.33	517.4	561.95	198														
	TUWPL	.334(**)	.509(**)	.641(**)	.422(**)	.570(**)	.520(**)	.670(**)	0.8433													
		209.96	183.01	122.84	222.14	159.51	176.01	104.29	202													
CI Efforts	CIPRC	.372(**)	.335(**)	.156(*)	.357(**)	.323(**)	.334(**)	0.127	.222(**)	0.9257	Section 4											
		311.53	305.69	289.51	237.9	589.17	604.27	632.79	234.36	200												
	CISKL	.194(**)	.171(*)	0.082	0.135	.143(*)	.282(**)	.187(**)	.164(*)	.564(**)	0.9194											
		355.04	333.87	310.19	278.15	644	607.36	643.32	234.61	807.68	205											
	CISFT	.171(*)	.337(**)	.216(**)	.280(**)	.351(**)	.290(**)	.180(*)	.241(**)	.683(**)	.446(**)	0.9281										
		334.25	329.15	291.67	264.12	645.89	628.8	707.81	242.69	422.62	643.06	202										
Learning Capacity	LCSYS	.378(**)	.265(**)	.156(*)	.209(**)	.160(*)	.324(**)	0.119	.155(*)	.182(*)	.152(*)	0.023	0.8670									
		385.67	350.68	318.39	281.56	444.29	398.35	437.53	242.71	457.35	462.46	481.83	203		Section 1							
	LCINT	.224(**)	.256(**)	0.113	.228(**)	.234(**)	.285(**)	0.04	0.072	.464(**)	.337(**)	.315(**)	0.121	0.6599								
		83.57	81.42	82.83	83.36	81.33	75.64	87.53	91.26	62.75	70.7	76.67	86.78	202								
	LCCIS	0.083	.174(*)	0.048	.149(*)	.182(*)	.254(**)	0.048	0.094	.492(**)	.279(**)	.459(**)	0.135	.424(**)	0.8614							
		338.36	342.12	302.46	257.84	374.45	423.04	451.85	228.04	352.76	431	359.36	432.7	45.86	198							
	LCTSK	.511(**)	.307(**)	0.138	.380(**)	.208(**)	.437(**)	0.132	.175(*)	.535(**)	.329(**)	.225(**)	.502(**)	.433(**)	.419(**)	0.8744						
		323.56	324.27	296.91	238.62	619.6	525.45	637.05	226.95	493.37	604.59	646.61	324.56	52.29	391.62	200						
Learning Motivation	LMGLS	.541(**)	.354(**)	.198(**)	.395(**)	.222(**)	.446(**)	.218(**)	0.138	.365(**)	.149(*)	0.121	.435(**)	.208(**)	.201(**)	.545(**)	0.8295	Section 2				
		205.7	294.19	339.31	276.25	331.17	260.52	344.37	271.46	311.74	359.17	381.65	288.97	84.56	352.15	198.73	205					
	LMITM	.576(**)	.528(**)	.298(**)	.393(**)	.374(**)	.509(**)	.256(**)	.349(**)	.265(**)	.190(**)	.172(*)	.194(**)	.204(**)	0.083	.334(**)	.522(**)	0.8805				
		285.25	288.85	279.36	233.88	452.95	425.22	491.67	221.82	481.47	504.04	482.63	444.19	82.58	434.86	506.59	251.33	202				
	LMSNM	.356(**)	.323(**)	.325(**)	.278(**)	.309(**)	.331(**)	.217(**)	.225(**)	0.088	.142(*)	0.137	.335(**)	0.056	0.059	.263(**)	.495(**)	.327(**)	0.8952			
		339.02	331.04	306.89	252.68	464.05	506.79	518.76	223	524.52	541	554.68	416.18	89.97	514.02	544.89	278.07	485.95	201			

		Impact on Work					IT Utilization			CI Efforts		
		IPTKP	IPTKI	IPMGC	IPCST	IPSPL	TUDSE	TUWIT	TUWPL	CIPRC	CISKL	CISFT
Empowerment	EPAUT	.541(**)	.495(**)	.150(*)	.478(**)	.305(**)	.446(**)	0.037	.167(*)	.390(**)	.217(**)	.201(**)
		150.89	165.32	205.08	155.14	198.56	180.96	226.27	222.98	180.26	220.67	209.84
	EPSEF	.608(**)	.476(**)	.224(**)	.444(**)	.372(**)	.468(**)	0.139	.223(**)	.443(**)	.274(**)	.286(**)
		194.48	239.51	274.58	246.22	285.94	235.56	274.78	284.26	234.25	278.81	262.48
	EPSPT	.410(**)	.213(**)	.170(*)	.240(**)	.234(**)	.299(**)	0.127	0.122	.189(**)	.204(**)	0.048
		277.77	310.52	301.99	296.36	275.54	306.06	309.01	311.12	314.35	338.22	327.88
Mean		3.71	3.17	2.89	3.37	2.69	3.29	3.02	2.64	2.70	3.02	2.11
Std. Deviation		1.08	1.16	1.17	1.14	1.23	1.15	1.27	1.15	1.09	0.99	1.10
Initial # of Items		3	3	3	6	7	8+5	8	4	6	6	7
Recommended #		3	3	3	3	4	4	4	3	5	5	4

		Learning Capacity				Learning Motivation			Empowerment		
		LCSYS	LCINT	LCCIS	LCTSK	LMGLS	LMITM	LMSNM	EPAUT	EPSEF	EPSPT
Empowerment	EPAUT	.150(*)	.327(**)	.207(**)	.433(**)	.513(**)	.544(**)	.189(**)	0.8282	Section 3	
		223.01	67.25	194.14	170.14	151.07	148.32	216.91	202		
	EPSEF	.395(**)	.286(**)	.244(**)	.563(**)	.601(**)	.561(**)	.390(**)	.631(**)	0.8625	
		269.67	71.53	269.43	191.59	141.86	199.76	269.38	97.08	205	
	EPSPT	.280(**)	0.113	0.05	.258(**)	.448(**)	.365(**)	.273(**)	.440(**)	.498(**)	0.8961
		330.63	92.48	328.7	313.71	293.84	302.1	315.23	196.6	235.2	202
Mean		3.78	2.36	1.93	3.54	4.06	3.65	3.62	3.66	3.97	4.01
Std. Deviation		0.78	0.87	0.97	0.89	0.65	0.84	0.82	0.81	0.80	0.81
Initial # of Items		6	6	7	6	5	6	6	7	7	6
Recommended #		4	3	4	5	4	4	4	3	3	3

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 4.5. The Predictive Power of the Scales and the R-Square of the Criteria

1. Learning Capacity				2. Learning Motivation			3. Empowerment			4. CI Efforts			5. IT Utilization				
SYS	INT	TSK	CIS	GLS	ITM	SNM	AUT	SEF	SPT	PRC	SKL	SFT	DSE	WIT	WPL	Criteria	R-Square
		.228	-.140		.237			.311					.229			Task productivity	.574
							.274						.492		.185	Task innovation	.592
						.123								.283	.417	Management control	.470
							.268						.349		.194	Customer satisfaction	.411
												.156	.398		.326	Supplier management	.499
.150		.179			.377							.176				Decision support	.370
					.179	.202										Work integration	.095
					.274	.151						.154				Work planning	.172
-.185		.381	.316					.255								Process improvement	.446
	.229	.167						.178								Skill enhancement	.198
-.179			.452					.302								Software improvement	.317

Legend for the abbreviation

SYS	Systematic problem solving	INT	Intuitive problem solving	TSK	Prior knowledge of work process
CIS	Prior knowledge of computers	GLS	Goal clarity	ITM	Intrinsic motivation
SNM	Social norms	AUT	Autonomy	SEF	Self-efficacy
SPT	Support	PRC	Process improvement	SKL	Skill enhancement
SFT	Software improvement	DSE	Decision support	WIT	Work integration
WPL	Work planning	TKP	Task productivity	TKI	Task innovation
MGC	Management control	CST	Customer satisfaction	SPL	Supplier management

scale and the prior knowledge of work process scale explain the decision support scale of the information technology utilization variable. The prior knowledge of computers and prior knowledge of work process scales explain the task productivity scale of the impact variable well. The standardized beta coefficients range from -.185 to .452.

Overall, 16 items and four scales (see Table 4.2.3) are proposed for measuring the learning capacity variable. The number of proposed items for each scale varies from three for intuitive problem solving to five for prior knowledge of work process. All scales are reliable and behave well.

4.1.2. Learning Motivation

Table 4.6.1 provides initial results for each scale of Learning Motivation. The reliability values vary from .85 for goal clarity to .92 for social norms. The corrected item-total correlation (CITC) values range from .61 for LMGLS2 to .83 for LMSNM5. The results suggest that all the measurement items could be retained for further analysis.

Table 4.6.1. The Initial Reliability Analysis of Learning Motivation

Goal Clarity (alpha=.8528; N=202)	
Measurement Items	Corrected Item-Total Correlation
LMGLS1	0.6555
LMGLS2	0.6079
LMGLS3	0.6943
LMGLS4	0.7335
LMGLS5	0.6353

Intrinsic Motivation (alpha=.9089; N=202)	
Measurement Items	Corrected Item-Total Correlation
LMITM1	0.6930
LMITM2	0.7938
LMITM3	0.8052
LMITM4	0.7175
LMITM5	0.7529
LMITM6	0.7284

Social Norms (alpha=.9226; N=201)	
Measurement Items	Corrected Item-Total Correlation
LMSNM1	0.7728
LMSNM2	0.7710
LMSNM3	0.7556
LMSNM4	0.8129
LMSNM5	0.8266
LMSNM6	0.7291

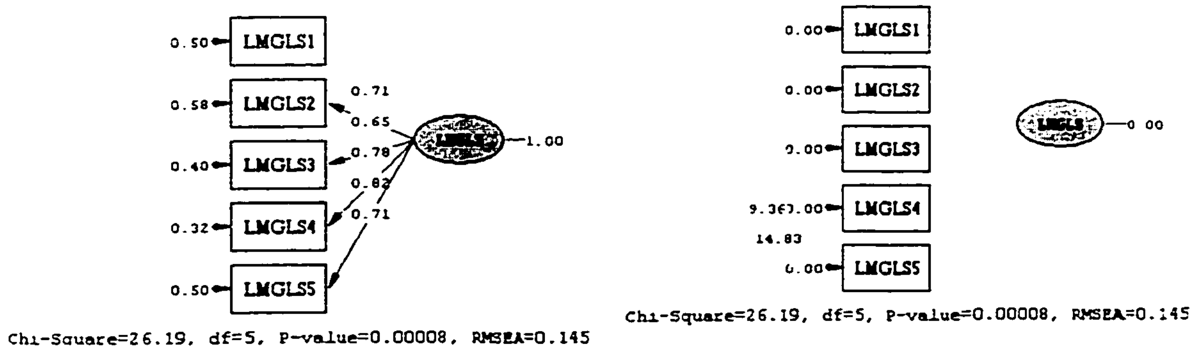
A LISREL measurement model is constructed for each scale with the hypothesized measurement items. Figure 4.2.1 shows the initial results for each scale of learning motivation. Many modification indices are suggested for goal clarity, intrinsic motivation, and social norms scales. Based on the same rules of item removal discussed in previous sections, Figure 4.2.2 shows the alternative measurement model(s) for each scale of learning motivation.

An exploratory factor analysis is conducted on the 12 items proposed after the data purification and the results are listed in Table 4.6.2. The ratio of respondents to items is 17 in this case, which meets the general guidelines for exploratory factor analysis. The criterion that is used to extract factors is that Eigen value is greater than one. Based on this criterion, three factors are derived from the data. The Eigen values for the three factors are 5.46, 2.06, and 1.29 for intrinsic motivation, social norms, and goal clarity respectively. The cumulative variance explained by the three factors is seventy three percent. All items loaded on their respective factors and there are no items with cross-loadings greater than 0.40. In general, all items have loadings greater than 0.60.

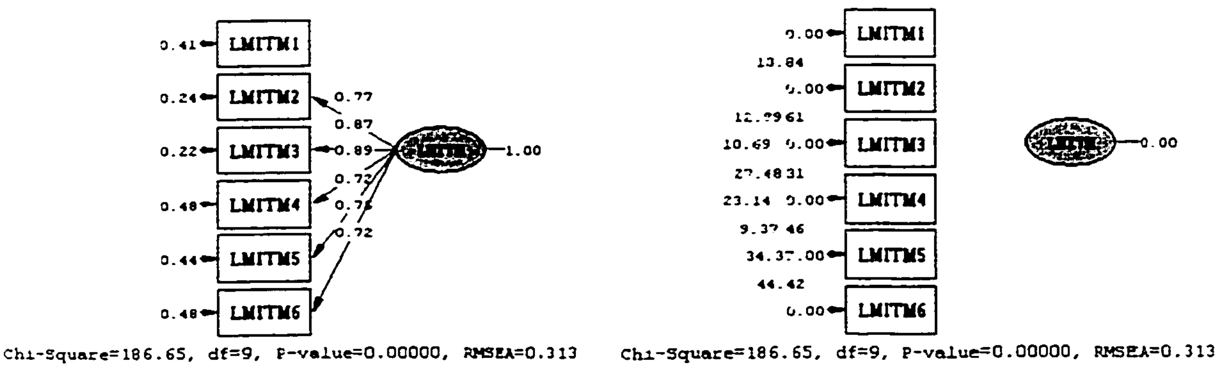
The item-factor loadings of the four items measuring the intrinsic motivation scale are high, ranging from .70 to .95. The items load lower (less than 0.30) on the social norms and goal clarity scales, indicating that the items are good indicators of the intrinsic motivation scale but not the good indicators of the social norms and/or goal clarity scales. The corresponding cells are illustrated as blanks for simplicity purpose. The items measuring the social norms scale are loaded together. The item-factor loadings are high, ranging from .70 to .92. The items are not loaded on the other two scales. The item-factor loadings of the measurement items of the goal clarity scale are high again, ranging from 0.64 to .93. The items load on the intrinsic motivation and social norms scales below .30, thus the values are not listed. Overall, the factor pattern matrix is simple; all of the items load high in their respective factors and low on others.

Figure 4.2.1 The Initial Measurement Results of Learning Motivation

Goal Clarity



Intrinsic Motivation



Social Norms

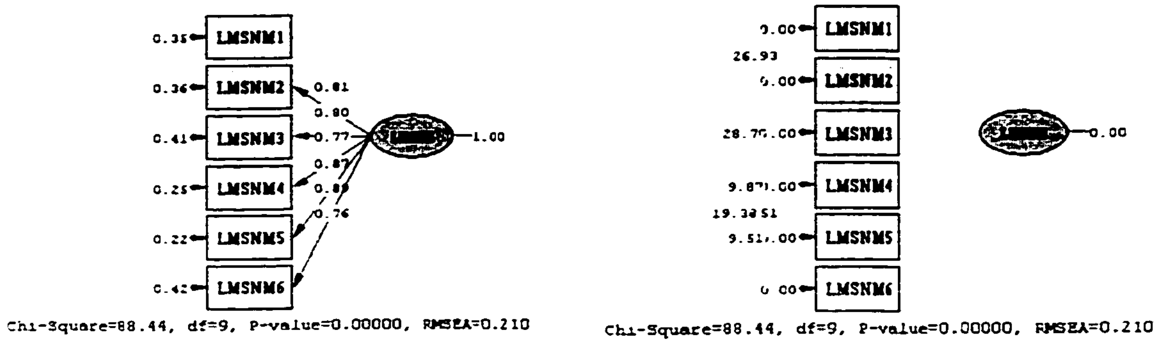
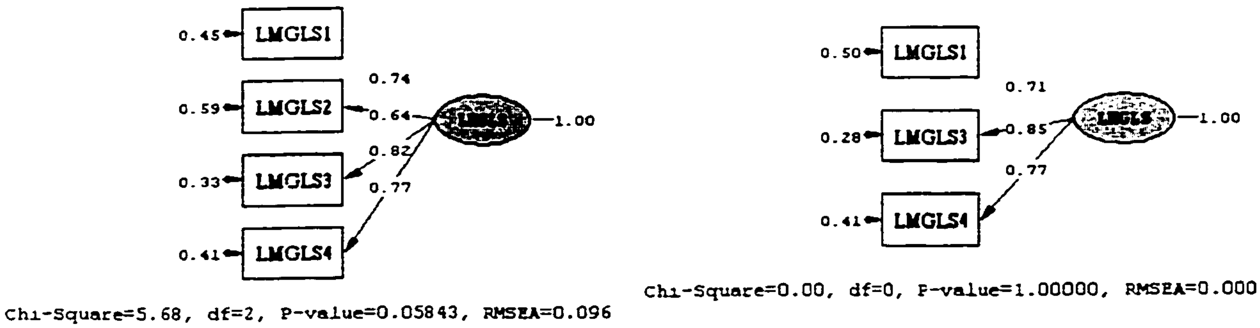
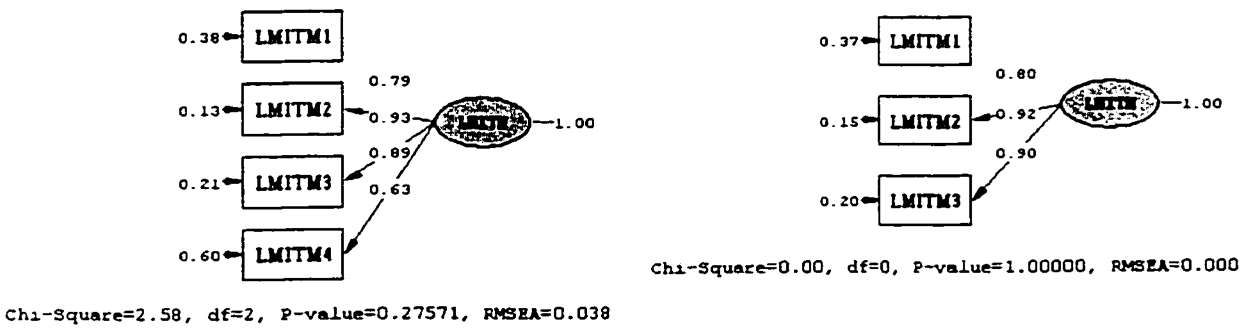


Figure 4.2.2. The Alternative Measurement Solutions for Learning Motivation

Goal Clarity



Intrinsic Motivation



Social Norms

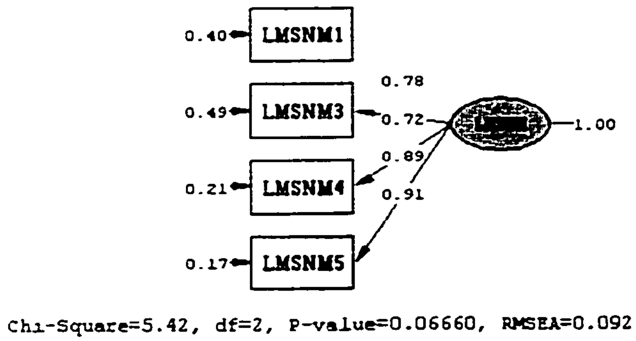


Table 4.6.2. Factorial Analysis Results of Learning Motivation

Pattern Matrix

Items	Component		
	Intrinsic Motivation	Social Norms	Goal Clarity
LMITM2	0.954		
LMITM3	0.943		
LMITM1	0.784		
LMITM4	0.701		
LMSNM5		0.927	
LMSNM1		0.894	
LMSNM4		0.880	
LMSNM3		0.702	
LMGLS1			-0.934
LMGLS3			-0.809
LMGLS2			-0.667
LMGLS4			-0.647

Component Correlation Matrix

Component	Intrinsic Motivation	Social Norms	Goal Clarity
Intrinsic Motivation	1		
Social Norms	0.302	1	
Goal Clarity	-0.453	-0.392	1

Eigen Value	5.456	2.063	1.291
% of Variance	45.465	17.190	10.757
Total Variance Explained: 73%			

Cronbach's alpha is computed for all factors (see Table 4.6.3). The goal clarity scale (LMGLS) has four measurement items and a reliability alpha of 0.83. The intrinsic motivation scale (LMITM) has four indicators and a reliability alpha of 0.88. The social norms scale (LMSNM) has an alpha of 0.90 for four measurement items. In summary, the reliabilities for the scales are high (greater than 0.80).

Table 4.6.3. Measurement Scales of Learning Motivation Recommended for Future Studies (12 items)

Label	Item Description	CITC
	Goal Clarity (No of Cases = 205; No of Items = 4; Alpha = .8295)	
LMGLS1	I foresee the overall picture of how this process fits in the whole project	0.6678
LMGLS2	I foresee the overall picture of how this process fits into other processes..	0.5839
LMGLS3	The objective of using the software for this process is clear to me.........	0.7083
LMGLS4	I have a clear goal in mind when using the software for this process......	0.6697
	Intrinsic Motivation (No of Cases = 202; No of Items = 4; Alpha = .8805)	
LMITM1	Using the software for this process is enjoyable............................	0.7222
LMITM2	Using the software for this process is pleasurable..........................	0.8508
LMITM3	Using the software for this process fosters enjoyment....................	0.8171
LMITM4	Using computers is fun..	0.5864
	Social Norms (No of Cases = 201; No of Items = 4; Alpha = .8952)	
LMSNM1	Management has set up a clear vision of using the software for this process	0.7458
LMSNM3	I understand the management's expectations of me for using the software for this process..	0.6916
LMSNM4	My supervisor has set up a clear goal for using the software for this process	0.8120
LMSNM5	My supervisor has given a clear direction for using the software for this process..	0.8264

Section 2 of Table 4.3 shows the data-model fit index for each scale of learning motivation. The chi-square values ranged from 2.58 for the intrinsic motivation scale to 5.68 for the goal clarity scale. The p-values are non-significant (> .05). However, the values of RMSEA, ECVI, NNFI, and CFI indicate that the goal clarity, intrinsic motivation, and social norms scales have good data-model fits.

The discriminant validity is evaluated by the difference between the chi-square values (one degree of freedom) for the fixed and free solutions for the 3 pairs listed in section 2 of Table 4.4. For 3 comparisons, the chi-square value for any pair must be equal to or greater than approximately 5.7308 for a significant level at 0.05 and 8.6172 for a significant level at 0.01 (Cohen & Cohen, 1983: 167). All the chi-square differences for the tests are greater than 278, which is the value of management control and supplier management. The high difference values indicate that the three scales have discriminant validity.

The correlations between the scales and descriptive statistics are shown in section 2 of Table 4.4. The correlations for all pairs are significant at 0.01 (> .327). However, the results of the discriminant validity test suggest that the scales of learning motivation are distinct constructs.

Learning motivation has a relative strong predictive power for the technology utilization scale but a relative weak explanation power for the impact scale. It has little power in explaining the continuous improvement scale. None of the learning motivation scales explains the scales of the continuous improvement variable. The goal clarity scale is not strong enough to predict the continuous improvement, information technology utilization, and impact variables. The standardized beta coefficients range from .123 to .377 (see section 2 of Table 4.5).

Overall, 12 measurement items and three scales (see Table 4.6.3) are proposed for the learning motivation variable. The number of proposed items is four for all three scales. All scales have good reliabilities.

4.1.3. Empowerment

Table 4.7.1 reports an initial result of data purification for each scale of the empowerment variable. All the CITC values for the self-efficacy scale are relative low (around .50). Indicators EPSEF4 and EPSEF7 of the self-efficacy scale have the lowest .13 and .31 CITC values respectively and are thus excluded from further analysis. Indicator EPSPT6 of the support scale has a low of .37 CITC value and is thus removed for further analysis too. The corrected item-total correlation (CITC) values of the revised measurement instrument range from .41 for EPSEF6 to .77 for EPAUT4. The reliability values are .78 for the self-efficacy scale, .86 for the support scale, and .88 for the autonomy scale. The results suggest that the revised measurement items can be retained for further analysis.

Figure 4.3.1 shows the initial results of LISREL for each scale of empowerment. Many modification indices are indicated for the autonomy and the support scales. The removal of some of the items of each scale will improve the model's data-model fit index. Based on the same rules of removing items discussed in the previous section, the alternative measurement models for each scale are derived and shown in Figure 4.3.2.

Table 4.7.1. The Initial Reliability Analysis of Empowerment

Autonomy (alpha=.8838; N=201)	
Measurement Items	Corrected Item-Total Correlation
EPAUT2	0.7146
EPAUT3	0.7347
EPAUT4	0.7738
EPAUT5	0.5755
EPAUT6	0.6527
EPAUT7	0.7338

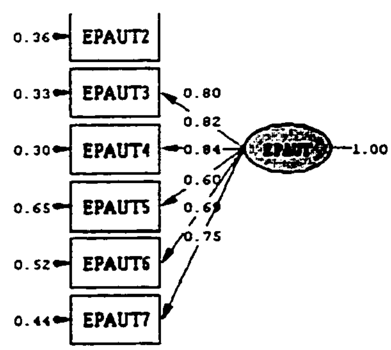
Self-Efficacy (alpha=.7088; N=200)	
Measurement Items	Corrected Item-Total Correlation

EPSEF1	0.5654
EPSEF2	0.5140
EPSEF3	0.4600
EPSEF4	**0.1313**
EPSEF5	0.5069
EPSEF6	0.5317
EPSEF7	**0.3069**
Revised Self-Efficacy Measurement (alpha=.7845; N=204)	
Measurement Items	Corrected Item-Total Correlation
EPSEF1	0.7260
EPSEF2	0.6289
EPSEF3	0.6182
EPSEF5	0.4721
EPSEF6	0.4102

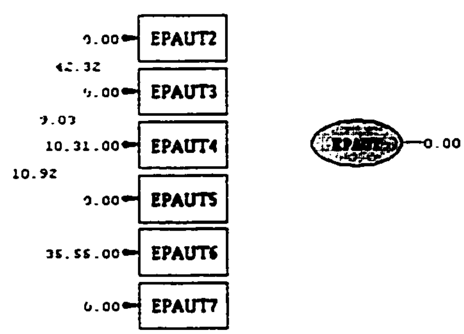
Support (alpha=.8241; N=202)	
Measurement Items	Corrected Item-Total Correlation
EPSPT1	0.6501
EPSPT2	0.5481
EPSPT3	0.6585
EPSPT4	0.7391
EPSPT5	0.7271
EPSPT6	**0.3695**
Revised Support Measurement (alpha=.8655; N=202)	
Measurement Items	Corrected Item-Total Correlation
EPSPT1	0.6504
EPSPT2	0.5552
EPSPT3	0.6973
EPSPT4	0.7693
EPSPT5	0.7651

Figure 4.3.1 The Initial Measurement Results of Empowerment

Autonomy

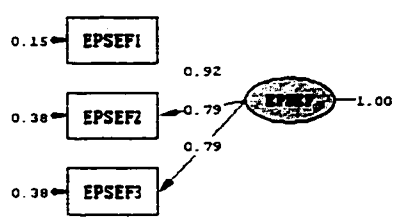


Chi-Square=76.08, df=9, P-value=0.00000, RMSEA=0.193

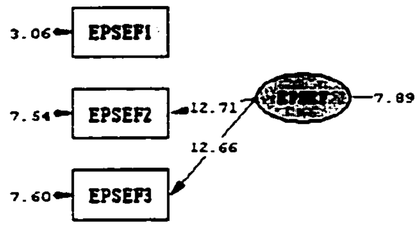


Chi-Square=76.08, df=9, P-value=0.00000, RMSEA=0.193

Self-Efficacy



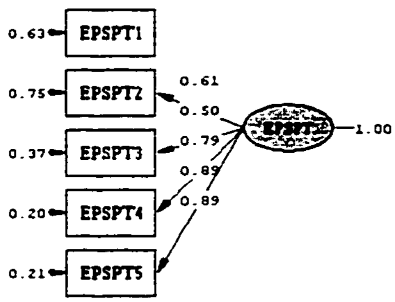
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000



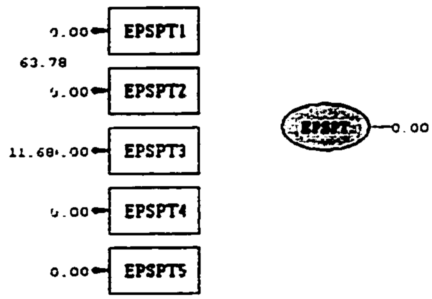
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

• T-Values

Support



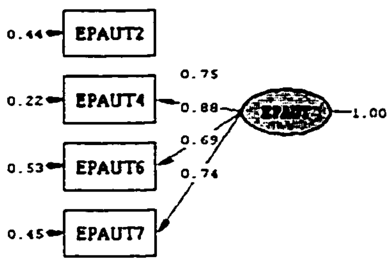
Chi-Square=70.48, df=5, P-value=0.00000, RMSEA=0.255



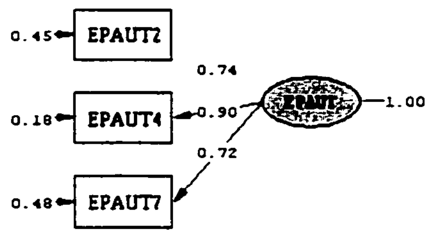
Chi-Square=70.48, df=5, P-value=0.00000, RMSEA=0.255

Figure 4.3.2. The Alternative Measurement Solutions for Empowerment

Autonomy

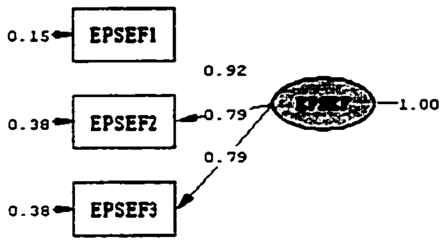


Chi-Square=1.77, df=2, P-value=0.41344, RMSEA=0.000



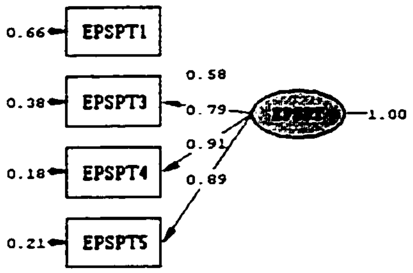
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Self-Efficacy

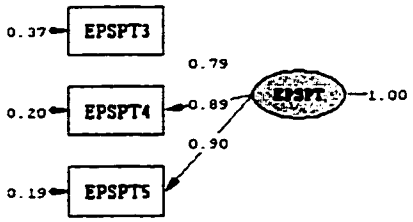


Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Support



Chi-Square=3.35, df=2, P-value=0.18750, RMSEA=0.058



Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

An exploratory factor analysis is conducted on the 9 items suggested from the purification phase (see Table 4.7.2). The ratio of respondents to items is 23 and meets the general guidelines for data analysis. By specifying three factors for the factor analysis, the model has a clean three-factor structure. The Eigen values are 4.89 for autonomy, 1.41 for support, and 0.85 for self-efficacy. The cumulative variance explained by the factors is eighty percent. All items load on their respective factors and there are no items with cross-loadings greater than 0.40. All items have loadings greater than 0.75.

All the measurement items of autonomy load together and their item-factor loadings are greater than 0.75. The items load low on the supports and self-efficacy scales, as their item-factor loadings are less than .30. The information suggests that the items are good indicators of the autonomy scale. The measurement items for self-efficacy and supports have a similar pattern. Items of supports load high on the hypothesized scale and low (<0.30) on other scales. The item-factor loadings of the items for the supports scale are greater that .82 and the loadings for self-efficacy are greater than .76. Overall, the factor pattern matrix is simple; all of the items load high in their respective scales and low on others.

Table 4.7.2. Factorial Analysis Results of Empowerment

Pattern Matrix

Items	Component		
	Autonomy	Support	Self-Efficacy
EPAUT2	0.888		
EPAUT4	0.870		
EPAUT7	0.756		
EPSPT5		0.932	
EPSPT4		0.926	
EPSPT3		0.825	
EPSEF3			-0.968
EPSEF1			-0.809
EPSEF2			-0.769

Component Correlation Matrix

Component	Autonomy	Supports	Self-Efficacy
Autonomy	1		
Support	0.401	1	
Self-Efficacy	-0.576	-0.474	1

Eigen Value	4.894	1.411	0.852
% of Variance	54.378	15.681	9.470
Total Variance Explained: 80%			

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Cronbach's alpha is calculated for each scale of empowerment (see Table 4.7.3). The autonomy scale (EPAUT) has three measurement items and a reliability alpha of

0.83. The self-efficacy scale (EPSEF) has three items and a reliability alpha of 0.86. The support scale (EPSPT) has an alpha of 0.89 for three items. Same as those of other variables, the reliabilities for the scales are high (greater than 0.80).

Section 3 of Table 4.3 shows the data-model fit index for each scale. Since each scale is measured with three items, all three scales have saturated measurement models.

The discriminant validity is examined through the difference between the chi-square values (one degree of freedom) for the fixed and free solutions for the 3 pairs listed in section 3 of Table 4.4. All the chi-square differences for the tests are greater than 97, which is the value of self-efficacy with autonomy, indicating discriminant validity of the scales. The correlations between the factors, and descriptive statistics are shown in Table 4.4. These correlations are derived from SPSS output. All pairs are significant at a 0.01 level (> .440). Although the scales are highly correlated, the results of the discriminant validity tests suggest that the scales are distinguishable.

Table 4.7.3. Measurement Scales of Empowerment Recommended for Future Studies (9 items)

Label	Item Description	CITC
	Autonomy (No of Cases = 202; No of Items = 3; Alpha = .8282)	
EPAUT2	I have considerable opportunity for independence in how I use the software for this process..	0.6609
EPAUT4	I have significant autonomy in determining how I use the software for this process..	0.7540
EPAUT7	I have a say in how I use this software for this process........................	0.6464
	Self-Efficacy (No of Cases = 205; No of Items = 3; Alpha = .8625)	
EPSEF1	I am confident about my ability to use the software to complete my work...	0.8059
EPSEF2	I believe my capabilities of using the software for my work..................	0.7205
EPSEF3	I have mastered the skills necessary for using this software for my work	0.7270
	Support (No of Cases = 202; No of Items = 3; Alpha = .8961)	
	When I had difficulty in using the software for this process, I can	
EPSPT3	exchange information with others who know how to better use the	0.7488

	software for the process..	
EPSPT4	talk to other people who are more knowledgeable..........................	0.8160
EPSPT5	discuss with others who know how to make better use of the software for the process	0.8220

* CITC: Corrected Item-Total Correlation.

Self-efficacy predicts continuous improvement efforts well. It predicts only the task productivity scale of the impact variable and does not predict information technology utilization. Autonomy predicts the impact variable moderately but does not predict the continuous improvement efforts and information technology utilization variables. None of the empowerment scales predicts the information technology utilization variable. The supports scale does not predict any criterion scales (i.e., continuous improvement efforts, information technology utilization, and impact). The standardized beta coefficients range from .178 to .311 (see Table 4.5).

Overall, nine items and three scales (see Table 4.7.3) are proposed as the measurement for the empowerment. The number of proposed items is three for autonomy, self-efficacy, and supports. All scales have high reliabilities and pure factorial structure.

4.1.4. Continuous Improvement Efforts

Table 4.8.1 provides an initial result of SPSS for each scale of continuous improvement efforts. The reliability values are .91, .92, and .96 for process improvement, skill enhancement, and software improvement respectively. The corrected item-total correlation (CITC) values range from .60 for CIPRC1 of process improvement to .89 for CISFT4 of software improvement. The results suggest that all the measurement items of continuous improvement efforts should be retained for further analysis.

Table 4.8.1. The Initial Reliability Analysis of Continuous Improvement Efforts

Process Improvement (alpha=.9192; N=200)	
Measurement Items	Corrected Item-Total Correlation
CIPRC1	0.6011
CIPRC2	0.8230
CIPRC3	0.8462
CIPRC4	0.8597
CIPRC5	0.8028
CIPRC6	0.6910

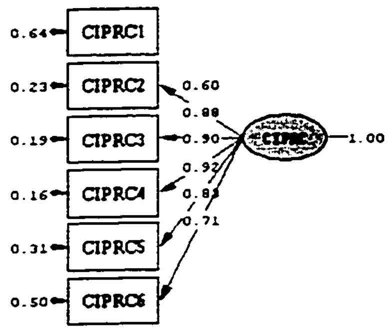
Skill Enhancement (alpha=.9260; N=205)	
Measurement Items	Corrected Item-Total Correlation
CISKL1	0.7360
CISKL2	0.8024
CISKL3	0.8058
CISKL4	0.7345
CISKL5	0.8297
CISKL6	0.8090

Software Improvement (alpha=.9615; N=201)	
Measurement Items	Corrected Item-Total Correlation
CISFT1	0.8563
CISFT2	0.8804
CISFT3	0.8238
CISFT4	0.8905
CISFT5	0.8636
CISFT6	0.8633
CISFT7	0.8731

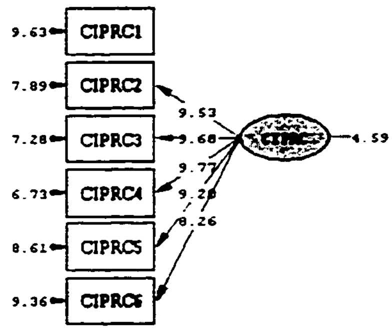
Figure 4.4.1 shows the initial results of LISREL for each scale of continuous improvement efforts. Many modification indexes are suggested for skill enhancement and software improvement scales. Based on the same rules of item removal discussed in previous sections, the alternative measurement models for each scale of continuous improvement efforts are derived. They are illustrated in Figure 4.4.2.

Figure 4.4.1 The Initial Measurement Results of Continuous Improvement Efforts

Process Improvement



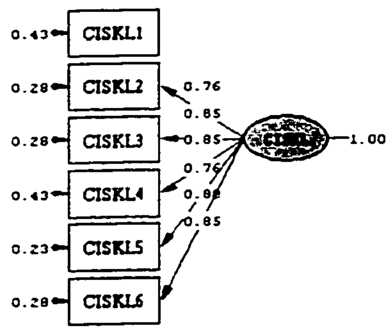
Chi-Square=23.68, df=9, P-value=0.00484, RMSEA=0.091



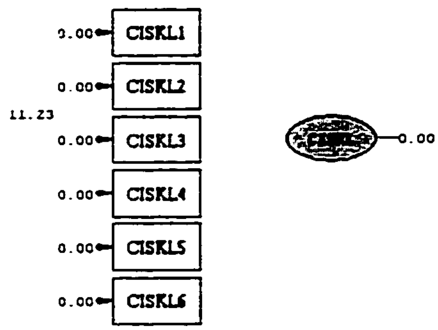
Chi-Square=23.68, df=9, P-value=0.00484, RMSEA=0.091

- T-Values

Skill Enhancement

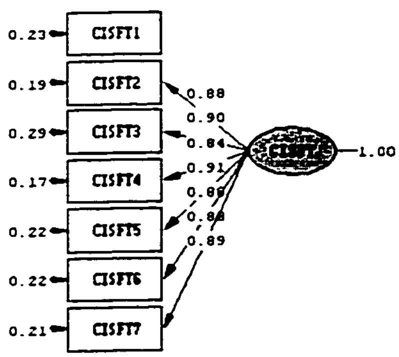


Chi-Square=17.49, df=9, P-value=0.04154, RMSEA=0.068

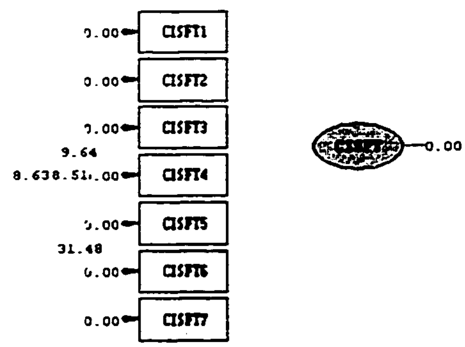


Chi-Square=17.49, df=9, P-value=0.04154, RMSEA=0.068

Software Improvement



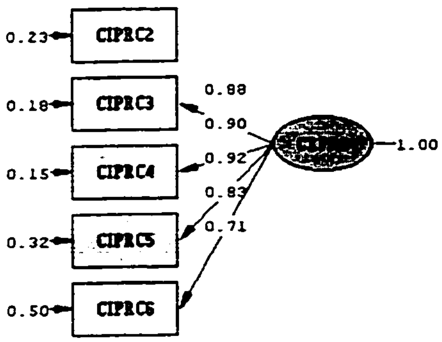
Chi-Square=57.21, df=14, P-value=0.00000, RMSEA=0.124



Chi-Square=57.21, df=14, P-value=0.00000, RMSEA=0.124

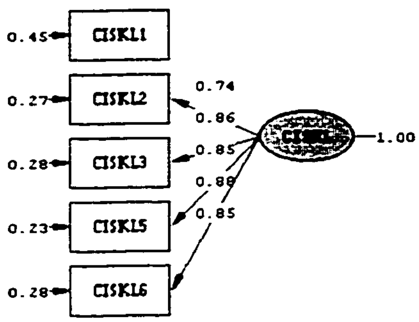
Figure 4.4.2. The Alternative Measurement Solutions for Continuous Improvement Efforts

Process Improvement

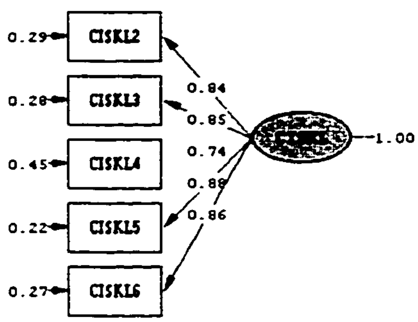


Chi-Square=9.77, df=5, P-value=0.08216, RMSEA=0.069

Skill Enhancement

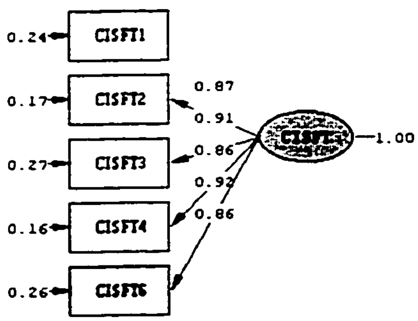


Chi-Square=2.30, df=5, P-value=0.80648, RMSEA=0.000

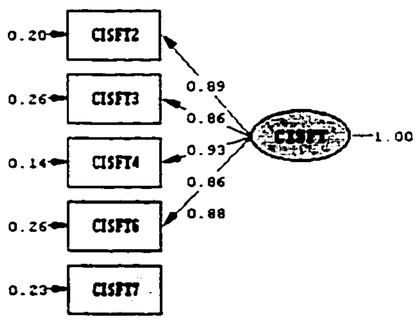


Chi-Square=3.57, df=5, P-value=0.61330, RMSEA=0.000

Software Improvement



Chi-Square=8.86, df=5, P-value=0.11465, RMSEA=0.062



Chi-Square=1.98, df=5, P-value=0.85143, RMSEA=0.000

An exploratory factor analysis is conducted on the 14 items proposed (see Table 4.8.2). The ratio of respondents to items is 15 and meets the general guidelines for data analysis. Eigen value (>= 1) is used as factor extracting criterion. Three factors/scales are derived via using SPSS based on the criterion. The Eigen values are 7.82 for process improvement, 2.14 for skill enhancement, and 1.12 for software improvement. The cumulative variance explained by the three scales is seventy nine percent. All items load high (greater than .73) on their respective scales and no items have cross-loadings greater than 0.30, indicating a good, clean factorial structure of the variable.

Table 4.8.2. Factorial Analysis Results of Continuous Improvement Efforts

Pattern Matrix

Items	Component		
	Process Improvement	Skill Enhancement	Software Improvement
CIPRC3	0.885		
CIPRC4	0.861		
CIPRC2	0.828		
CIPRC6	0.804		
CIPRC5	0.768		
CISKL2		0.895	
CISKL6		0.894	
CISKL3		0.887	
CISKL5		0.810	
CISKL1		0.735	
CISFT3			0.907
CISFT6			0.860
CISFT2			0.835
CISFT7			0.828

Component Correlation Matrix

Component	Process Improvement	Skill Enhancement	Software Improvement
Process Improvement	1		
Skill Enhancement	0.507	1	
Software Improvement	0.592	0.360	1

Eigen Value	7.819	2.139	1.121
% of Variance	55.849	15.280	8.006
Total Variance Explained: 79%			

The item-factor loadings of the measurement items of the process improvement scale are greater than 0.76. For the skill enhancement scale, the item-factor loadings are greater than 0.73. The loadings for the software improvement scale are greater than 0.82. All the items load low (less than .30) on other scales. They show a simple, clean factorial structure for continuous improvement efforts variable, as summarized in Table 4.8.2.

The Cronbach's alphas of the scales are summarized in Table 4.8.3. The process improvement scale (CIPRC) is measured in five items and has a reliability alpha of 0.93. The skill enhancement scale (CISKL) has five measurement items and a reliability alpha of 0.92. The software improvement scale (CISFT) has an alpha of 0.93 with four measurement items. The results indicate that each scale of continuous improvement efforts is reliable and ready for further structural analysis.

Table 4.8.3. Measurement Scales of Continuous Improvement Efforts Recommended for Future Studies (14 items)

Label	Item Description	CITC
	Process Improvement (No of Cases = 200; No of Items = 5; Alpha = .9257)	
CIPRC2	I make changes in this process that make it easier to use......................	0.8197
CIPRC3	I make changes in this process that make it more useful......................	0.8630
CIPRC4	I make changes in this process that improve the quality of my work.........	0.8785
CIPRC5	I change the way this process works...	0.7924
CIPRC6	I look for ways to improve this process..	0.6815
	Skill Enhancement (No of Cases = 205; No of Items = 5; Alpha = .9194)	
CISKL1	I spend time on-the-job learning how to use the software more efficiently...	0.7088
CISKL2	I spend significant time on-the-job learning how to make full use of the software..	0.8162
CISKL3	I spend time learning more about how to use the software for my work.......	0.8072
CISKL5	I spend time on-the-job learning how to use advanced functions of the software	0.8292
CISKL6	I spend time on-the-job learning how to use additional features of the software	0.8003
	Software Improvement (No of Cases = 202; No of Items = 4; Alpha = .9281)	
CISFT2	I make changes in the software that make it easier to use......................	0.8511
CISFT3	I make changes in the software that make it applicable to different processes	0.8167
CISFT6	I make changes in the software that give me greater control over my work...	0.8275
CISFT7	I make changes in the software that make it better fit to my work..............	0.8381

Section 4 of Table 4.3 illustrates the data-model fit index for each scale of the continuous improvement efforts variable. The chi-square values are from 1.00 for software improvement to 9.77 for process improvement. All p-values are non-significant (> .08). However, the values of RMSEA, ECVI, NNFI, and CFI indicate that the data fit the hypothesized measurement model well.

The chi-square differences with one degree of freedom for three pairs of the scales are reported in section 4 of Table 4.3. All the chi-square differences are greater than 422, which is the chi-square difference of process improvement and software improvement. This number is greater than 8.6172 required for a significant level at 0.01 for three comparisons (Cohen & Cohen, 1983: 167), suggesting that the three scales of the continuous improvement efforts variable have discriminant validity.

Table 4.4 also illustrates the correlations between the scales and the mean and standard deviation of each scale. The correlations are from SPSS. They are significant at 0.01 (>.446). The results show that while the scales are highly correlated, they are distinguishable.

The continuous improvement efforts variable is hypothesized as a mediating variable. It is an output measure of learning capacity, learning motivation, and empowerment. The values of the R-square are 0.198 for skill enhancement, 0.317 for software improvement, and 0.446 for process improvement, indicating that the scales of continuous improvement efforts are reasonably explained in the model (see Table 4.5). The scales have a weak power to predict information technology utilization and impact variables. Only the software improvement scale presents some predictive power in explaining information technology utilization and a limited power in explaining impact. The standardized beta coefficients range from .154 to .176 (see Table 4.5).

Overall, 14 items and three scales are proposed for measuring the continuous improvement efforts variable (see Table 4.8.3). The number of proposed measurement items is five for process improvement, five for skill enhancement, and four for software improvement. Each scale is reliable and the overall factorial structure of the scales is simple and clean.

4.1.5. Information Technology Utilization

Table 4.9.1 provides an initial result of SPSS for each scale of IT utilization. The reliability values for decision support, problem solving, work integration, and work planning are .95, .92, .94, and .85 respectively. The CITC values range from .57 for TUWIT2 of work integration to .88 for TUWIT4 of work integration. The results suggest that all the measurement items should be retained for further analysis.

Table 4.9.1. The Initial Reliability Analysis of Information Technology Utilization

Decision Support (alpha=.9524; N=194)	
Measurement Items	Corrected Item-Total Correlation
TUDPI1	0.8466
TUDPI2	0.8787
TUDPI3	0.7513
TUDPI4	0.8074
TUDPI5	0.7853
TUDPI6	0.8204
TUDPI7	0.8183
TUDPI8	0.8695

Problem Solving (alpha=.9210; N=194)	
Measurement Items	Corrected Item-Total Correlation
TUPSE1	0.7774
TUPSE2	0.8455
TUPSE3	0.7597

TUPSE4	0.7811
TUPSE5	0.8144

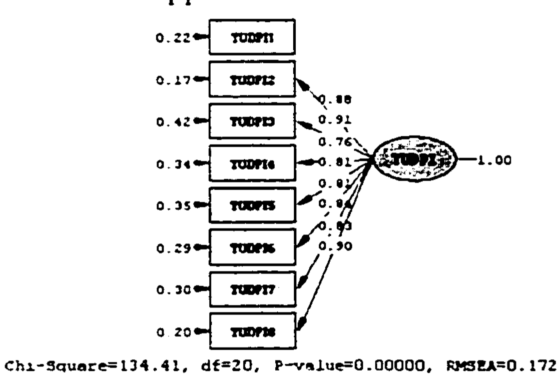
Work Integration (alpha=.9464; N=192)	
Measurement Items	Corrected Item-Total Correlation
TUWIT1	0.8122
TUWIT2	0.5669
TUWIT3	0.8095
TUWIT4	0.8847
TUWIT5	0.8302
TUWIT6	0.8474
TUWIT7	0.8357
TUWIT8	0.8561

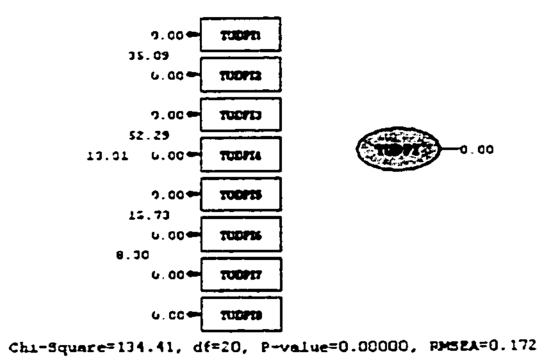
Work Planning (alpha=.8545; N=201)	
Measurement Items	Corrected Item-Total Correlation
TUWPL1	0.6666
TUWPL2	0.7539
TUWPL3	0.7411
TUWPL4	0.6281

Figure 4.5.1 illustrates the initial results of LISREL for each scale of IT utilization. Many modification indices are suggested for decision support and work integration scales. One index is shown for the problem solving scale and none is suggested for the work planning scale. The correlated items are removed based on the same rules of item removal discussed in previous sections. Figure 4.5.2 demonstrates the alternative measurement model(s) for each scale of information technology utilization.

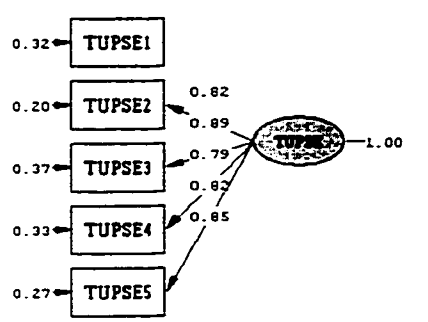
Figure 4.5.1 The Initial Measurement Results of Information Technology Utilization

Decision Support

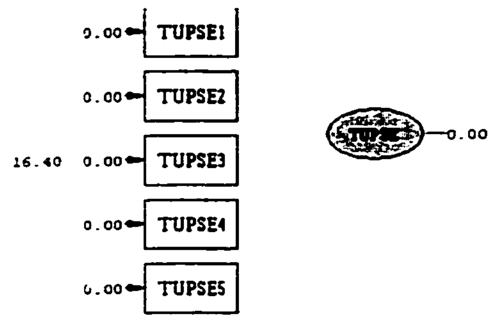




Problem Solving

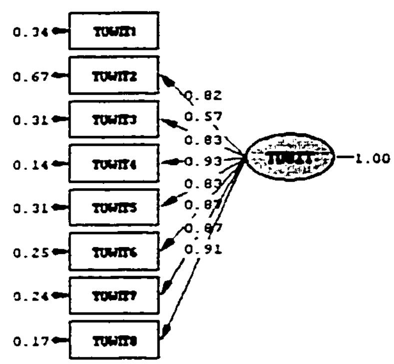


Chi-Square=23.66, df=5, P-value=0.00025, RMSEA=0.139

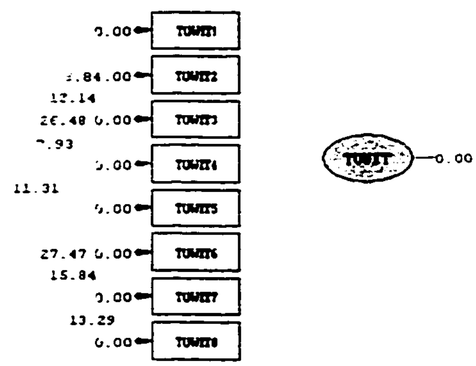


Chi-Square=23.66, df=5, P-value=0.00025, RMSEA=0.139

Work Integration

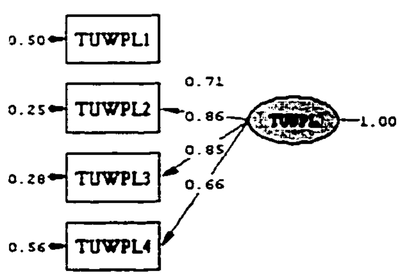


Chi-Square=116.47, df=20, P-value=0.00000, RMSEA=0.159

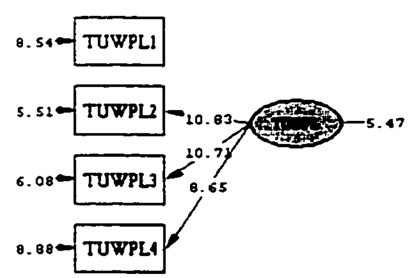


Chi-Square=116.47, df=20, P-value=0.00000, RMSEA=0.159

Work Planning



Chi-Square=5.51, df=2, P-value=0.06367, RMSEA=0.094

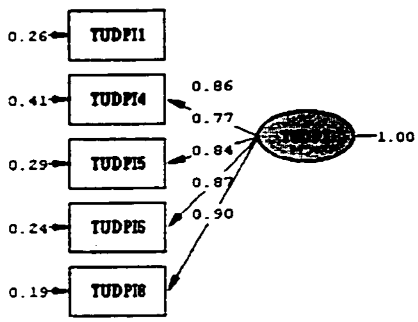


Chi-Square=5.51, df=2, P-value=0.06367, RMSEA=0.094

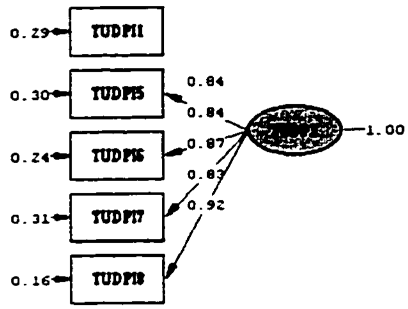
- T-Values

Figure 4.5.2. The Alternative Measurement Solutions for Information Technology Utilization

Decision Support

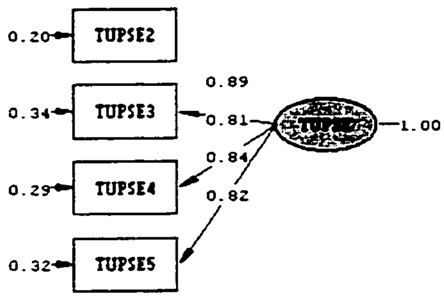


Chi-Square=10.53, df=5, P-value=0.06159, RMSEA=0.076



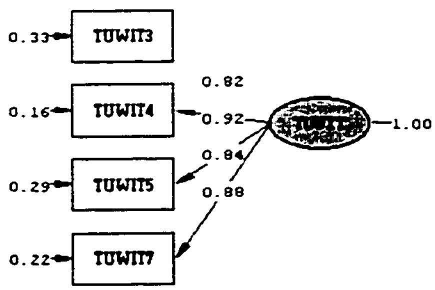
Chi-Square=11.32, df=5, P-value=0.04543, RMSEA=0.081

Problem Solving

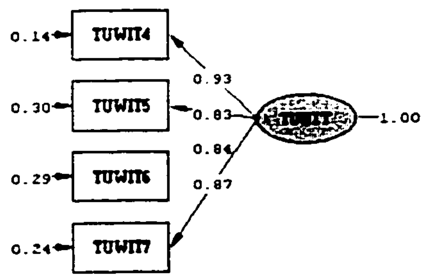


Chi-Square=4.32, df=2, P-value=0.11504, RMSEA=0.078

Working Integration

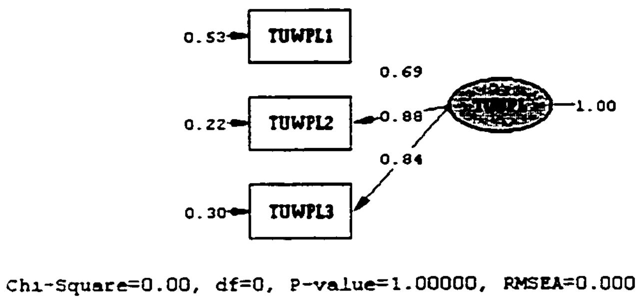


Chi-Square=3.09, df=2, P-value=0.21384, RMSEA=0.053



Chi-Square=5.42, df=2, P-value=0.06658, RMSEA=0.095

Work Planning



An exploratory factor analysis is conducted for the 11 items suggested from data purification (see Table 4.9.2). The ratio of respondents to items is 19 and the number meets the general guidelines for an exploratory factor analysis. The data analysis suggests a three-factor structure for the IT utilization variable. Previously hypothesized decision support and problem solving scales are merged to one scale. The merged scale is still named as decision support based on the contents of the measurement items. The Eigen values for work integration, decision support and work planning are 6,19, 1.72, and 0.85 respectively. The cumulative variance explained by the three factors is eighty percent. All items load high on their respective scales and low on other scales.

The item-factor loadings for the items measuring the decision support scale are from .82 to .95. The loadings for the items of the work integration scale are from .84 to .93. The loadings for the items of the work planning scale are from .73 to .92. The items are loaded low on the other scales (less than .30). As illustrated in Table 4.9.2, the factor pattern matrix of the IT utilization variable is simple and clean.

Table 4.9.2. Factorial Analysis Results of Information Technology Utilization

Pattern Matrix

Items	Component		
	Work Integration	Decision Support	Work Planning
TUWIT4	0.930		
TUWIT7	0.886		
TUWIT5	0.885		
TUWIT3	0.849		
TUPSE4		0.955	
TUDPI4		0.869	
TUDPI7		0.862	
TUPSE3		0.827	
TUWPL3			0.924
TUWPL2			0.898
TUWPL1			0.732

Component Correlation Matrix

Component	Work Integration	Decision Support	Work Planning
Work Integration	1		
Decision Support	0.469	1	
Work Planning	0.656	0.488	1

Eigen Value	6.194	1.721	0.854
% of Variance	56.305	15.647	7.766
Total Variance Explained: 80%			

Cronbach's alpha is calculated for all scales of the variable (see Table 4.9.3). The decision support scale (TUDSE) has four measurement items and a reliability alpha of 0.91. The work integration scale (TUWIT) has four items and reliability alpha of 0.92. The work planning scale (TUWPL) has an alpha of 0.84 for three items. Overall, the results suggest that the scales are reliable.

Section 5 of Table 4.3 shows the data-model fit index for each scale. The chi-square values for decision support and work integration scales are 2.58 and 3.09 respectively with 2 degrees of freedom. The non-significant p-values are .2753 and .2138 respectively. The small RMSEA (i.e., 0.039 and 0.053) and ECVI (i.e., 0.099 and 0.100) values indicate good data-model fits. Both models have achieved excellent NNFI and CFI values that are greater than 0.99. The work planning scale is a saturated model.

Table 4.9.3. Measurement Scales of Information Technology Utilization Recommended for Future Studies (11 items)

Label	Item Description	CITC
	Decision Support (No of Cases = 203; No of Items = 4; Alpha = .9127)	
TUDPI4	I use this application to improve the efficiency of the decision process......	0.7975
TUDPI7	I use this application to help me make explicit the reasons for my decisions	0.7973
TUPSE3	I use this application to make sense out of data...............................	0.7683
TUPSE4	I use this application to analyze why problems occur..........................	0.8424
	Work Integration (No of Cases = 198; No of Items = 4; Alpha = .9223)	
TUWIT3	I use this application to communicate with people I report to.................	0.7833
TUWIT4	I use this application to communicate with people in other work groups...	0.8638
TUWIT5	I use this application to communicate with people in other departments......	0.8106
TUWIT7	I use this application to keep people in other departments informed.........	0.8238
	Work Planning (No of Cases = 202; No of Items = 3; Alpha = .8433)	
TUWPL1	I use this application to help me manage my work............................	0.6335
TUWPL2	I use this application to monitor my own performance.......................	0.7599
TUWPL3	I use this application to plan my work..	0.7369

All the chi-square differences for the three pairs are greater than 104. Since the chi-square difference for any pair must be equal to or greater than approximately 8.6172 for a significant level at 0.01 for 3 comparisons, the three scales of the IT utilization variable are distinct (see section 4 of Table 4.4).

Table 4.4 also reports the correlations between the scales and the descriptive statistics (i.e., the mean and standard deviation) of the scales. Statistics tool SPSS is used to calculate the correlations. The results indicate that the scales are highly correlated at a 0.01 significant level (> .500), even though the scales have discriminant validity.

IT utilization is hypothesized as a mediating variable in the research model. Thirty seven percent (37%) of the variance of the decision support scale is explained by its antecedents: learning capacity, learning motivation, empowerment, and continuous improvement efforts variables. About seventeen percent (17%) of the variance of the work planning scale is predicted by its antecedents. Only nine percent (9%) of the variance of the work integration scale is attributed to its antecedents.

Decision support and work planning scales have strong predictive power in explaining the scales of impact. The decision support scale is a good predictor of task productivity, task innovation, customer satisfaction, and supplier management scales. The work planning scale predicts task innovation, management control, customer satisfaction, and supplier management scales well. The work integration scale has a relatively weak predictive power. It only predicts the management control scale of the impact variable. The standardized beta coefficients range from .185 to .492 (see Table 4.5).

Overall, 11 items and three scales (see Table 4.9.3) are suggested from the data analysis for measuring the information technology utilization variable. The number of proposed items is four for decision support and work integration scales and three for the work planning scale.

4.1.6. Impact on Work

Table 4.10.1 shows initial results of SPSS for each scale of impact on work. The reliability values for task productivity, task innovation, management control, customer satisfaction, and supplier management are .90, .89, .89, .90, and .95 respectively. The CITC values range from .69 for IPCST1 of customer satisfaction to .87 for IPSPL5 of supplier management. The results indicate that all the measurement items are good for further analysis.

Table 4.10.1. The Initial Reliability Analysis of Impact on Work

Task Productivity (alpha=.9076; N=202)	
Measurement Items	Corrected Item-Total Correlation (CITC)
IPTKP1	0.7698
IPTKP2	0.8192
IPTKP3	0.8590

Task Innovation (alpha=.8994; N=202)	
Measurement Items	Corrected Item-Total Correlation
IPTKI1	0.8300
IPTKI2	0.8037
IPTKI3	0.7713

Management Control (alpha=.8912; N=197)	
Measurement Items	Corrected Item-Total Correlation
IPMGC1	0.7586
IPMGC2	0.8159
IPMGC3	0.7861

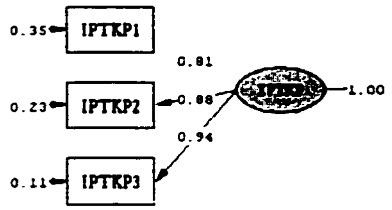
Customer Satisfaction (alpha=.9067; N=194)	
Measurement Items	Corrected Item-Total Correlation
IPCST1	0.6850
IPCST2	0.7476
IPCST3	0.7744
IPCST4	0.7764
IPCST5	0.7690
IPCST6	0.7007

Supplier Management (alpha=.9544; N=188)	
Measurement Items	Corrected Item-Total Correlation
IPSPL1	0.8588
IPSPL2	0.8586
IPSPL3	0.8668
IPSPL4	0.8058
IPSPL5	0.8685
IPSPL6	0.8393
IPSPL7	0.8077

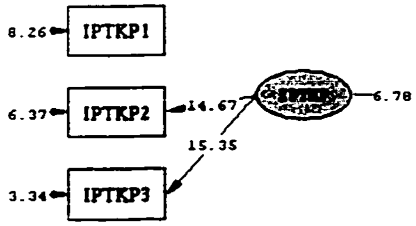
Figure 4.6.1 reports the initial results of LISREL for each scale of impact. Many modification index are suggested for customer satisfaction and suppliers management scales. Figure 4.6.2 shows the alternative measurement model(s) for each scale of impact when some of the correlated items are removed from the original measurement model.

Figure 4.6.1 The Initial Measurement Results of Impact on Work

Task Production



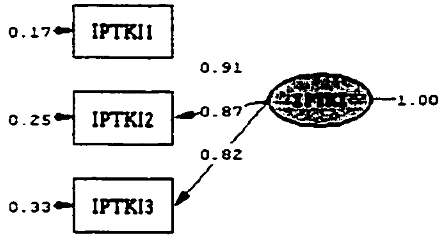
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000



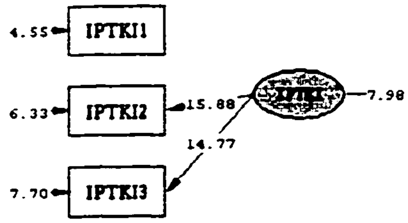
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

- T-Values

Task Innovation



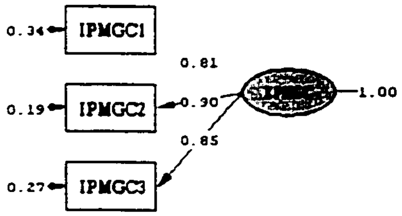
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000



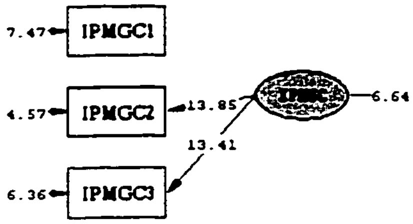
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

- T-Values

Management Control



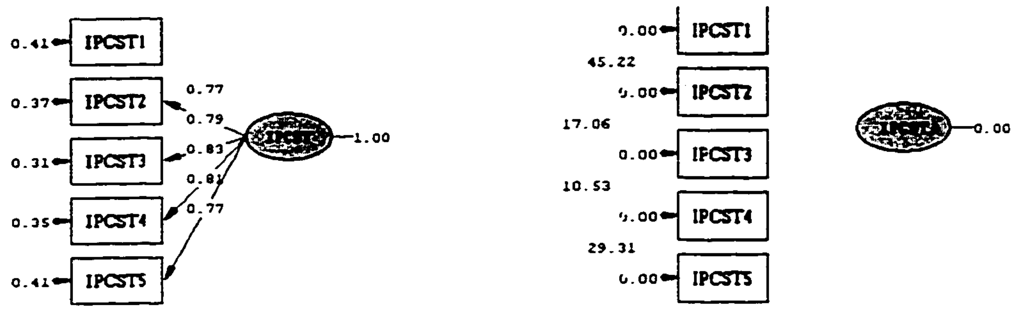
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000



Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

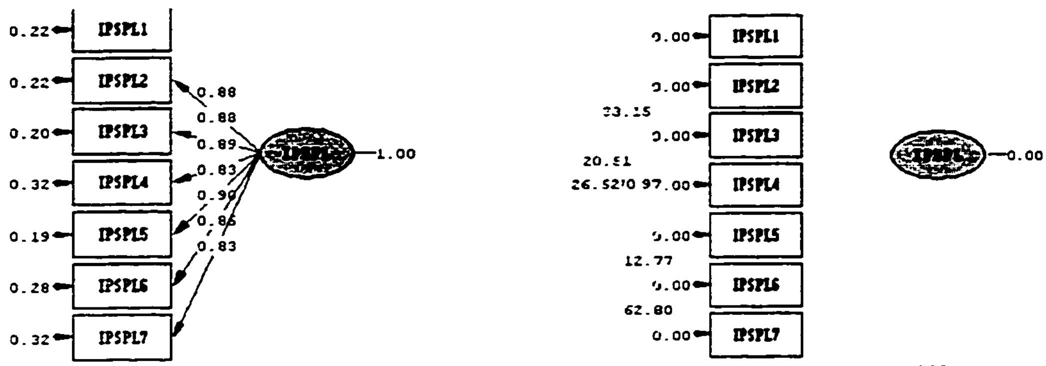
- T-Values

Customer Satisfaction



Chi-Square=61.90, df=5, P-value=0.00000, RMSEA=0.240 Chi-Square=61.90, df=5, P-value=0.00000, RMSEA=0.240

Supplier Management



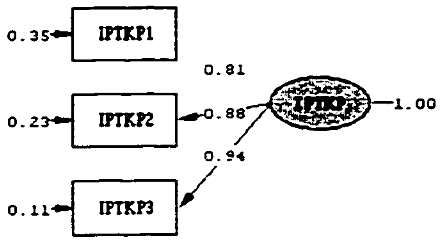
Chi-Square=148.93, df=14, P-value=0.00000, RMSEA=0.227 Chi-Square=148.93, df=14, P-value=0.00000, RMSEA=0.227

An exploratory factor analysis is conducted for the 16 measurement items purified from the above data analysis (see Table 4.10.2). The ratio of respondents to items is 13 and satisfies the general guideline of data analysis. Five scales are specified in the model as the criterion of extracting factors/scales. The Eigen values for task productivity, task innovation, management control, customer satisfaction, and supplier management are 2.06, 0.71, 1.07, 0.62, and 8.91 respectively. The cumulative variance explained by the five factors is 84 percent. All items load on their respective factors and there are no items with cross-loadings greater than 0.40 except item IPCST2 of customer satisfaction, which has a cross loading (-0.433) on the task innovation scale. In general, all items have loadings greater than 0.60.

The item-factor loadings for the measurement items of the task productivity scale are from .77 to .94. The loadings for the task innovation scale are from .67 to .89. The loadings for the management control scale are from .70 to .86. The loadings for the customer satisfaction scale are from .60 to .73. The loadings for the supplier management scale range from .61 to .82. Overall, the factor pattern matrix is simple; all of the items load high in their respective factors and low on others.

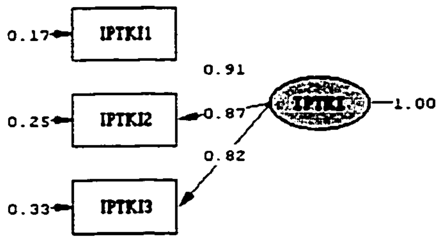
Figure 4.6.2. The Alternative Measurement Solutions for Impact on Work

Task Productivity



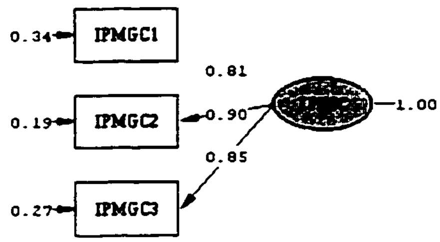
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Task Innovation



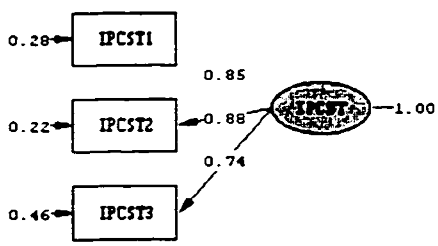
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Management Control



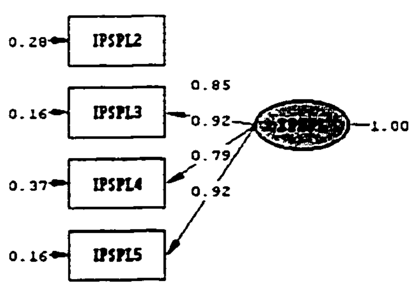
Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Customer Satisfaction

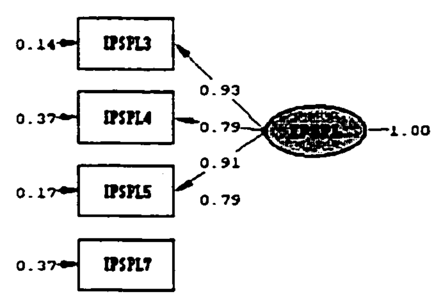


Chi-Square=0.00, df=0, P-value=1.00000, RMSEA=0.000

Supplier Management



Chi-Square=3.50, df=2, P-value=0.17402, RMSEA=0.063



Chi-Square=1.64, df=2, P-value=0.44045, RMSEA=0.000

Cronbach's alpha is computed for all scales (see Table 4.10.3). The task productivity scale (IPTKP) has three measurement items and a reliability alpha of 0.91.

The task innovation scale (IPTKI) has three items and reliability alpha of 0.90. The management control scale (IPMGC) has an alpha of 0.89 for three items. The customer satisfaction scale (IPCST) with three measurement items has an alpha of 0.86. The reliability of the supplier management scale is 0.93 for four items. Overall, the scales are reliable and the size of the measurement items is from three to four.

Section 6 of Table 4.3 reports the data-model fit index for each scale. Since four of the five scales (i.e., task productivity, task innovation, management control, and customer satisfaction) are measured with three items, these four scales have saturated data-model fit index. They have zero chi-square values and zero degree of freedom. The p-values and the RMSEA of them are 1 and 0 respectively. Supplier management scale has four measurement items. Its chi-square is 3.50 and the degree of freedom is 2. The p-value of the model is .1740. The RMSEA and ECVI of the model are 0.063 and 0.10 respectively, indicating small correlated error terms. The NNFI and CFI values of the model are 0.99 and 1.00 respectively, which show the excellent data-model fit.

Table 4.10.2. Factorial Analysis Results of Impact on Work

Pattern Matrix

Items	Component				
	Supplier Management	Task Productivity	Management Control	Task Innovation	Customer Satisfaction
IPSPL4	0.829				
IPSPL5	0.773				
IPSPL3	0.757				
IPSPL2	0.618				
IPTKP1		0.942			
IPTKP3		0.867			
IPTKP2		0.777			
IPMGC2			0.868		
IPMGC3			0.821		
IPMGC1			0.707		
IPTKI2				-0.897	

IPTKI1				-0.690	
IPTKI3				-0.676	
IPCST1					-0.738
IPCST3					-0.719
IPCST2				-0.433	-0.609

Component Correlation Matrix

Component	Supplier Management	Task Productivity	Management Control	Task Innovation	Customer Satisfaction
Supplier Management	1				
Task Productivity	0.351	1			
Management Control	0.513	0.190	1		
Task Innovation	-0.513	-0.506	-0.371	1	
Customer Satisfaction	-0.359	-0.498	-0.399	0.427	1

Eigen Value	8.919	2.069	1.070	0.716	0.622
% of Variance	55.746	12.929	6.684	4.475	3.885
Total Variance Explained: 84%					

The discriminant validity is examined by the difference between the chi-square values (one degree of freedom) for the fixed and free solutions for the 10 pairs listed in section 6 of Table 4.4. All the chi-square differences for the tests are greater than 117 (for management control with supplier management). The number is far exceeded 10.8276 for a significant level at a 0.01 level of 10 comparisons, indicating that the scales have discriminant validity.

Table 4.4 shows the correlations between the scales and descriptive statistics of each scale of the impact variable. These correlations are derived from SPSS output. While all pairs (> .376) are significant at a 0.01 level, the scales are distinct.

All scales of the impact on work variable are explained by their antecedents (i.e., learning capacity, learning motivation, empowerment, continuous improvement efforts, and information technology utilization). The values of the R-square for task productivity, task innovation, management control, customer satisfaction, and supplier management are .574, .592, .470, .411, and .499 respectively (see Table 4.7), indicating that most of the variance of the scales are explained by the model.

Overall, sixteen (16) items and five scales (see Table 4.10.3) are proposed for measuring the impact variable. The number of proposed items varies from three for task productivity, task innovation, management control, and customer satisfaction to four for supplier management.

Table 4.10.3. Measurement Scales of Impact on Work Recommended for Future Studies (16 items)

Label	Item Description	CITC*
	Task Productivity (No of Cases = 202; No of Items = 3; Alpha = .9076)	
IPTKP1	This application increases my productivity....................................	0.7698
IPTKP2	This application saves me time..	0.8192
IPTKP3	This application allows me to accomplish more work than would otherwise be possible..	0.8590
	Task Innovation (No of Cases = 202; No of Items = 3; Alpha = .8994)	
IPTKI1	This application helps me come up with new ideas............................	0.8300
IPTKI2	This application helps me create new ideas....................................	0.8037
IPTKI3	This application helps me try out innovative ideas............................	0.7713
	Management Control (No of Cases = 197; No of Items = 3; Alpha = .8912)	
IPMGC1	This application helps management control the work process.................	0.7586
IPMGC2	This application helps management control performance.......................	0.8159
IPMGC3	This application improves management control..............................	0.7861
	Customer Satisfaction (No of Cases = 199; No of Items = 3; Alpha = .8612)	
IPCST1	This application helps me meet customer needs...............................	0.7579
IPCST2	This application improves customer satisfaction...............................	0.7741
IPCST3	This application improves customer service....................................	0.6839
	Supplier Management (No of Cases = 192; No of Items = 4; Alpha = .9262)	
IPSPL2	This application improves the cooperation with suppliers.......................	0.8186
IPSPL3	This application improves the communication with suppliers..................	0.8671
IPSPL4	This application helps suppliers meet our needs...............................	0.7697
IPSPL5	This application helps me communicate requirements to suppliers...........	0.8621

4.1.7. Summary of the Measurement Results

Overall, total 78 measurements are retained to measure 21 scales of six variables hypothesized in the research model. The measurement scales have high discriminant validity. With total 21 groups and 210 pair comparisons, the alpha value is adjusted (alpha is divided by the number of comparisons). The chi-square value for any pair must be equal to or greater than approximately 13.5044 for a significant level at 0.05 or 16.5406 for a significant level at 0.01. The minimum Chi-square difference between pairs of the scales is 45.86 for prior knowledge of computers with intuitive problem solving, indicating that all scales have discriminant validity at a 0.01 significant level (see Table 4.4).

All measurement models have low Chi-square values (from 0 for 0 degree of freedom to 9.98 for 5 degrees of freedom). The p-values are non-significant at a 0.05 significant level. All models show RMSEA values from 0 to 0.096, indicating satisfactory correlated error terms. For non-saturated models (i.e., the number of measurement items is greater than 3), the high values for NNFI and CFI indicate an excellent model-data fit (see Table 4.3).

All scales have reliability values greater than 0.80 except for the intuitive problem solving scale, whose reliability value is only 0.66 (see Table 4.4). The variables of continuous improvement efforts, IT utilization, and impact on work are explained well by learning capacity, learning motivation, and empowerment (i.e., R-square > .30) except for work integration (R-square = .095), work planning (R-square = .172), and skill enhancement (R-square = .198) scales (see the rightmost column in Table 4.5). For learning capacity, learning motivation, empowerment, continuous improvement efforts, and information technology utilization, most scales of the variables can predict the corresponding criterion variables except for the goal clarity, support, process improvement, and skill enhancement scales (see Table 4.5). A discussion for those exceptions is in Chapter 5.

4.2. Exploratory Structural Analysis

To explore the antecedent role of learning capacity, learning motivation, and empowerment and the mediating role of continuous improvement efforts and information technology utilization, linear structural equations modeling is used. This not only allows the assessment of construct validity in a nomological network of constructs, but it also gives an initial opportunity of testing substantive hypothesis. Although a two-step process is followed, first measurement and then structural, results should be interpreted with caution since the same data is used for both the measurement and structural models.

The data are first examined for sufficient evidence of normality. After the test is conducted, the hypothesized model is then specified and tested.

4.2.1. Normality

As the maximum likelihood (ML) method of estimation is sensitive to departures from multivariate normality (Joreskog & Sorbom, 1993), it is of particular interest to examine whether the individual measures are distributed according to univariate normality. Joreskog and Sorbom note that the assumption of multivariate normality is seldom fulfilled in practice. Moreover, they suggest that as the violation of normality increases the value of chi-square, the analysis should be viewed as a conservative test of the model.

Table 4.11. The Normality (i.e., Kolmogorov-Smirnov) Test

Variables	N	Normal Parameters		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
IP	**184**	**3.17**	**0.95**	**0.08**	**0.06**	**-0.08**	**1.06**	**0.2160**
IPTKP	202	3.71	1.08	0.18	0.12	-0.18	2.50	0.0000
IPTKI	202	3.17	1.16	0.13	0.07	-0.13	1.83	0.0020
IPMGC	197	2.89	1.17	0.14	0.09	-0.14	1.98	0.0010
IPCST	199	3.37	1.14	0.14	0.09	-0.14	1.97	0.0010
IPSPL	192	2.69	1.23	0.12	0.12	-0.10	1.72	0.0050
TU	**195**	**2.97**	**1.01**	**0.05**	**0.04**	**-0.05**	**0.69**	**0.7260**
TUDSE	203	3.29	1.15	0.14	0.07	-0.14	2.04	0.0000
TUWIT	198	3.02	1.27	0.12	0.08	-0.12	1.75	0.0050
TUWPL	202	2.64	1.15	0.09	0.09	-0.08	1.31	0.0640
CI	**198**	**2.60**	**0.90**	**0.08**	**0.08**	**-0.05**	**1.07**	**0.2010**
CIPRC	200	2.70	1.09	0.10	0.10	-0.07	1.34	0.0550
CISKL	205	3.02	0.99	0.10	0.08	-0.10	1.36	0.0510
CISFT	202	2.11	1.10	0.18	0.18	-0.16	2.54	0.0000
LC	**187**	**2.90**	**0.63**	**0.05**	**0.05**	**-0.03**	**0.65**	**0.7980**
LCSYS	203	3.78	0.78	0.19	0.13	-0.19	2.73	0.0000
LCINT	202	2.36	0.87	0.10	0.10	-0.09	1.45	0.0300
LCCIS	198	1.93	0.97	0.17	0.16	-0.17	2.37	0.0000
LCTSK	200	3.54	0.89	0.09	0.06	-0.09	1.26	0.0850
LM	**196**	**3.76**	**0.61**	**0.08**	**0.07**	**-0.08**	**1.13**	**0.1530**
LMGLS	205	4.06	0.65	0.14	0.09	-0.14	2.05	0.0000
LMITM	202	3.65	0.84	0.14	0.07	-0.14	2.05	0.0000
LMSNM	201	3.62	0.82	0.16	0.12	-0.16	2.20	0.0000
EP	**197**	**3.89**	**0.67**	**0.10**	**0.05**	**-0.10**	**1.34**	**0.0560**
EPAUT	202	3.66	0.81	0.14	0.14	-0.14	2.04	0.0000
EPSEF	205	3.97	0.80	0.15	0.10	-0.15	2.20	0.0000
EPSPT	202	4.01	0.81	0.23	0.15	-0.23	3.25	0.0000

Although univariate normality across variables does not guarantee a joint multivariate normal distribution, the presence of multivariate non-normality is reflected in univariate distributions (Stevens, 1986). For this test, Kolmogorov-Smirnov statistics are calculated for each variable.

The Kolmogorov-Smirnov tests are summarized in Table 4.11. Correcting for the number of tests, alpha (i.e., the level of significance) is divided by the number of variables (i.e., 0.01/6 = 0.0017) and then used as the cutoff value to test for normality. Notice that non-significant values indicate univariate normality. All aggregated variables (i.e., IP, TU, CI, LC, LM, and EP) have passed the univariate normality test. According to the results of these tests, the use of maximum likelihood estimation may not be constrained by normality considerations.

4.2.2. Exploratory Correlation and Structural Analysis Methods

The covariance matrix (see Table 4.12) that is entered into LISREL is used to preliminarily assess the hypothesized relationships. The measurement models for the scales of learning capacity, learning motivation, empowerment, continuous improvement efforts, information technology utilization, and impact on work have been identified in previous sections.

Table 4.12. Descriptive Statistics and Covariance for Variables in the Structural Model.

Variables	Mean	s.d.	1	2	3	4	5	6
1. Impact on Work	3.1711	0.9475	0.9334					
2. IT Utilization	2.9721	1.0095	0.6799	1.0384				
3. CI Efforts	2.5981	0.8992	0.3521	0.3316	0.8701			
4. Learning Capacity	2.8955	0.6261	0.2373	0.2249	0.3297	0.3938		
5. Learning Motivation	3.7589	0.6116	0.3394	0.3079	0.2060	0.1650	0.3834	
6. Empowerment	3.8861	0.6659	0.3938	0.2558	0.2653	0.2082	0.2823	0.4756

Note: s.d. means standard deviation

To be congruent with the hypothesized model in Figure 2.4, learning capacity, learning motivation, and empowerment are treated as exogenous variables (ξ_1, ξ_2, ξ_3). The endogenous variables include impact on work (η_1), information technology utilization (η_2), and continuous improvement efforts (η_3). The terms exogenous variables and endogenous variables are synonymous with independent and dependent variables respectively. These terms are introduced here (and will be used in the rest of the chapter) to emphasize that endogenous variables have their causal antecedents specified within the model under consideration, whereas the causes of exogenous variables are outside the model and not of present interest. The two measurement models (i.e., exogenous and endogenous) can be specified as:

$X = \Lambda_x\xi + \delta$ .... (1)

$Y = \Lambda_y\eta + \varepsilon$ .... (2)

In factor equation (1), X is a (10×1) vector of the observed measurement items corresponding to the exogenous latent variable. The measures of learning capacity, learning motivation, and empowerment are second order measures with four, three, and three first-order constructs respectively. Xi (ξ) is a (3x1) vector of the latent exogenous variables. Lambda X (Λ_x) is a (10×3) vector of factor loading of X on ξ. Delta (δ) is a (11×1) vector of measurement errors of X.

In equation (2), Y is a (11×1) vector of observed measures of latent endogenous variables. Eta (η) is (3×1) vector of latent endogenous variables. Lambda Y (Λ_y) is a

(11×3) matrix of factor loadings of Y on η. Epsilon (ε) is a (11×1) vector of measurement errors of Y.

These two measurement models are linked by a structural equation model:

$$\eta = \beta\eta + \Gamma\xi + \zeta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where Beta (β) is a (3×3) matrix of coefficients relating the endogenous variables to one another. Gamma (Γ) is a (3×3) vector of structural coefficients relating the exogenous variables to the endogenous variables. Zeta (ζ) is a (3×1) vector of errors in structural equations. ζ indicates that the endogenous variables are not perfectly predicted by the structural equations.

The structural equation model, as expressed by equations (1), (2), and (3), can be translated into a path diagram shown in Figure 2.4. The exogenous variables, learning capacity (ξ_1), learning motivation (ξ_2), and empowerment (ξ_3), are located on the left side of Figure 2.4. There are three structural equations (Γ) parameters in Figure 2.4, which are represented by the arrows from the three exogenous variables to the one endogenous variable (i.e., continuous improvement efforts). On the right of Figure 2.4, the three endogenous variables (i.e., continuous improvement efforts, information technology utilization, and impact on work) are listed. Because it is postulated that the information technology utilization scale (η_2) is related to impact on work (η_1) and the continuous improvement efforts scale (η_3) is related to information technology utilization (η_2), two causal paths represented by β_1 and β_2 are specified between η_2 and η_1, and η_3 and η_2 respectively.

For the sake of clarity, the symbols for these arrows (i.e., Γ's and β's) are not given in Figure 2.4. If the model fits the data adequately, the magnitudes and t-values of the Gamma and Beta coefficients will be evaluated to test the research hypotheses. A t-value is the ratio of an estimated parameter to its standard error (Marsch & Hocevar, 1985). A value that is greater than 1.96 is significant at $p<0.05$. A t-value that is greater than 2.33 is significant at $p<0.01$.

To assess the fit of the model to the data, various fit statistics are computed. These include the chi-square, root mean square error of approximation (RMSEA), non-normed fit index (NNFI), and comparative fit index (CFI). The chi-square statistic is a global test of a model's ability to reproduce the sample variance/covariance matrix, but it is sensitive to sample size and departures for multivariate normality (Bollen, 1989). Thus, the chi-square statistic must be interpreted with caution in most applications (Joreskog & Sorbom, 1993). Nonsignificant chi-square values are desirable and provide evidence of good fit. Two widely used incremental fit indices are the Bentler and Bonnet's (1980) non-normed-fit-index (NNFI) and Bentler's (1990) comparative-fit-index (CFI). NNFI is a relative comparison of the proposed model to the null model. CFI avoids the underestimation of fit often noted in small samples for normed fit index (NFI) (Bentler, 1990). Values those are greater than 0.90 can be considered indicative of good fits for both indices.

4.2.3. The Results of the Structural Analysis

The correlation matrix (see Table 4.13) has showed that all coefficients are ranged from .35 for learning capacity with information technology utilization to .69 for information technology utilization with impact on work, indicating that the six variables are significantly related to each other.

Table 4.13. Descriptive Statistics and Correlation for Variables in the Structural Model.

Variables	Mean	s.d.	1	2	3	4	5	6
1. Impact on Work	3.1711	0.9475	1					
2. IT Utilization	2.9721	1.0095	0.6906	1				
3. CI Efforts	2.5981	0.8992	0.3907	0.3488	1			
4. Learning Capacity	2.8955	0.6261	0.3914	0.3516	0.5632	1		
5. Learning Motivation	3.7589	0.6116	0.5674	0.4880	0.3566	0.4246	1	
6. Empowerment	3.8861	0.6659	0.5910	0.3640	0.4123	0.4810	0.6611	1

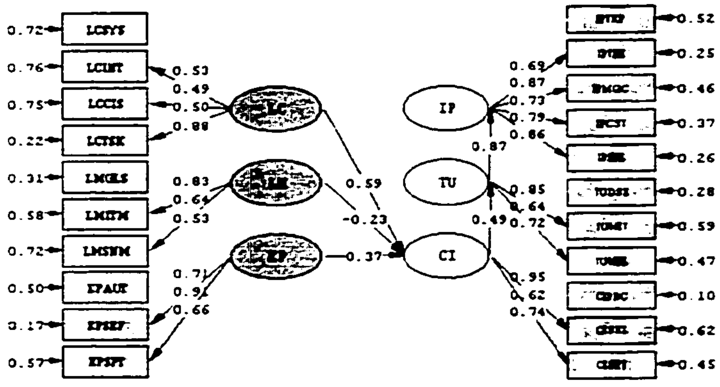
Note: s.d. means standard deviation

The model is a partial aggregation model. In the model, the composite of the items for each dimension of a scale is treated as an indicator of the underlying factor (Bagozzi & Heatherton, 1994). For example, learning capacity has four dimensions: systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers. In the partial aggregation model, the respective average values of the items measuring systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers are used as indicators measuring learning capacity.

To further assess the relationships, LISREL methodology is used to conduct an exploratory path analysis. The results of fitting the model to the data (see section 1 in Figure 4.7) indicate that the model has a poor model-data fit (chi-square=625, df = 181; p= 0.0000). The root mean square error of approximation (RMSEA) is 0.13. The non-normed fit index (NNFI) and the comparative fit index (CFI) are 0.75 and 0.78 respectively.

Figure 4.7. Structural Analysis for IT Learning Model

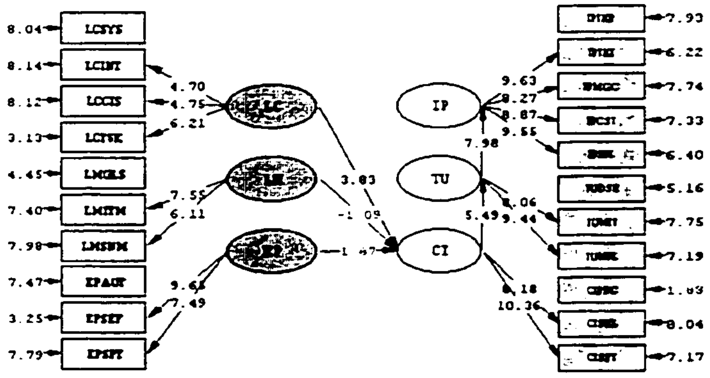
1. Standardized Solutions for the Basic Model



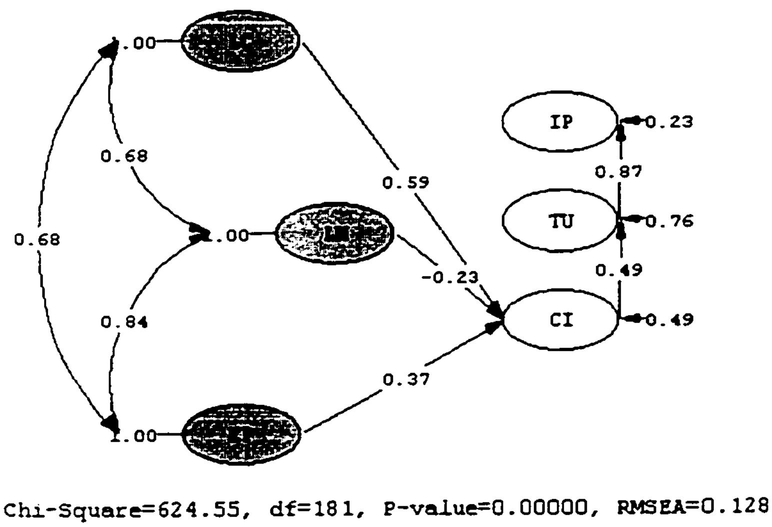
FIT STATISTICS:

- Chi-Square with 181 df = 624.55 (P = 0.0000)
- Root Mean Square Error of Approximation (RMSEA) = 0.13
- Non-Normed Fit Index (NNFI) = 0.75
- Comparative Fit Index (CFI) = 0.78

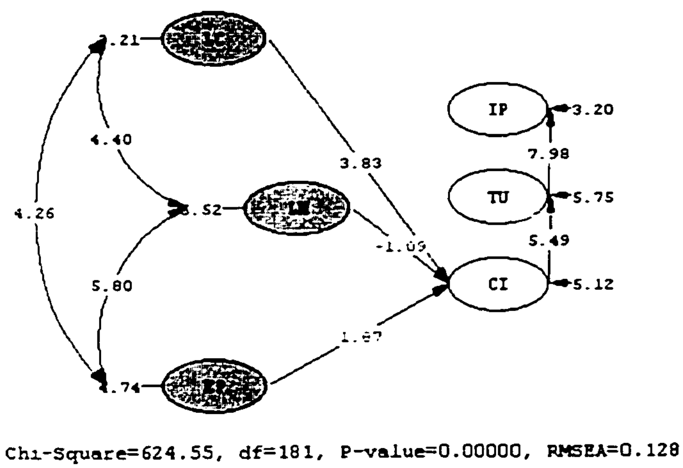
2. T-Values for the Basic Model



3. Standardized Solution for Structural Model



4. T-values for Structural Model



Section 2 of Figure 4.7 shows the t-values of the basic model. Section 3 reports the standardized solution of the structural model. Section 4 of the Figure shows the t-values of the structural model.

The findings for the structural equation model are summarized in Table 4.14. To examine the total effects, the coefficients for indirect effects are calculated (Joreskog &

Sorbom, 1993). It is possible to break total effects into direct, indirect, and noncausal. Learning capacity is hypothesized to be an antecedent to continuous improvement efforts. The data support the relationship as manifested by the high positive t-value (3.83). Learning capacity increases continuous improvement efforts. No indirect relationships are hypothesized and noncausal effects are not present.

The structural coefficient from learning motivation to continuous improvement efforts is negative and nonsignificant (t=-1.09). No indirect relationships are hypothesized and noncausal effects are not present. The structural coefficient from empowerment to continuous improvement efforts is nonsignificant (t=1.87). No indirect relationships are hypothesized and noncausal effects are not present.

Turning now to the endogenous to endogenous relationships, it is postulated that continuous improvement efforts will have a significant impact on information technology utilization. Indeed, the Beta coefficient is positive and significant (t=5.49), indicating that continuous improvement efforts enhance information technology utilization. MIS literature also supports that information technology utilization will have an effect on impact on work. This effect is manifested in the direct relationship. The structural coefficient Beta that links the two variables indicates that the direct effect is positive and significant (t=7.98). This structural coefficient is the strongest among all coefficients in the model. Information technology utilization improves impact on individual's work.

As a measure of the entire structural equation, an overall coefficient of determination (R-square) is calculated for each endogenous variable. The coefficient is similar to that found in multiple regression. Although no test of statistical significance can be performed, it provides a relative measure of fit for each structural equation. For η_1, the impact on work scale, R-square is 0.77 and is the highest among the three coefficients. For the information technology utilization scale (η_2) it is the lowest and is equal to 0.24. The coefficient for continuous improvement efforts is 0.51, indicating that fifty-one percent of the variation in the continuous improvement efforts scale (η_3) can be explained by the suggested model.

Table 4.14. Decomposition of Effects for the Structural Model (Standardized Coefficients)

Relationship	Total Effects	Direct Effect	Indirect Effects	Noncausal Effects
Learning Capacity to Impact on Work (KSI1 to ETA1)	0.25 (3.06**)		0.25 (3.06**)	
Learning Capacity to IT Utilization (KSI1 to ETA2)	0.29 (3.18**)		0.29 (3.18**)	
Learning Capacity to CI Efforts (KSI1 to ETA3)	0.59 (3.83**)	0.59 (3.83**)		
Learning Motivation to Impact on Work (KSI2 to ETA1)	-0.10 (-1.06)		-0.10 (-1.06)	
Learning Motivation to IT Utilization (KSI2 to ETA2)	-0.11 (-1.07)		-0.11 (-1.07)	
Learning Motivation to CI Efforts (KSI2 to ETA3)	-0.23 (-1.09)	-0.23 (-1.09)		
Empowerment to Impact on Work (KSI3 to ETA1)	0.16 (1.75)		0.16 (1.75)	
Empowerment to IT Utilization (KSI3 to ETA2)	0.18 (1.78)		0.18 (1.78)	
Empowerment to CI Efforts (KSI3 to ETA3)	0.37 (1.87)	0.37 (1.87)		
IT Utilization to Impact on Work (ETA2 to ETA1)	0.87 (7.98**)	0.87 (7.98**)		
CI Efforts to Impact on Work (ETA3 to ETA1)	0.43 (4.93**)		0.43 (4.93**)	
CI Efforts to IT Utilization (ETA3 to ETA2)	0.49 (5.49**)	0.49 (5.49**)		

** t-values (in parentheses) are significant at 0.01 (t-values greater than 2.33).

Squared Multiple Correlations for Structural Equations:

ETA1 (IP)	ETA2 (TU)	ETA3 (CI)
0.77	0.24	0.51

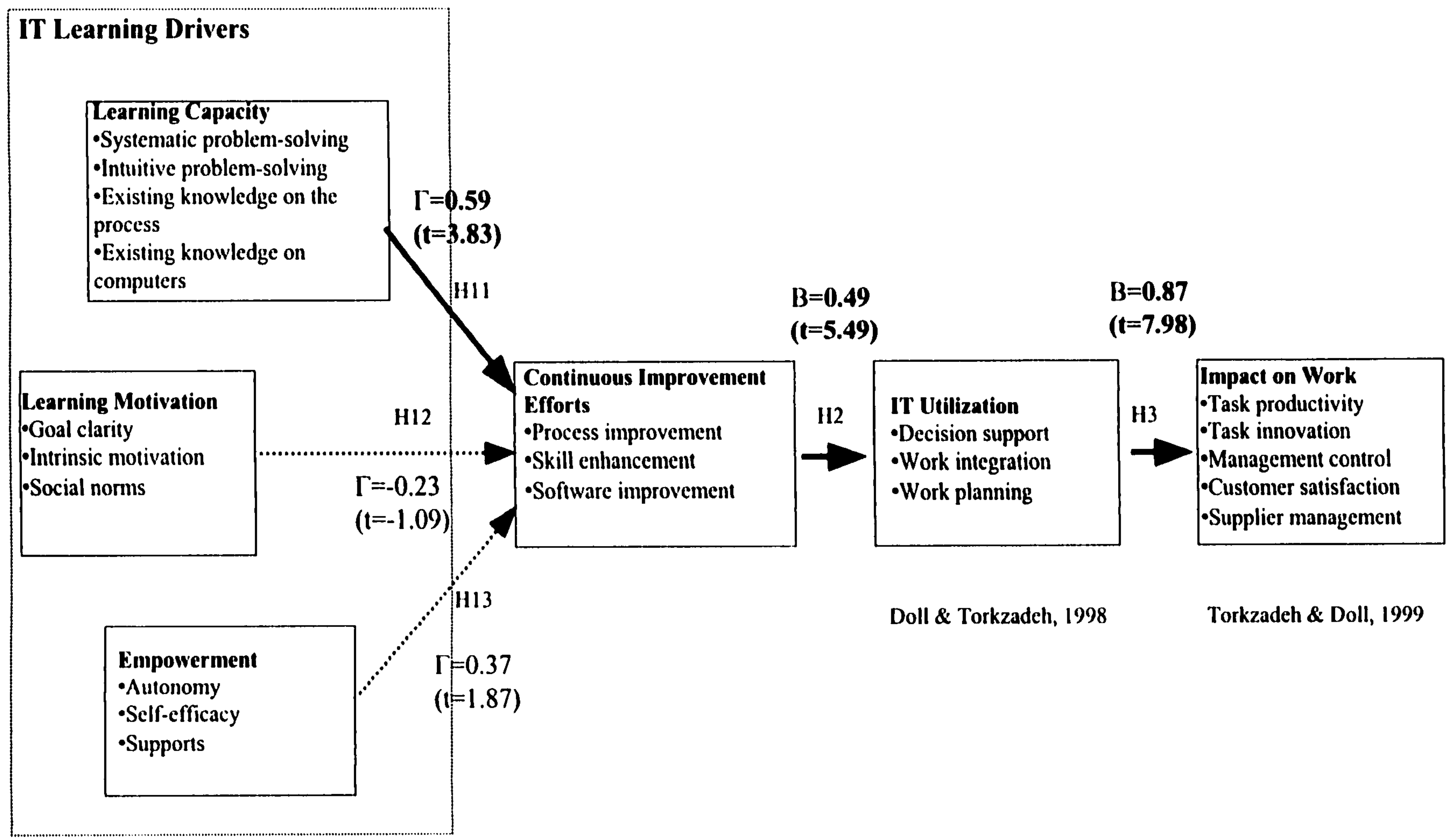
Overall, the data indicate that learning capacity leads to continuous improvement efforts. Empowerment has positive but non-significant relationship with continuous improvement efforts while learning motivation has a negative but non-significant relationship with continuous improvement efforts. Continuous improvement efforts enhance the information technology utilization, and IT utilization improves impact on work (see Figure 4.8). Therefore, hypotheses H11, H2, and H3 are evidenced from the dataset. Hypotheses H12 and H13 are rejected by the dataset (see Table 4.15).

These conclusions should be drawn with caution, as they may only be applicable to the particular sample of this research that includes primarily CAD and CAM applications. It is possible that there is a measurement problem with the intuitive problem solving, goal clarity, and supports scales. Additional efforts should be expended in future researches to establish valid and reliable measures of those scales. After the revised measurement scales have been obtained, alternative structural models may be tested.

Table 4.15. Test Results of the Hypotheses

Hypothesis	Result	T-Value
H11: Learning Capacity → Continuous Improvement Efforts	Not rejected	3.83
H12: Learning Motivation → Continuous Improvement Efforts	Rejected	-1.09
H13: Empowerment → Continuous Improvement Efforts	Rejected	1.87
H2: Continuous Improvement Efforts → IT Utilization	Not rejected	5.49
H3: IT Utilization → Impact on Work	Not rejected	7.98

Figure 4.8. The Summary of the IT Learning Model in a CIM Context

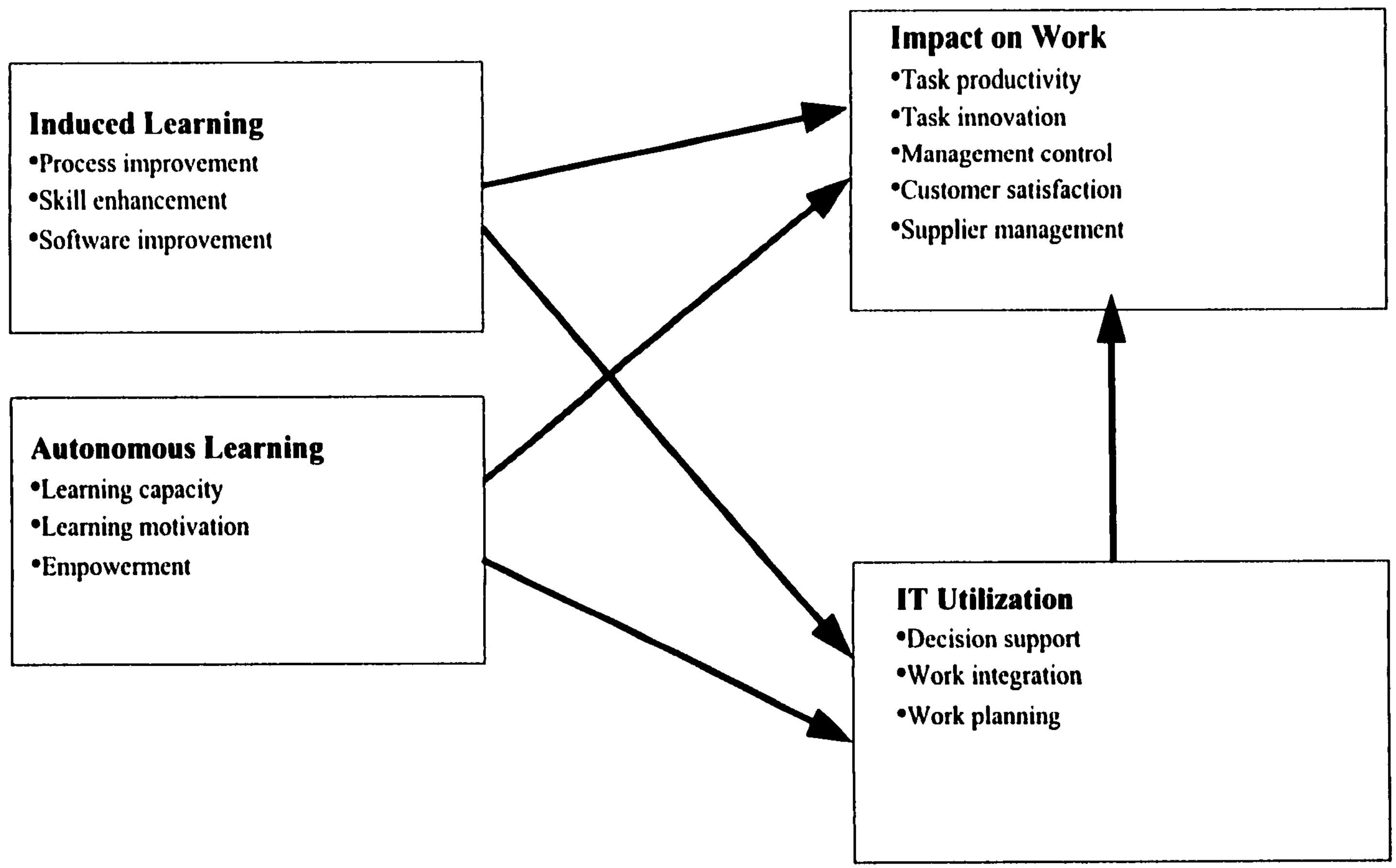


4.2.4. The Alternative Structural Model

This study tests an alternative structural model suggested in learning theory using current measurement scales (see Figure 4.9). The alternative model employs autonomous and induced learning as exogenous variables to explain both IT utilization and IT's impact on individual work. Both IT utilization and IT's impact are viewed as learning performance or outcomes. Same as the hypothesized model, the alternative model hypothesizes that IT's impact on individual work comes from IT utilization. Different from the hypothesized model, the alternative model hypothesizes that both IT utilization and IT's impact on individual work are determined by autonomous learning and induced learning. Autonomous learning (see chart a in Figure 4.10) is the improvement in performance (usage or impact) due to individual experience at the job (Li & Rajagopalan, 1998; Upton & Kim, 1998; Adler & Clark, 1991; Dutton & Thomas, 1984; Levy, 1965). It is sometimes referred to as "learning by doing". Different learning environments affect the slope of the learning curve. For example, a conducive environment may facilitate an individual's learning, thus may create a steeper learning curve for the individual (see the dashed curve in chart a of Figure 4.10). While it is not due to conscious improvement efforts, it is enhanced by the individual's capabilities, motivation, and empowerment.

Induced learning (see chart b in Figure 4.10) is the improvement in performance (usage or impact) due to an individual's conscious planning and implementation of continuous improvement efforts (Li & Rajagopalan, 1998; Adler & Clark, 1991; Dutton & Thomas, 1984; Levy, 1965). It is also referred to as "learning by planning" or "continuous improvement". It is similar to Deming's "plan-do-check-act" (PDCA) model of continuous improvement for manufacturing employees. While small, each PDCA

Figure 4.9. An Alternative IT Learning Model in a CIM Context



cycle may shift the learning curve downward (see the dashed curve in chart b of Figure 4.10). Each downward movement of the learning curve means that the person learns. Any of the continuous improvement efforts or their combinations can cause the downward movement of the learning curve. The more efforts, the larger movement of the curve, representing the greater learning.

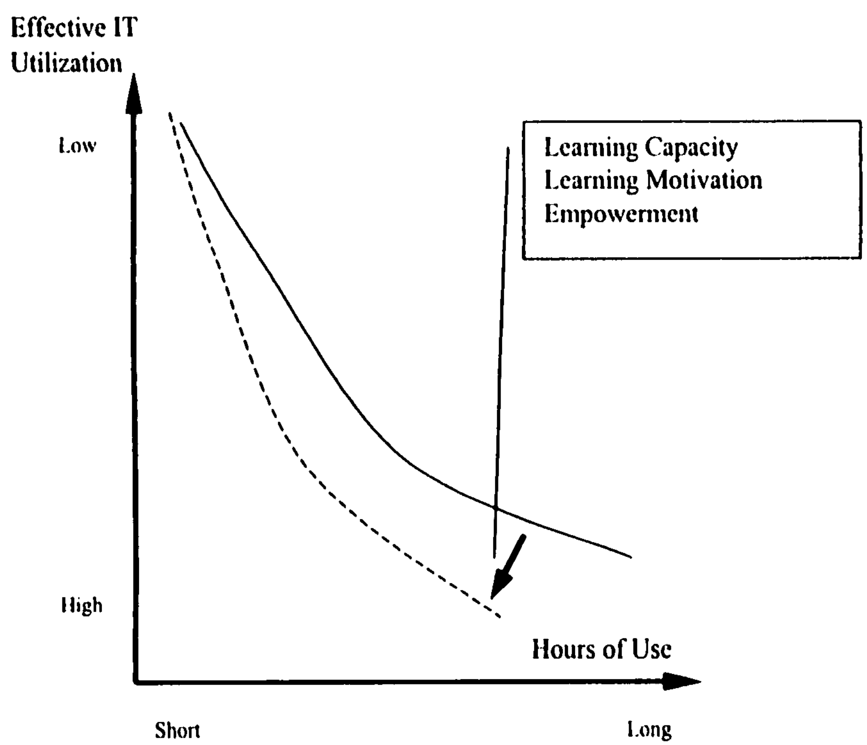
The alternative model captures both "learning by doing" (i.e., autonomous learning) and "learning by planning" (i.e., induced learning) effects. While autonomous learning improves ones performance along the learning curve, induced learning may result in a great-leap-forward in performance (Li & Rajagopalan, 1998; Adler & Clark, 1991). Without identifying possible complex causal relationships, the alternative model simple hypothesizes that performance improvements result from the combination of both autonomous learning and induced learning.

Autonomous learning represents the "practice makes perfect" phenomenon. It is the improvement in the performance of fixed tasks (Li & Rajagopalan, 1998). In manufacturing setting, it involves automatic improvements that result from sustained production. Reaping its benefits requires little conscious managerial efforts. In the alternative model, learning capacity, learning motivation, and empowerment are used as the measurement indicators of autonomous learning since they reflect the person's typical working climates or practices. Engineers complete their daily work and improve their performance unconsciously along their learning curve in this environment.

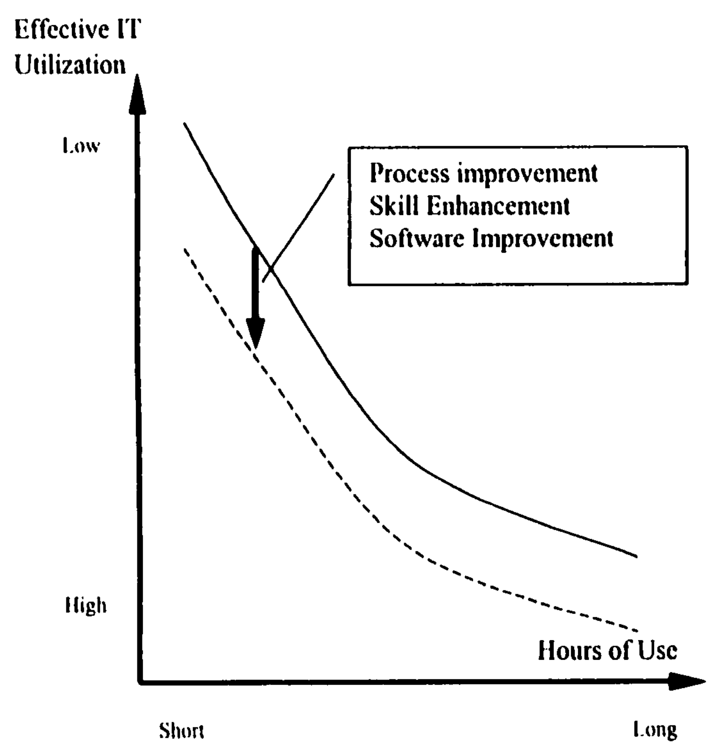
Induced learning is evidenced through one's continuous improvement efforts. Three types of continuous improvement efforts identified in the hypothesized model are employed as the measurement indicators of induced learning. Thus, the alternative model

Figure 4.10. Autonomous vs. Induced Learning

a. Autonomous Learning



b. Induced Learning



views the process improvement, skill enhancement, and software improvement efforts as the measurement indicators of induced learning.

The measurement models for autonomous learning and induced learning take a partial aggregation approach (Bagozzi & Heatherton, 1994). For example, the value for learning capacity is derived through averaging the values of all items measuring systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers. This rule is applicable to all indicators measuring autonomous learning and induced learning.

IT utilization and impact on work are evaluated through the same instruments identified in the hypothesized model. However, in order to reduce correlated error terms, the measurement items are reorganized. Three indicators (i.e., IP1 through IP3) are generated for IT's impact variable and four (i.e., TU1 through TU4) for IT utilization variable. The value of each indicator is the average value of a group of items that are randomly picked up from existing dimensions. For example, the value of indicator IP1 is the average value of five items; each of them is randomly coming from one of the task productivity, task innovation, management control, customer satisfaction, and supplier management scales respectively.

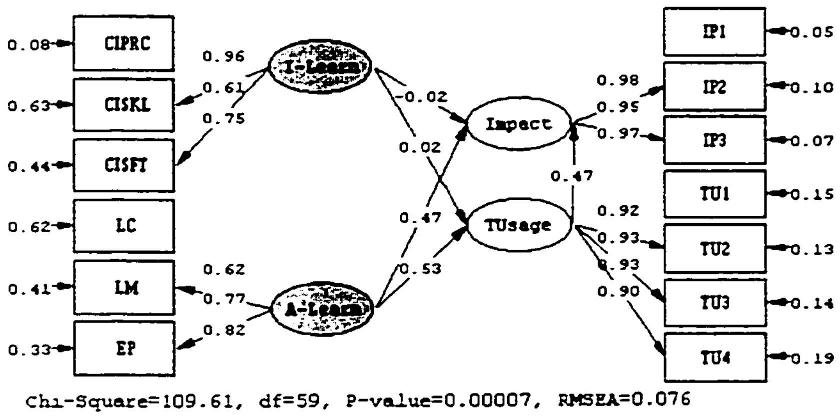
Figure 4.11 shows the result of the model. Label I-Learn stands for induced learning construct and A-Learn represents autonomous learning construct. Label TUsage represents information technology utilization construct. Section 1 of Figure 4.11 is the standardized solution for the basic model. The item-factor loadings of autonomous learning are ranged from .62 for learning capacity (LC) to .82 for empowerment (EP). The item-factor loadings of induced learning are ranged from .61 for skill enhancement

(CISKL) to .96 for process improvement (CIPRC). The t-values for the basic model are shown in section 2 of the figure.

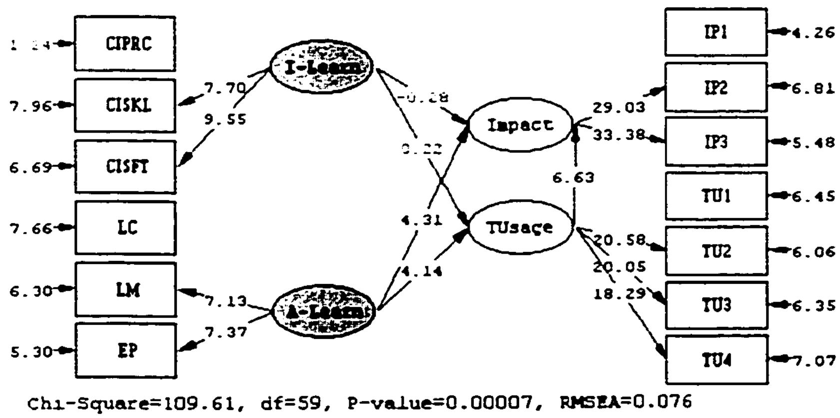
The chi-square of the model is 109.61 with 59 degree of freedom (see section 3 of Figure 4.11). The p-value for the model is 0.0001. RMSEA and ECVI are 0.076 and 1.17 respectively, indicating good data-model fit. The NNFI and CFI are 0.96 and 0.97 respectively, suggesting an excellent data-model fit.

Figure 4.11. Structural Analysis for the Alternative Model

1. The Standardized Solution for Basic Model



2. T-Values for Basic Model



3. FIT STATISTICS:

- Chi-Square with 59 df = 109.61 (P = 0.0001)
- Root Mean Square Error of Approximation (RMSEA) = 0.076
- Expected Cross-Validation Index (ECVI) = 1.17
- Non-Normed Fit Index (NNFI) = 0.96
- Comparative Fit Index (CFI) = 0.97

The findings for the structural equation model are summarized in Table 4.16. Autonomous learning and induced learning are hypothesized to be antecedents to information technology utilization and impact on work. The data support the direct paths from autonomous learning to impact on work and from autonomous learning to IT utilization as manifested by the high positive t-values of 4.31 and 4.14 respectively. The t-value (3.89) for the indirect path from autonomous learning to impact on work through information technology utilization is positive and significant at alpha = 0.01. Noncausal effects are not present. The total effect of autonomous learning on impact on work is positive and significant at alpha = 0.01 (t-value = 5.57). No indirect relationships are hypothesized between autonomous learning and information technology learning and noncausal effects are not present for the path from autonomous learning to IT utilization. Autonomous learning enhances impact on individual's work and leads to IT utilization.

The t-value (-0.28) for the direct path from induced learning to impact on work is negative but non-significant. The t-value (0.22) for the indirect path from induced learning to impact on work through information technology utilization is positive but non-significant. Noncausal effects are not present. The total effect of induced learning on impact on work is negative and non-significant (t-value = -0.11). The t-value (0.22) for the direct path from induced learning to information technology utilization is positive but non-significant. No indirect relationships are hypothesized and noncausal effects are not present for the path from induced learning to information technology utilization. Induced learning does not affect information technology utilization and impact on work.

Table 4.16. Decomposition of Effects for the Alternative Structural Model (Standardized Coefficients)

Relationship	Total Effects	Direct Effect	Indirect Effects	Noncausal Effects
Induced Learning to Impact on Work (KSI1 to ETA1)	-0.01 (-0.11)	-0.02 (-0.28)	0.01 (0.22)	
Induced Learning to IT Utilization (KSI1 to ETA2)	0.02 (0.22)	0.02 (0.22)		
Autonomous Learning to Impact on Work (KSI2 to ETA1)	0.72 (5.57**)	0.47 (4.31**)	0.25 (3.89**)	
Autonomous Learning to IT Utilization (KSI2 to ETA2)	0.53 (4.14**)	0.53 (4.14**)		
IT Utilization to Impact on Work (ETA2 to ETA1)	0.47 (6.63**)	0.47 (6.63**)		

** t-values (in parentheses) are significant at 0.01 (t-values greater than 2.33).

Squared Multiple Correlations for Structural Equations:

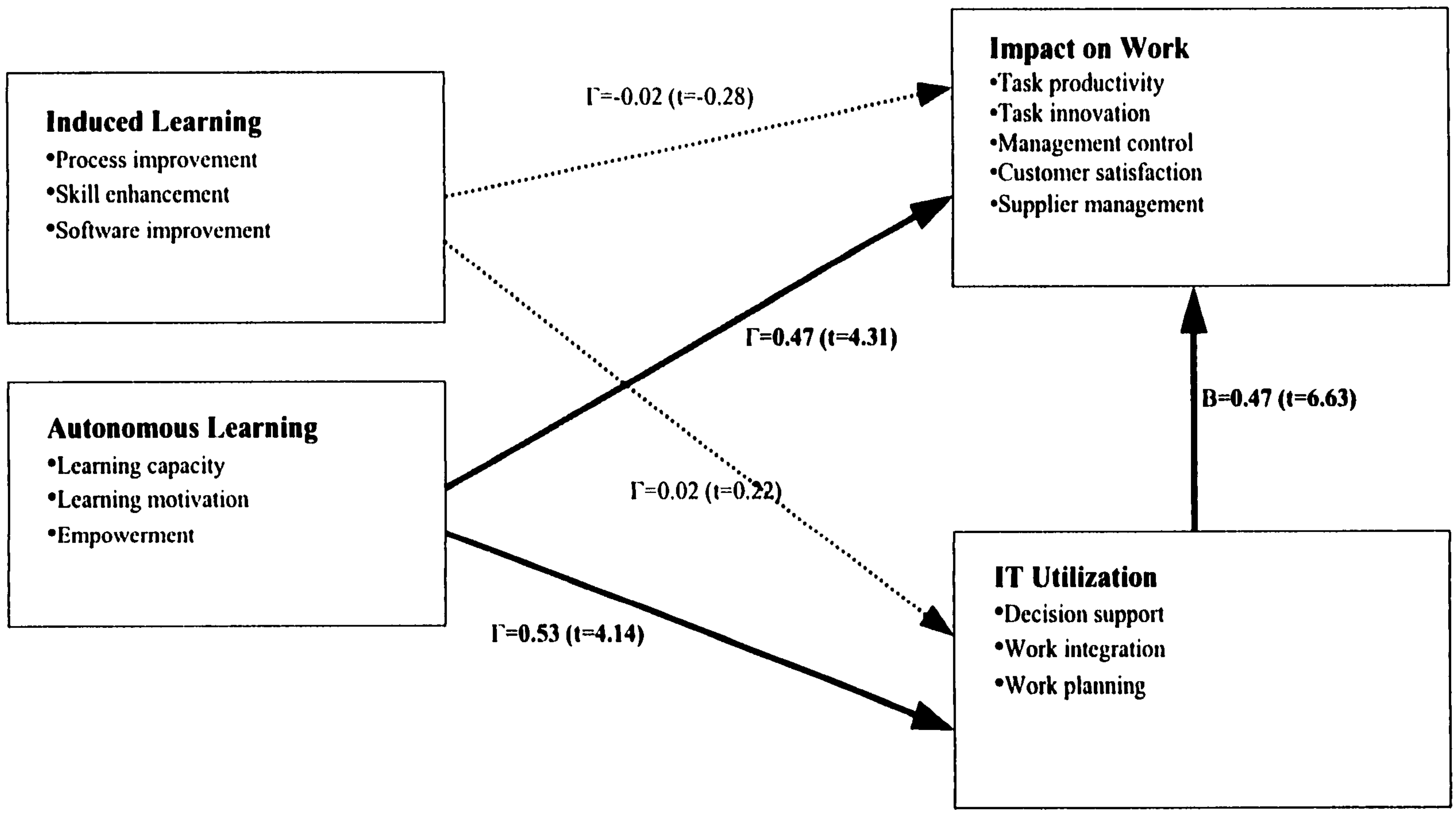
ETA1 (IP)	ETA2 (TU)
0.67	0.30

For the endogenous to endogenous relationships, MIS theory has indicated that information technology utilization will have an effect on IT's impact. This effect is evidenced in the direct relationship between IT utilization and IT's impact on work. The structural coefficient Beta that connects the two variables indicates that the direct effect is positive and significant (t=6.63). In fact, this structural coefficient is the strongest among all coefficients in the model. The information suggests that information technology utilization improves impact on individual's work.

A coefficient of determination (R-square) is calculated for information technology utilization and impact on individual's work. The R-squares for the impact on work and information technology utilization are 0.67 and 0.30 respectively, indicating that sixty seven percent and thirty percent of the variations of the respective variables are explained in the alternative model.

Overall, the data indicate that the major learning in IT/CIM applications is autonomous (see Figure 4.12). While IT/CIM utilization predicts IT/CIM's impact on individual work, both CIM utilization and CIM's impact on individual work are affected directly by autonomous learning rather than through continuous improvement efforts.

Figure 4.12. The Results of the Alternative IT Learning Model in a CIM Context



Chapter 5: Discussions and Conclusion

By developing an information technology (IT) learning model and conducting an analysis with a 208 sample across several CIM applications, this study presents an empirical investigation of the relationships between IT learning drivers, continuous improvement efforts, IT utilization, and impact on work. The study contributes to the knowledge of IT learning and IT's impact on work in the following ways.

First, the IT learning model identifies three IT learning drivers as learning capacity (i.e., systematic problem solving, intuitive problem solving, prior knowledge of work process, and prior knowledge of computers), learning motivation (i.e., goal clarity, intrinsic motivation, social norms), and empowerment (i.e., autonomy, self-efficacy, and support). Continuous improvement efforts of individual users are classified as process improvement, skill enhancement, and software enhancement. The model then hypothesizes that learning drivers cause continuous improvement efforts; continuous improvement efforts enhance IT utilization, and IT utilization impacts on individual work. This model provides a preliminary work in IT learning. The constructs identified in the model enable researchers to formulate and test numerous propositions of how to learn information technology.

Second, the study provides reliable and valid instruments to measure learning drivers and continuous improvement efforts. Measurement instruments for IT utilization and IT's impact on work have been adapted to and validated in a CIM context.

Researchers may use the instruments with confidence to investigate the effectiveness of learning information technology.

Third, the validated instruments provide IT/CIM managers a valuable tool set to benchmark their learning environment (i.e., drivers), continuous improvement efforts, IT utilization, and IT's impact on work. The results can help the managers make informed decisions on how to build learning environment where continuous improvement efforts are encouraged, IT is effectively utilized, and a bigger IT's impact on individual work is achieved.

Fourth, the study provides preliminary empirical results of the hypothesized relationships. In particular, the results suggest that higher levels of learning capacity enhance continuous improvement efforts, greater efforts to continuous improvement produce higher levels of IT utilization, and higher levels of IT utilization improve the IT's impact on an individual's work.

However, the results suggest non-significant relationships between two learning drivers (i.e., learning motivation and empowerment) and continuous improvement efforts. The unsupported relationships provide an opportunity to test the alternative model suggested in learning theory. Results on the alternative model are discussed in section 5.1; conclusions are then made in section 5.2. Sections 5.3 and 5.4 provide recommendations about measurement models and structural models for future researches respectively.

5.1. Discussions

In computer-mediated work, the data suggest that learning is primarily learning by doing (autonomous learning). No significant improvement in performance is found due to induced learning at an individual level. The finding seems to contradict the widely accepted PDCA cycle in continuous improvement literature. However, while other explanations exist, this study identifies the following possible interpretations.

First, the use of the integrated software on operational tasks may not permit engineers to plan and implement continuous improvement efforts without disturbing on-going operations. This is the situation where improvement at one station may happen, but the overall efficiency of the system may be damaged due to the complex interrelationships among the system. For the integrated software, different parts are highly interdependent. To produce the overall system performance, the engineers need to address IT and manufacturing challenges and trade-offs as a part of the continuous improvement efforts. This is normally beyond a single person's capability.

Second, the software is not flexible: it does not permit the engineers to plan and execute alternative ways of doing their work. This is the situation where the improvement of a single workstation will not affect the efficiency of other workstations and the overall system. The improvement of the overall system is complex and difficult to comprehend, thus prohibiting the engineer from further efforts.

Third, engineers may view their jobs as selecting the appropriate software package for each task rather than improving the software. Because of the availability of many sophisticated software packages on the market, the expenses spent on improving a software package may far exceed the expenditures on a new software package or an updated version of the existing package. Thus, engineers may focus on the availability and the functionality of new software packages. They may pay less attention to the improvement of the existing software packages.

Fourth, role constraints and task specific performance measures may inhibit engineers to plan and experiment with alternative ways of doing their work. In most cases, engineers are hired to perform manufacturing or engineering tasks. While they need to use IT applications for their job, software improvement is not their responsibility. In other cases, the performance of engineers is measured by their productivity, not by the number of improvements they made. Edmondson (1999) has observed that continuous improvements may promote productivity. However, it consumes time without assurance of results, suggesting that there are conditions in which it may reduce efficiency and detract from performance, such as when an engineer is responsible for highly routine, repetitive tasks with little need for improvement or modification.

This alternative model indicates that the relationships between learning drivers, continuous improvement efforts, IT utilization, and IT's impact on work are more complicated than originally expected. Many questions remain to investigate in order to have a clear understanding of the above discussions. The answers to the questions will greatly benefit both academia and practitioners in the field.

5.2. Conclusion

This research conducts an initial attempt of the research in IT learning at an individual level. The results suggest that learning how to effectively use computer-mediated technology (i.e., CIM technology) is more complex than originally thought. While effective IT utilization enhances the impact on individual work, learning computer-mediated work is largely autonomous. Induced learning at an individual level is not a primary contributor of IT learning. While learning has been advocated as a key element in post-industrial environment (Doll & Vonderembse, 1991), traditional organizational structures, management practices, and organizational policies are providing inadequate investigation for IT learning. A paradigm shift may be required to cope with the new challenges facing IT managers in manufacturing and/or engineering service firms.

The new management mind-set must be based on the realization that IT learning at an individual level is autonomous. The generic nature of IT learning, utilization, and impact renders them readily available to be tested with other context variables beyond those measured in this research. The scales developed in the study behave well when subjected to validity and reliability tests.

The study suggests three practical implications for IT managers. First, IT managers may use the instruments to benchmark their current status of the IT learning. After they identify their existing levels of IT learning drivers, continuous improvement, IT utilization, and impact on work, IT managers can concentrate on specific aspects with the biggest potential to improve.

Second, IT managers may focus more on building learning environment. Since learning in computer-mediated work is autonomous and autonomous learning happens along with the individual's learning curve, managers may build a conducive environment to facilitate the individual's autonomous learning. Hatch and Mowery (1998) find that the learning (curve) is not an exogenous result of output expansion but is influenced primarily by the systematic allocation of engineering labor to problem-solving activities. In other words, learning is subject to managerial discretion and control.

Third, IT managers may not focus on individuals if they are to use incentives. Incentives may bring some conscious improvement efforts. However, these improvement efforts (i.e., induced learning) contribute relatively small on the effectiveness of IT utilization and IT impact in a CIM context. This may provide an explanation to a situation where organizations with greater experience of continuous improvement in quality management tend to place greater emphasis on group, departmental, or organizational-wide, rather than individual, rewards (Hackman & Wageman, 1995).

This study indicates that the relationships between learning drivers, continuous improvement efforts, IT utilization, and IT's impact on work are more complicated than originally expected. Many questions remain to investigate in order to have a clear understanding of the relationships. The answers to the questions will greatly benefit both academia and practitioners. A full understanding of how individuals learn to make effective use of IT applications in a CIM context is a long journey. The following recommendations on both measurement and structural issues may provide some directions to help overcome some barriers on the road.

5.3. Recommendations on Measurement Issues

For further examination of the alternative models, some suggestions are recommended on the measurement variables.

Recommendation M1: Future research should validate the measurement instruments using a wide range of working processes and software packages.

The generic nature of the learning drivers and continuous improvement efforts scales allows for their broad usage. With technology learning, a researcher may have to be careful in using the proposed scales. With current sample size, it is not recommended to access the general applicability of the measurement instruments. Due to the exploratory nature of this study, these instruments should be revalidated with different working processes and different software packages in manufacturing industry. They should also be validated in other industries.

Recommendation M2: Future research should conduct confirmatory factor analysis.

This study has presented the development of the instruments for measuring IT learning drivers and continuous improvement efforts. It is exploratory in nature. The research cycle for developing standardized instruments has two steps: (1) exploratory studies that develop hypothesized measurement model(s) via the analysis of empirical data from a referent population; and (2) confirmatory studies that test hypothesized measurement models against new data gathered from the same referent population.

Confirmatory factor analysis is needed to provide a more rigorous and systematic test of alternative factor structures than is possible within the framework of exploratory factor analysis. Confirmatory factor analysis has been used extensively in psychology, marketing, and counseling for validating instruments and testing theoretical models. Confirmatory factor analysis involves the specification and estimation of one or more putative models of factor structure, each of which proposes a set of latent variables (factors) to account for covariance among a set of observed variables.

In exploratory factor analysis, there are no preconceived notions regarding factor structure. In contrast, confirmatory factor analysis requires an *a priori* designation of plausible factor patterns from previous theoretical or empirical work. These alternative models are then explicitly tested statistically against sample data. The methodology may be used to assess first-order and second-order models. Linear structural equations modeling provides indices of how well the researcher's hypothesized model fits the data and *a priori* models can be subjectively and statistically compared in a systematic fashion (Marsh & Hocevar, 1985).

Recommendation M3: Future research should conduct factorial invariance tests.

The general applicability of measurement instruments may be supported by factorial invariance tests. Using the instruments developed in this research, one may test for their factorial invariance across manufacturing processes (e.g., designing vs. engineering vs. manufacturing), across different software packages (i.e., CAD vs. CAE vs. PIMS), and/or across different stages of IT innovation. The instruments are developed to be widely applicable, and the factor structure is expected to be similar across different groups.

Marsh and Hocevar (1985) provide a detailed account to carry out factorial invariance tests using LISREL methodology. Such tests are relevant to researchers who use factor analysis in theory development. The value of one factor is greatly enhanced if the same factor can be replicated in random samples from the same population and identified in responses from different populations (Gorsuch, 1997). Although it is rarely tested, an implicit assumption in the comparison of different groups is that the underlying construct being measured is the same for the two groups, and this is an issue of factorial invariance (Marsch & Hocevar, 1985). To conduct factorial invariance tests, it is necessary to collect sufficient data for each of the groups for comparison. The factor structure of one group is essentially compared with the factor structure of other groups.

Recommendation M4: Future research should establish a better measurement for intuitive problem-solving scale.

Of all the scales, intuitive problem-solving scale has the lowest and unacceptable reliability (alpha = .6599) (see Table 4.4.1). Current literature does not provide good measurement for this construct. Future research should develop a more reliable scale to measure intuitive problem solving. Without a reliable and valid measurement scale, it is impossible to examine the relationships hypothesized among the related variables. The revised measurement items are listed in italic in section 1 of Appendix 3.

Recommendation M5: Future research should modify the measurement items for goal clarity scale to make it a better predictor of continuous improvement efforts, technology utilization, and impact.

Goal setting has long been posited to enhance an individual's performance. However, the predictive power of the goal clarity is poor, as the scale does not predict any scales it is supposed to predict (see section 2 in Table 4.5). One possible explanation would be that for computer-mediated work, a clear understanding of what to do does not mean that 1) the performance will increase automatically; 2) the usage of the CIM technology might be the same as before; and 3) the continuous improvement efforts might not be related to whether an individual has a clear understanding what to do or not.

The other possible explanation would be that it is goal importance rather than goal clarity that can lead to the continuous improvement behaviors, and thus to the effective usage of CIM application and to the CIM impact. Future research might replace goal clarity with goal importance in the model. The revised measurement items are listed in italic in section 2 of Appendix 3.

Recommendation M6: Future research should incorporate group and/or process level variables for continuous improvement efforts.

Learning motivation and empowerment are not correlated significantly with continuous improvement efforts (see Table 4.14). One possible explanation is that the continuous improvement efforts are measured at an individual level rather than at a group and/or process level. Recognizing the fact that individual continuous improvement may or may not lead to group and/or process continuous improvement, measurement items for group level continuous improvement efforts are generated for future test (see the items in italic in section 4 of Appendix 3).

A second possible explanation is that only subjective measurement of continuous improvement efforts is used for this research. Future research may utilize objective measurements, not self-reported. For example, the continuous improvement efforts could be measured by the times and/or frequency of the improvement made within a certain period of time.

Recommendation M7: Future research should use multiple methods of obtaining data.

The use of a single respondent to answer the variables across the system-to-value chain may generate some inaccuracy. Key informants are often asked to respond to complex questionnaires dealing with a wide range of subject variables. More than the usual amount of random error is likely, because informants are asked to make inferences about system-to-value chain phenomena or perform aggregations over persons, tasks, organization subunits or events (Bagozzi, Yi, & Phillips, 1991). Over-reporting or under-reporting of certain phenomena may occur as a function of the informant's position, length of time in the organization, job satisfaction, or other personal or role characteristics (e.g., Bagozzi et al., 1991). It is also sometimes recognized that biases arising from a common method used to derive measures across independent and dependent variables can artificially increase the association observed therein.

In all these cases it is suggested that multiple methods should be used to derive estimates of measurements. It may be even appropriate to use both subjective and objective methods of measurement. For example, CIM utilization could be measured by the actual usage time and/or the frequency of the usage of specific software for a specific process. The actual usage time and the frequency of the usage could be measured through subjective estimates or the actual computer log files.

Having a construct measured with multiple methods, random error and method variance may then be assessed. This can be done using the Multitrait-multimethod approach (Campbell & Fiske, 1959) or LISREL methodology. Bagozzi et al. (1991) provide an overview of various methods and examples of such construct validity tests.

5.4. Recommendations on Structural Issues

After the measurement instruments have been modified, structural models could be tested with the following suggestions.

Recommendation S1: Future research should test IT learning and impact hypotheses at both an individual level and a group and/or process level.

Learning happens both at an individual and aggregated level. The aggregated level of learning is not the simple addition of individual learning (Senge, 1990; Kim, 1993). The relationships hypothesized in Figure 2.4 may be different at different levels. It is possible that some process and/or group level measures are added to the structural model for future studies.

Recommendation S2: Future research should examine the hypothesized structural relationships for different CIM processes, software packages, and populations.

Current data set includes a wide variety of CIM processes and software packages, suggesting some general applicability of the results. However, learning environment and technology utilization may be different for different CIM processes and different CIM software packages. Thus, structural relationships between variables may be different across processes and/or software packages. Traditionally, research uses Analysis of Variance (ANOVA) and Multivariate Analysis of Variance (MANOVA) to establish that there is no difference in means across sub-groups (i.e., processes and/or software packages). It is argued that if the data show no difference in means, then one can proceed to analyze the whole data together rather than assessing the data separately for each process and/or software. Invariance of structural relationships across sub-groups, however, can hardly be determined by comparisons of means alone.

Assuming an adequate sample in each process and/or software package, one may study the covariance or correlation matrices by the sub-group and check for significant differences. Where significant differences are apparent and a sufficient sample is available for a sub-group, structural invariant analyses may be done by a sub-group.

The alleged technology learning and impact relationships can be tested in both end-user as well as system analyst population. It is possible that the induced learning – technology utilization and the induced learning – impact relationships for system developer may be more evident.

Recommendation S3: Future research should test structural relationships for specific learning drivers and/or a learning type.

This research has tested the relationships at an aggregate level of learning drivers (see Figure 4.7) and learning types (see Figure 4.11). The use of the partial aggregate variables is supported by Bagozzi and Heatherton (1994). Alleged relationships are then tested at the aggregate level. Practitioners, however, will be interested in knowing how each learning driver or learning type affects a particular competitive capability.

It is of interest to study relationships at a specific learning driver and learning type level. For example, this research has been concerned with the relationship between learning capacity and continuous improvement efforts. It has not examined how a specific scale, such as systematic problem solving, intuitive problem solving, prior knowledge of work process, or prior knowledge of computers, affects a specific continuous improvement effort, like process improvement, skill enhancement, or software improvement.

It is also possible that the aggregated variables may not be correlated, but specific scales may be related. For example, at an aggregated level, learning motivation does not relate to continuous improvements, but a specific scale (i.e., goal clarity, intrinsic motivation, or social norms) might relate to a particular continuous improvement effort (e.g., process improvement, skill enhancement, or software improvement). Some empowerment scales may also relate to some continuous improvement efforts even though the empowerment does not relate to continuous improvement efforts at an aggregated level. In the future research, one can investigate the relationships between a specific learning driver and a continuous improvement effort in a structural model.

Recommendation S4: Future research should incorporate contextual variables in the structural model.

The proposed structural relationships may be affected by contextual variables. This research focuses on technology learning and CIM impact at an individual level and has no *a priori* hypotheses concerning the relationships between contextual variables and variables in the model. Future research may explore the roles of contextual variables.

The nature of CIM processes may affect the relationships between the variables in the model. Some processes (e.g., part designing in CAD) are simple and a regular software package will cover the requirements for the work. Some processes (e.g., collision simulation in CAE) are complex and several specialized software packages may be required to satisfy the job requirements. Even for the same process (e.g., CAE), engineers may choose different software packages for their jobs depending on the nature of the project.

The sophistication of software packages may affect the relationships between the variables. For example, for a new CIM package, bugs are expected. Thus, a relatively high software improvement (i.e., debugging) and low task productivity will not be surprising. For sophisticated packages, high process improvement and skill enhancement efforts of engineers may be expected. The usage of these kinds of packages, as indicated by some engineers, will stimulate more process improvement efforts, thus increasing the task productivity. This type of package may create higher task innovation impact.

Recommendation S5: Future research should investigate alternative models of structural relationships.

This research has explored relationships between learning drivers, continuous improvement efforts, IT utilization, and impact via a hypothesized model. The relationships seem to be more complex than expected. The non-significance of several paths (i.e., learning motivation – continuous improvement efforts and empowerment – continuous improvement efforts) has provided more room for possible explanations of the relationships between the constructs. Alternative structural models can be developed and tested, and their relative efficacy in explaining variation in endogenous variables can be evaluated in the future research.

Recommendation S6: Future research should undertake a longitudinal approach to study the alleged structural relationships at different stages of CIM applications.

Finally, it has become almost a truism to conclude a study by recommending a longitudinal study, noting the limitations of the cross-sectional research design. Nevertheless, the same recommendation is made here because all the data used in the study come from a cross-sectional survey. Inferences offered in this research shall be evaluated with caution. In particular, the learning drivers (i.e., learning capacity, learning motivation, and empowerment) and continuous improvement efforts may take different roles in predicting the technology utilization and impact at different stages of the information technology innovation process. The link from continuous improvement efforts to information technology utilization is most vulnerable to reverse causality arguments.

A longitudinal study of both information technology learning and IT's impact on work may determine the different roles of the learning drivers and continuous improvement efforts for different stages. The direction of causal relationships between continuous improvement efforts and information technology utilization can be observed along the stages of the information technology innovation process. At some point of time, continuous improvement efforts may have impact on effective information technology utilization. At some other point of time the relationship may be the reverse.

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Appendix 1. The Questionnaire Used for the Pilot Study

COMPUTER-INTEGRATED MANUFACTURING (CIM) APPLICATIONS BENCHMARKING SURVEY

GENERAL INSTRUCTIONS

The purpose of this survey is to explore how individuals learn to make more effective use of computers in manufacturing and engineering tasks. The survey seeks to identify specific factors that drive individuals to use computers more effectively. It also asks how you use software for <u>the specific task/process named on the title page</u>. Finally, it asks your perception of the software application's impact on your work. The word 'application' refers to using computer software for a specific task or process.

This study is being conducted by Mr. Xiaodong Deng of The University of Toledo as part of his dissertation under the supervision of Dr. William J. Doll. It is estimated that it will take you 25-30 minutes to complete this questionnaire. You will not be required to give any classified information. No additional file search is needed to answer the questions. There are no right or wrong answers. We are interested in your perceptions and experiences. Your response will be entered in a coded format and will be strictly confidential; only group data will be analyzed and reported. In no instance will a company and/or an individual ever be identified as having given a particular response.

Thank you for your time and your cooperation. We believe that, with your assistance, this survey can help clarify a number of issues pertaining to how to effectively use CIM applications.

Section 1. The following statements describe possible ways to obtain new knowledge about how to use software for the specific task/process named on the title page. For each item, please **X** the appropriate number to the right of each item which best reflects your experience.

①. To none or a little extent ②. To some extent ③. To a moderate extent ④. To a great extent ⑤. To a very great extent

I have used different software packages for this task/process	①	②	③	④	⑤
I have used different types of software packages, e.g., spreadsheet, word processing	①	②	③	④	⑤
I have used programming languages for information system development	①	②	③	④	⑤
I have implemented computer information systems	①	②	③	④	⑤
I have participated in cross-function training courses	①	②	③	④	⑤
I have rotated several positions	①	②	③	④	⑤
I have experience in non-technical analysis, e.g., feasibility studies	①	②	③	④	⑤
I have experience in designing computer information systems	①	②	③	④	⑤
I have general knowledge of this task/process for which I am using the software	①	②	③	④	⑤
I have field knowledge of this task/process for which I am using the software	①	②	③	④	⑤
I have hands-on experience of how to use the software for my job assignments	①	②	③	④	⑤
I have knowledge about how to design this task/process	①	②	③	④	⑤
I have expertise on this task/process	①	②	③	④	⑤
I have knowledge of the cause and effect relationships in this task/process	①	②	③	④	⑤
I have a theoretical understanding of this task/process	①	②	③	④	⑤
I have knowledge about how to design the computer software for this task/process	①	②	③	④	⑤
I have knowledge of the database/input data required by this application	①	②	③	④	⑤
I have an understanding of what the output of this application should look like	①	②	③	④	⑤
I have a conceptual understanding of how the computer can be used to help me with this task/process	①	②	③	④	⑤
When using the software for this task/process, I					
adhere to the commonly established rules of my area of work	①	②	③	④	⑤
adhere to the well-known techniques, methods, and procedures of my area of work.	①	②	③	④	⑤
adhere to the standards of my area of work	①	②	③	④	⑤
follow well-established ways and generally accepted methods for solving problems	①	②	③	④	⑤
accept the usual and generally proven methods of solutions	①	②	③	④	⑤
pay strict regard to the sequence of steps needed for the completion of a job	①	②	③	④	⑤
tackle a problem, particularly if it takes me into areas I don't know much about....	①	②	③	④	⑤
search for novel approaches not required at the time	①	②	③	④	⑤
struggle to make connections between apparently unrelated ideas	①	②	③	④	⑤
spend time tracing relationships between disparate areas of work	①	②	③	④	⑤
make unusual connections about ideas even if they are trivial	①	②	③	④	⑤
use more than one concept, method, or solution	①	②	③	④	⑤
deal with a maze of ideas which may, or may not, lead to somewhere	①	②	③	④	⑤
link ideas that stem from more than one area of investigation	①	②	③	④	⑤
When using the software for this task/process, I am					
strict on the production of results, as and when required	①	②	③	④	⑤
methodical and consistent in the way I tackle problems	①	②	③	④	⑤
full of what appears to be novel methods of solving problem	①	②	③	④	⑤
precise and exact about production of results and reports	①	②	③	④	⑤
aware beforehand of the sequence of steps required in solving problems....	①	②	③	④	⑤

Section 2. The following statements describe an individual's beliefs, norms, and objectives of using software for the specific task/process named on the title page. For each item, please **X** the appropriate number to the right of each item to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree ②. Disagree ③. Neutral ④. Agree ⑤. Strongly Agree

Using the software for this task/process is enjoyable	①	②	③	④	⑤
Using the software for this task/process is important to me	①	②	③	④	⑤
Using the software for this task/process is pleasurable	①	②	③	④	⑤
Using the software for this task/process fosters enjoyment	①	②	③	④	⑤
I foresee what I am going to achieve when using software for this task/process	①	②	③	④	⑤
I foresee what my colleagues expect of me when using software for this task/process	①	②	③	④	⑤
I foresee what important people expect of me when using the software package for this task/process	①	②	③	④	⑤
I foresee what benefits can be achieved by the use of the software for this task/process	①	②	③	④	⑤
I foresee the overall picture of how this task/process fits in the whole project	①	②	③	④	⑤
I foresee the overall picture of how this task/process fits into other tasks/processes	①	②	③	④	⑤
The objective in using software for this task/process makes sense to me	①	②	③	④	⑤
The people I work with expect me to use this application effectively	①	②	③	④	⑤
The people I work with expect me to improve this application	①	②	③	④	⑤
The people I work with expect me to master this application	①	②	③	④	⑤
The people I work with expect me to use the computer to improve my work process	①	②	③	④	⑤
The goal of using the software for this task/process is meaningful to me	①	②	③	④	⑤
The goal that will be achieved through using the software for this task/process is important to the company's success	①	②	③	④	⑤
The objective of using the software for this task/process is clear to me	①	②	③	④	⑤
The goal that will be achieved through using the software for this task/process is clear to me	①	②	③	④	⑤
I have a clear goal in mind when using the software for this task/process	①	②	③	④	⑤
I can achieve my goal by using the software for this task/process	①	②	③	④	⑤
Management has set up a clear vision of using the software for this task/process	①	②	③	④	⑤
Management has established a clear objective for using the software for this task/process	①	②	③	④	⑤
My supervisor has set up a clear goal for using the software for this task/process	①	②	③	④	⑤

Section 3. The following statements describe an individual's perception of the impact of using software for the specific task/process named on the title page. For each item, please **X** the appropriate number to the right of each item which best reflects your perception.

①. Not At All ②. A Little ③. Moderate ④. Much ⑤. A Great Deal

This application

helps management control the work process	①	②	③	④	⑤
helps me come up with new ideas	①	②	③	④	⑤
helps management control performance	①	②	③	④	⑤
helps me create new ideas	①	②	③	④	⑤
helps me provide a clear vision for suppliers	①	②	③	④	⑤
helps me meet customer needs	①	②	③	④	⑤

helps me try out innovative ideas	①	②	③	④	⑤
improves management control	①	②	③	④	⑤
improves the coordination with suppliers	①	②	③	④	⑤
improves customer satisfaction	①	②	③	④	⑤
helps me meet supplier needs	①	②	③	④	⑤
improves customer service	①	②	③	④	⑤
increases my productivity	①	②	③	④	⑤
improves the cooperation with suppliers	①	②	③	④	⑤
saves me time	①	②	③	④	⑤
allows me to accomplish more work than would otherwise be possible	①	②	③	④	⑤
improves the communication with suppliers	①	②	③	④	⑤

Section 4-1. Task/Process Improvement --The following statements describe the extent that individuals improve their work process or enhance their skills in performing this process. For each item, please **X** the appropriate number to the right of each item which best reflects your situation.

①. To none or a little extent ②. To some extent ③. To a moderate extent ④. To a great extent ⑤. To a very great extent

I train on-the-job to use the task/process more effectively	①	②	③	④	⑤
When necessary, I change the way this task/process works	①	②	③	④	⑤
I spend time on-the-job learning how to					
perform this task/process more efficiently	①	②	③	④	⑤
improve this task/process	①	②	③	④	⑤
perform this task/process more effectively	①	②	③	④	⑤
apply this task/process to different projects	①	②	③	④	⑤
I make changes in this task/process that					
make it easier to use	①	②	③	④	⑤
make it more useful	①	②	③	④	⑤
make it applicable to different tasks	①	②	③	④	⑤
improve my productivity	①	②	③	④	⑤
improve the quality of my work	①	②	③	④	⑤
give me greater control over my work	①	②	③	④	⑤

Section 4-2. Computer Software or Skill Improvement -- The following statements describe the extent to which individuals modify the software they are using and/or enhance their skills in using this software. For each item, please **X** the appropriate number to the right of each item which best reflects your situation.

①. To none or a little extent ②. To some extent ③. To a moderate extent ④. To a great extent ⑤. To a very great extent

I spend time on-the-job learning how to					
use the software for this task/process more efficiently	①	②	③	④	⑤
use additional features of the software	①	②	③	④	⑤
use the software for different tasks/processes	①	②	③	④	⑤
I make changes in the software that					
make it easier to use	①	②	③	④	⑤
make it more useful	①	②	③	④	⑤
make it applicable to different tasks/processes	①	②	③	④	⑤
improve my productivity	①	②	③	④	⑤
improve the quality of my work	①	②	③	④	⑤
give me greater control over my work	①	②	③	④	⑤
I spend significant time on-the-job learning how to make full use of the software	①	②	③	④	⑤
I spend time learning more about how to use the software for the task/process	①	②	③	④	⑤

I train on-the-job to use the software more effectively	①	②	③	④	⑤
When necessary, I change the way the software works	①	②	③	④	⑤

Section 5. The following statements describe possible ways individuals might use software for the task/process specified on the title page. For each item, please **X** the appropriate number to the right of the item which best reflects how you use the software in your work.

①. To none or a little extent ②. To some extent ③. To a moderate extent ④. To a great extent ⑤. To a very great extent

I use software for this task/process to

help me explain my decisions	①	②	③	④	⑤
help me justify my decisions	①	②	③	④	⑤
help me think through problems	①	②	③	④	⑤
help me make explicit the reasons for my decisions	①	②	③	④	⑤
help me manage my work	①	②	③	④	⑤
communicate with other people in my work group	①	②	③	④	⑤
communicate with people who report to me	①	②	③	④	⑤
communicate with people I report to	①	②	③	④	⑤
communicate with suppliers	①	②	③	④	⑤
communicate with people in other work groups/departments	①	②	③	④	⑤
control or shape the decision process	①	②	③	④	⑤
coordinate activities with others in my work group	①	②	③	④	⑤
coordinate activities with suppliers	①	②	③	④	⑤
coordinate activities with people in other work groups/departments	①	②	③	④	⑤
exchange information with people who report to me	①	②	③	④	⑤
exchange information with our suppliers	①	②	③	④	⑤
exchange information with people in my work group	①	②	③	④	⑤
exchange information with people in other work groups/departments	①	②	③	④	⑤
keep my supervisor informed	①	②	③	④	⑤
keep our suppliers informed	①	②	③	④	⑤
keep people in other work groups/departments informed	①	②	③	④	⑤
improve the effectiveness of the decision process	①	②	③	④	⑤
improve the efficiency of the decision process	①	②	③	④	⑤
make sense out of data	①	②	③	④	⑤
make sure the data matches my analysis of problems	①	②	③	④	⑤
make the decision process more rational	①	②	③	④	⑤
analyze why problems occur	①	②	③	④	⑤
get feedback on job performance	①	②	③	④	⑤
decide how to best approach a problem	①	②	③	④	⑤
rationalize my decisions	①	②	③	④	⑤
monitor my own performance	①	②	③	④	⑤
plan my work	①	②	③	④	⑤
check my thinking against the data	①	②	③	④	⑤
My work group and I use the software for this task/process to coordinate our activities	①	②	③	④	⑤

Section 6. The following statements describe an individual's empowerment (e.g., cognitive, authoritative, and resource readiness) for using computers for the specific task/process named on the title page. Please **X** the appropriate number to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree ②. Disagree ③. Neutral ④. Agree ⑤. Strongly Agree

I can decide on my own how to use the software for this task/process	①	②	③	④	⑤
Cross training on other jobs is available to me	①	②	③	④	⑤
Software training is available to me	①	②	③	④	⑤

Training for this task/process is available to me	①	②	③	④	⑤
Technical training opportunities are available to me	①	②	③	④	⑤
I am confident about my ability to use the software for this task/process	①	②	③	④	⑤
I am self-assured about my capabilities of using the software to perform my work...	①	②	③	④	⑤
I am well-supported in using the software for this task/process	①	②	③	④	⑤
I have considerable opportunity for independence in how I use the software for this task/process	①	②	③	④	⑤
I have the necessary help tc become familiar with this application	①	②	③	④	⑤
I have the necessary resources to get acquainted with this application	①	②	③	④	⑤
I have mastered the skills necessary for using this application	①	②	③	④	⑤
I have considerable opportunity for freedom in how I use the software for this task/process	①	②	③	④	⑤
I have significant autonomy in determining how I use this application	①	②	③	④	⑤

I could complete the job using this application if

I only had the software manuals for reference	①	②	③	④	⑤
I just had the built-in help facility for assistance	①	②	③	④	⑤
I had enough time to complete the job for which the application was provided	①	②	③	④	⑤
I had used similar applications before this one to do the same job	①	②	③	④	⑤
I had seen someone else using it before trying it myself	①	②	③	④	⑤
I had never used an application like it before	①	②	③	④	⑤
someone showed me how to do it first	①	②	③	④	⑤
someone else had helped me get started	①	②	③	④	⑤
I could call someone for help if I got stuck	①	②	③	④	⑤
there was no one around to tell me what to do as I go	①	②	③	④	⑤

When I had difficulty in using the software for this task/process, I can

exchange information with others who know how to better use this application	①	②	③	④	⑤
talk to other people who are more knowledgeable	①	②	③	④	⑤
consult with our Help Desk	①	②	③	④	⑤
discuss with others who know how to make better use of this application...	①	②	③	④	⑤

Section 7. General Information

Thank you for your assistance in this project. Please provide the following information for statistical purpose.

1. The software is installed on... ☐ PC ☐ Work Station ☐ Mainframe ☐ Other ____________

2. Are you required to use the software for the task/process?...... ☐ Yes ☐ No

3. Please indicate the degree of the integration of the software with other software packages
☐ Stand alone ☐ Integrated through business activities
☐ Integrated through input/output files ☐ Integrated through network/internet

4 For your work requirements, how would you rate your knowledge/skills in using the software for the task/process compared to someone who is knowledgeable/skillful enough to make **full use** of the software for the task/process in your job?
☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

5. How would you rate the capabilities/ features of the software compared to a software package that has all the capabilities/ features necessary in your job?
☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

6. Overall, how much do you use the software for the task/process?
☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

7 Please indicate how long have you been using the software for the task/process

☐ More than five years ☐ Between one and five years
☐ Several months but less than a year ☐ Several weeks but less than a month

Optional questions

8. Please indicate your gender ☐ Female ☐ Male

9 Please identify your position within the overall organization:
☐ Top level management ☐ Middle level management
☐ First level supervisor ☐ Professional employee without supervisory responsibility
☐ Other (e.g., operating personnel).

10.Please indicate how long have you been at this position
☐ More than five years ☐ Between one and five years
☐ Several months but less than a year ☐ Several weeks but less than a month

11 Please indicate the highest degree you have received
☐ High School ☐ Associate ☐ Bachelor ☐ Master ☐ Doctorate

Appendix 2. The Questionnaire Administrated for the Large-Scale Study

Section 1. The following statements describe possible ways to obtain new knowledge about how to use software for the specific process named on the title page. For each item, please **X** the appropriate number to the right of each item which best reflects your experience.

①. None or to a little extent ②. To some extent ③. To a moderate extent ④. To a great extent ⑤. To a very great extent

Item					
When using the software for this process, I adhere to the commonly established rules of my area of work	①	②	③	④	⑤
I have used programming languages for computer information system development	①	②	③	④	⑤
When using the software for this process, I search for novel approaches not required at the time	①	②	③	④	⑤
When using the software for this process, I adhere to the well-known techniques, methods, and procedures of my area of work	①	②	③	④	⑤
I have used different software packages for this process	①	②	③	④	⑤
When using the software for this process, I struggle to make connections between apparently unrelated ideas	①	②	③	④	⑤
I have implemented computer information systems	①	②	③	④	⑤
When using the software for this process, I adhere to the standards of my area of work	①	②	③	④	⑤
When using the software for this process, I make unusual connections about ideas even if they are trivial	①	②	③	④	⑤
I have knowledge about how to design this process	①	②	③	④	⑤
When using the software for this process, I spend time tracing relationships between disparate areas of work	①	②	③	④	⑤
I have knowledge of computer database software.	①	②	③	④	⑤
I have a conceptual understanding of how the computer can be used to help me with this process	①	②	③	④	⑤
When using the software for this process, I follow well-established ways for solving problems	①	②	③	④	⑤
I have a theoretical understanding of this process	①	②	③	④	⑤
When using the software for this process, I deal with a maze of ideas which may, or may not, lead to somewhere	①	②	③	④	⑤
I have expertise on this process	①	②	③	④	⑤
When using the software for this process, I follow generally accepted methods for solving problems	①	②	③	④	⑤
I have experience in designing computer information systems.	①	②	③	④	⑤
I have general knowledge of this process for which I am using the software	①	②	③	④	⑤
When using the software for this process, I link ideas that stem from more than one area of the investigation	①	②	③	④	⑤
I have implemented a database application.	①	②	③	④	⑤
I have an understanding of what the output of this application should look like	①	②	③	④	⑤
When using the software for this process, I accept the usual proven methods of solution	①	②	③	④	⑤
I have knowledge of computer networking software	①	②	③	④	⑤

Section 2. The following statements describe an individual's beliefs, norms, and objectives of using software for the specific process named on the title page. For each item, please **X** the appropriate number to the right of each item to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree	②. Disagree	③. Neutral	④. Agree	⑤. Strongly Agree

I foresee the overall picture of how this process fits in the whole project.................	① ② ③ ④ ⑤
Using the software for this process is enjoyable.	① ② ③ ④ ⑤
Management has established a clear objective for using the software for this process...	① ② ③ ④ ⑤
I understand my supervisor's expectations of me for using the software for this process	① ② ③ ④ ⑤
Computers make my work more enjoyable.	① ② ③ ④ ⑤
I foresee the overall picture of how this process fits into other processes.................	① ② ③ ④ ⑤
Working with computers is satisfying.	① ② ③ ④ ⑤
I understand the management's expectations of me for using the software for this process	① ② ③ ④ ⑤
The objective of using the software for this process is clear to me.	① ② ③ ④ ⑤
Using the software for this process fosters enjoyment.	① ② ③ ④ ⑤
Management has set up a clear vision of using the software for this process.	① ② ③ ④ ⑤
I have a clear goal in mind when using the software for this process.	① ② ③ ④ ⑤
Using the software for this process is pleasurable.	① ② ③ ④ ⑤
My supervisor has set up a clear goal for using the software for this process.	① ② ③ ④ ⑤
Using computers is fun.	① ② ③ ④ ⑤
I can achieve my goal by using the software for this process.	① ② ③ ④ ⑤
My supervisor has given a clear direction for using the software for this process.........	① ② ③ ④ ⑤
Internet does NOT provide much help for my work...	① ② ③ ④ ⑤

Section 3. The following statements describe an individual's empowerment (e.g., cognitive, authoritative, and resource readiness) for using computers for the specific process named on the title page. Please **X** the appropriate number to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree	②. Disagree	③. Neutral	④. Agree	⑤. Strongly Agree

I could complete my work using this software if I just had the built-in help facility for assistance....................	① ② ③ ④ ⑤
I have considerable opportunity for independence in how I use the software for this process..........................	① ② ③ ④ ⑤
I believe my capabilities of using the software for my work.	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can exchange information with others who know how to better use the software for this process.	① ② ③ ④ ⑤
I have considerable opportunity for freedom in how I use the software for this process...	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can talk to other people who are more knowledgeable.	① ② ③ ④ ⑤
I am well-supported in using the software for this process.	① ② ③ ④ ⑤
I am confident about my ability to use the software to complete my work.................	① ② ③ ④ ⑤
Intranet offers much convenience to my work...	① ② ③ ④ ⑤
I could complete my work using this software if I had seen someone else using it before trying it myself...........	① ② ③ ④ ⑤
I have significant autonomy in determining how I use the software for this process.........	① ② ③ ④ ⑤
I have had the necessary resources for using the software for this process.	① ② ③ ④ ⑤
I have control over my work..	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can discuss with others who know how to make better use of the software for the process.	① ② ③ ④ ⑤
I have mastered the skills necessary for using this software for my work.	① ② ③ ④ ⑤
I am self-assured about my capabilities of using the software to perform my work.........	① ② ③ ④ ⑤

I could complete my work using this software if I had used similar software packages before this one to do the same job.	① ② ③ ④ ⑤
I have influence in how this software is used in this process.	① ② ③ ④ ⑤
I could complete my work using this software if I had enough time to complete the job for which the application was provided.	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can go to my supervisor for help.	① ② ③ ④ ⑤
I have a say in how I use this software for this process.	① ② ③ ④ ⑤
Internet is useful for my work.	① ② ③ ④ ⑤

Section 4. Process Improvement --The following statements describe the extent that individuals improve their work process and enhance their skills in learning and improving the software. For each item, please **X** the appropriate number to the right of each item which best reflects your situation. The term change(s) refers to the changes made directly by you and/or made indirectly based on your suggestions.

①. None or to a little extent	②. To some extent	③. To a moderate extent	④. To a great extent	⑤. To a very great extent

I make changes in the software that improve the quality of my work.	① ② ③ ④ ⑤
I spend time on-the-job learning how to improve this process.	① ② ③ ④ ⑤
I make changes in the software that give me greater control over my work.	① ② ③ ④ ⑤
I spend time on-the-job learning how to use the software more efficiently.	① ② ③ ④ ⑤
I make changes in this process that make it easier to use.	① ② ③ ④ ⑤
When necessary, I change the way the software works.	① ② ③ ④ ⑤
I spend significant time on-the-job learning how to make full use of the software.	① ② ③ ④ ⑤
I make changes in the software that make it better fit to my work.	① ② ③ ④ ⑤
I train on-the-job to use the software more effectively.	① ② ③ ④ ⑤
I make changes in this process that make it more useful.	① ② ③ ④ ⑤
I spend time learning more about how to use the software for my work.	① ② ③ ④ ⑤
I make changes in this process that improve the quality of my work.	① ② ③ ④ ⑤
I make changes in the software that make it easier to use.	① ② ③ ④ ⑤
I spend time on-the-job learning how to use advanced functions of the software.	① ② ③ ④ ⑤
I make changes in the software that improve my productivity.	① ② ③ ④ ⑤
I make changes in the software that make it applicable to different processes.	① ② ③ ④ ⑤
I spend time on-the-job learning how to use additional features of the software.	① ② ③ ④ ⑤
I change the way this process works.	① ② ③ ④ ⑤
I make changes in the software that make it more useful.	① ② ③ ④ ⑤
I look for ways to improve this process.	① ② ③ ④ ⑤

Section 5. The following statements describe possible ways individuals might use software for the process (i.e., the application) specified on the title page. For each item, please **X** the appropriate number to the right of the item which best reflects how you use the software in your work.

①. Not At All	②. A Little	③. Moderate	④. Much	⑤. A Great Deal

I use this application to improve the effectiveness of the decision process.	① ② ③ ④ ⑤
I use this application to make sense out of data.	① ② ③ ④ ⑤
I use this application to communicate with people who report to me.	① ② ③ ④ ⑤
I use this application to help me manage my work..	① ② ③ ④ ⑤
I use this application to communicate with people in other departments.	① ② ③ ④ ⑤
I use this application to improve the efficiency of the decision process.	① ② ③ ④ ⑤
I use this application to analyze why problems occur.	① ② ③ ④ ⑤
I use this application to help me make explicit the reasons for my decisions	① ② ③ ④ ⑤
I use this application to communicate with other people in my work group	① ② ③ ④ ⑤
I use this application to help me think through problems.	① ② ③ ④ ⑤
I use this application to coordinate activities with others in my work group	① ② ③ ④ ⑤
I use this application to exchange information with people who report to me	① ② ③ ④ ⑤
I use this application to check my thinking against the data	① ② ③ ④ ⑤

I use this application to keep my supervisor informed.	①	②	③	④	⑤
I use this application to decide how to best approach a problem.	①	②	③	④	⑤
My work group and I use the software for this process to coordinate our activities.	①	②	③	④	⑤
I use this application to rationalize my decisions.	①	②	③	④	⑤
I use this application to keep people in other departments informed.	①	②	③	④	⑤
I use this application to control the decision process.	①	②	③	④	⑤
I use this application to shape the decision process.	①	②	③	④	⑤
I use this application to communicate with people I report to.	①	②	③	④	⑤
I use this application to monitor my own performance.	①	②	③	④	⑤
I use this application to communicate with people in other work groups.	①	②	③	④	⑤
I use this application to plan my work.	①	②	③	④	⑤
I use this application to keep people in other work groups informed.	①	②	③	④	⑤
I use this application get feedback on job performance.	①	②	③	④	⑤
I use this application to exchange information with people in my work group.	①	②	③	④	⑤
I use this application to coordinate my work with my work group.	①	②	③	④	⑤
I use this application to help me explain my decisions.	①	②	③	④	⑤
I use this application to help me justify my decisions.	①	②	③	④	⑤
I use this application to make the decision process more rational.	①	②	③	④	⑤
I use this application to make sure the data matches my analysis of problems	①	②	③	④	⑤
I use this application to make the decision process better fit to my work.	①	②	③	④	⑤

Section 6. The following statements describe an individual's perception of the impact of using software for the specific process (i.e., the application) named on the title page. For each item, please **X** the appropriate number to the right of each item which best reflects your perception. The term **customer** refers to internal and/or external people who you service by providing them the output from this application.

①. Not At All	②. A Little	③. Moderate	④. Much	⑤. A Great Deal

This application saves me time.	①	②	③	④	⑤
This application helps suppliers meet our needs.	①	②	③	④	⑤
This application helps me come up with new ideas.	①	②	③	④	⑤
This application improves the communication with suppliers.	①	②	③	④	⑤
This application helps management control the work process.	①	②	③	④	⑤
This application helps me meet customer needs.	①	②	③	④	⑤
This application helps me meet supplier needs.	①	②	③	④	⑤
This application allows me to accomplish more work than would otherwise be possible.	①	②	③	④	⑤
This application allows me to get the feedback from customers.	①	②	③	④	⑤
This application helps me communicate requirements to suppliers.	①	②	③	④	⑤
This application helps understand customers.	①	②	③	④	⑤
This application helps me create new ideas.	①	②	③	④	⑤
This application improves customer satisfaction.	①	②	③	④	⑤
This application helps management control performance.	①	②	③	④	⑤
This application improves the cooperation with suppliers	①	②	③	④	⑤
This application increases my productivity	①	②	③	④	⑤
Internet does NOT help me create ideas for my work	①	②	③	④	⑤
This application improves customer service	①	②	③	④	⑤
This application improves management control	①	②	③	④	⑤
This application enhances communication with customers	①	②	③	④	⑤
This application helps me manage our supplier chain	①	②	③	④	⑤
This application helps me try out innovative ideas	①	②	③	④	⑤
This application improves the effectiveness of our supplier alliances	①	②	③	④	⑤
I use Internet to improve my job performances	①	②	③	④	⑤

Section 7. General Information
Please provide the following information for statistical purpose.

---

1. I learned how to use this software through:

☐ attending formal training seminars ☐ on-the-job training ☐ using previous version ☐ using other similar software ☐ using other dis-similar software ☐ the help of my colleagues

2. The software is installed on: ☐ Standalone PC ☐ Networked PC ☐ Standalone Work Station ☐ Networked Work Station ☐ Midrange Computer ☐ Mainframe ☐ Other__________

3. Are you required to use the software for the process?...................... ☐ Yes ☐ No

4. Please indicate the degree of the integration of the software with other software packages

☐ Stand alone ☐ Integrated through business activities
☐ Integrated through input/output files ☐ Integrated through network/internet

5 For your work requirements, how would you rate your knowledge/skills in using the software for the process compared to someone who is knowledgeable/skillful enough to make **full use** of the software for the process in your job?

☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

6. How would you rate the capabilities/ features of the software compared to a software package that has all the capabilities/ features necessary in your job?

☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

7. Overall, how much do you use the software for the process?

☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

8. Please indicate how long have you been using the software for the process

☐ Several weeks but less than a month ☐ Several months but less than a year
☐ Between one and five years ☐ More than five years

9. Please indicate your gender ☐ Female ☐ Male

10. Please identify your position within the overall organization:

☐ Top level management ☐ Middle level management
☐ First level supervisor ☐ Professional employee without supervisory responsibility
☐ Other (e.g., operating personnel).

11 Please indicate the highest degree you have received

☐ High School ☐ Associate ☐ Bachelor ☐ Master ☐ Doctorate

12 I would like to have a copy of the summary report. My e-mail address is: ______________________

Appendix 3. The Questionnaire Recommended for Future Studies

Section 1. The following statements describe possible ways to obtain new knowledge about how to use software for the specific process named on the title page. For each item, please **X** the appropriate number to the right of each item that best reflects your experience.

①. None or to a little extent	②. To some extent	③. To a moderate extent	④. To a great extent	⑤. To a very great extent

When using the software for this process, I adhere to the commonly established rules of my area of work.........	① ② ③ ④ ⑤
I have used programming languages for computer information system development......	① ② ③ ④ ⑤
When using the software for this process, I adhere to the well-known techniques, methods, and procedures of my area of work..	① ② ③ ④ ⑤
I have implemented computer information systems..	① ② ③ ④ ⑤
When using the software for this process, I adhere to the standards of my area of work...	① ② ③ ④ ⑤
When using the software for this process, I make intuitive connections between ideas......	① ② ③ ④ ⑤
I have implemented a database application.	① ② ③ ④ ⑤
When using the software for this process, I try new ideas......................................	① ② ③ ④ ⑤
I have a conceptual understanding of how the computer can be used to help me with this process.................	① ② ③ ④ ⑤
When using the software for this process, I follow well-established ways for solving problems....................	① ② ③ ④ ⑤
I have a theoretical understanding of this process...	① ② ③ ④ ⑤
When using the software for this process, I generate a number of ideas.......................	① ② ③ ④ ⑤
I have expertise on this process..	① ② ③ ④ ⑤
When using the software for this process, I consider different approaches to getting my work done.................	① ② ③ ④ ⑤
I have experience in designing computer information systems.	① ② ③ ④ ⑤
When using the software for this process, I identify relationships between different areas of work....................	① ② ③ ④ ⑤
I have general knowledge of this process for which I am using the software...............	① ② ③ ④ ⑤
When using the software for this process, I apply different methods to the problem.........	① ② ③ ④ ⑤
I have an understanding of what the output of this application should look like............	① ② ③ ④ ⑤
I use intuitive insights when using the software for this process...............................	① ② ③ ④ ⑤

Section 2. The following statements describe an individual's beliefs, norms, and objectives of using software for the specific process named on the title page. For each item, please **X** the appropriate number to the right of each item to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree	②. Disagree	③. Neutral	④. Agree	⑤. Strongly Agree

Using the software for this process is important to me.	① ② ③ ④ ⑤
My supervisor has given a clear direction for using the software for this process.	① ② ③ ④ ⑤
Using the software for this process is enjoyable.	① ② ③ ④ ⑤
I understand the management's expectations of me for using the software for this process	① ② ③ ④ ⑤
Using the software for this process is valuable to me.	① ② ③ ④ ⑤
Using the software for this process fosters enjoyment.	① ② ③ ④ ⑤
Management has set up a clear vision of using the software for this process.	① ② ③ ④ ⑤
Using the software for this process is significant to me.	① ② ③ ④ ⑤
Using the software for this process is pleasurable.	① ② ③ ④ ⑤
My supervisor has set up a clear goal for using the software for this process.	① ② ③ ④ ⑤
Using computers is fun.	① ② ③ ④ ⑤
Using the software for this process is meaningful to me.	① ② ③ ④ ⑤
Internet does NOT provide much help for my work.	① ② ③ ④ ⑤
Using the software for this process is helpful for my career development	① ② ③ ④ ⑤

Section 3. The following statements describe an individual's empowerment (e.g., cognitive, authoritative, and resource readiness) for using computers for the specific process named on the title page. Please **X** the appropriate number to indicate the extent to which you agree or disagree with each statement.

①. Strongly Disagree	②. Disagree	③. Neutral	④. Agree	⑤. Strongly Agree

I have considerable opportunity for independence in how I use the software for this process	① ② ③ ④ ⑤
I believe my capabilities of using the software for my work.	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can exchange information with others who know how to better use the software for this process.	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can talk to other people who are more knowledgeable.	① ② ③ ④ ⑤
I am confident about my ability to use the software to complete my work.	① ② ③ ④ ⑤
Intranet offers much convenience to my work.	① ② ③ ④ ⑤
I have significant autonomy in determining how I use the software for this process.	① ② ③ ④ ⑤
When I had difficulty in using the software for this process, I can discuss with others who know how to make better use of the software for the process.	① ② ③ ④ ⑤
I have mastered the skills necessary for using this software for my work.	① ② ③ ④ ⑤
I have a say in how I use this software for this process.	① ② ③ ④ ⑤
Internet is useful for my work.	① ② ③ ④ ⑤

Section 4. Process Improvement --The following statements describe the extent that individuals and their working groups improve their work process and enhance their skills in learning and improving the software. For each item, please **X** the appropriate number to the right of each item that best reflects your situation. The term change(s) refers to the changes made directly by you (or group) and/or made indirectly based on your (or group's) suggestions.

①. None or to a little extent	②. To some extent	③. To a moderate extent	④. To a great extent	⑤. To a very great extent

My working group and I, directly and/or indirectly,	
make changes in the software that improve control over our work.	① ② ③ ④ ⑤
spend time on-the-job learning how to use the software more efficiently.	① ② ③ ④ ⑤
make changes in the process that make it easier to use.	① ② ③ ④ ⑤
spend significant time on-the-job learning how to make full use of the software.	① ② ③ ④ ⑤

make changes in the software that make it better fit work needs.	① ② ③ ④ ⑤
make changes in this process that make it more useful.	① ② ③ ④ ⑤
spend time learning more about how to use the software for work.	① ② ③ ④ ⑤
make changes in this process that improve the quality of work.	① ② ③ ④ ⑤
make changes in the software that make it easier to use.	① ② ③ ④ ⑤
spend time on-the-job learning how to use advanced functions of the software.	① ② ③ ④ ⑤
make changes in the software that make it applicable to different processes.	① ② ③ ④ ⑤
spend time on-the-job learning how to use additional features of the software.	① ② ③ ④ ⑤
change the way this process works.	① ② ③ ④ ⑤
look for ways to improve this process.	① ② ③ ④ ⑤

Section 5. The following statements describe possible ways individuals might use software for the process (i.e.. the application) specified on the title page. For each item, please **X** the appropriate number to the right of the item that best reflects how you use the software in your work.

①. Not At All ②. A Little ③. Moderate ④. Much ⑤. A Great Deal

I use this application to make sense out of data.	① ② ③ ④ ⑤
I use this application to help me manage my work..	① ② ③ ④ ⑤
I use this application to communicate with people in other departments.	① ② ③ ④ ⑤
I use this application to improve the efficiency of the decision process.	① ② ③ ④ ⑤
I use this application to analyze why problems occur.	① ② ③ ④ ⑤
I use this application to help me make explicit the reasons for my decisions	① ② ③ ④ ⑤
I use this application to keep people in other departments informed.	① ② ③ ④ ⑤
I use this application to communicate with people I report to.	① ② ③ ④ ⑤
I use this application to monitor my own performance.	① ② ③ ④ ⑤
I use this application to communicate with people in other work groups.	① ② ③ ④ ⑤
I use this application to plan my work.	① ② ③ ④ ⑤

Section 6. The following statements describe an individual's perception of the impact of using software for the specific process (i.e., the application) named on the title page. For each item, please **X** the appropriate number to the right of each item that best reflects your perception. The term **customer** refers to internal and/or external people who you service by providing them the output from this application.

①. Not At All ②. A Little ③. Moderate ④. Much ⑤. A Great Deal

This application saves me time.	① ② ③ ④ ⑤
This application helps suppliers meet our needs.	① ② ③ ④ ⑤
This application helps me come up with new ideas.	① ② ③ ④ ⑤
This application improves the communication with suppliers.	① ② ③ ④ ⑤
This application helps management control the work process.	① ② ③ ④ ⑤
This application helps me meet customer needs.	① ② ③ ④ ⑤
This application allows me to accomplish more work than would otherwise be possible.	① ② ③ ④ ⑤
This application helps me communicate requirements to suppliers.	① ② ③ ④ ⑤
This application helps me create new ideas.	① ② ③ ④ ⑤
This application improves customer satisfaction.	① ② ③ ④ ⑤
This application helps management control performance.	① ② ③ ④ ⑤
This application improves the cooperation with suppliers	① ② ③ ④ ⑤
This application increases my productivity	① ② ③ ④ ⑤
Internet does NOT help me create ideas for my work	① ② ③ ④ ⑤
This application improves customer service	① ② ③ ④ ⑤
This application improves management control	① ② ③ ④ ⑤
This application helps me try out innovative ideas	① ② ③ ④ ⑤
I use Internet to improve my job performances	① ② ③ ④ ⑤

Section 7. General Information
Please provide the following information for statistical purpose.

---

1. I learned how to use this software through:
☐ Formal training ☐ On-the-job training ☐ Using previous version ☐ Using software of the same type ☐ Using software of different type ☐ The help of my colleagues

2. The software is installed on: ☐ Standalone PC ☐ Networked PC ☐ Standalone Work Station
☐ Networked Work Station ☐ Midrange Computer ☐ Mainframe ☐ Other__________

3. Are you required to use the software for the process?......... ☐ Yes ☐ No

4. Please indicate the degree of the integration of the software with other software packages
☐ Stand alone ☐ Integrated through business activities
☐ Integrated through input/output files ☐ Integrated through network/internet

5 For your work requirements, how would you rate your knowledge/skills in using the software for the process compared to someone who is knowledgeable/skillful enough to make **full use** of the software?
☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

6. How would you rate the capabilities/features of the software compared to a software package that has all the capabilities/ features necessary for your job?
☐ Less than 20% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80% or more

7. Does management sponsor efforts to improve your work process?
☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

8. Does management sponsor upgrading and/or replacing the software package you use for this process?
☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

9. Does management sponsor on-the-job training to enhance your skills in using the software package?
☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

10. Does management sponsor your attendance at seminars to enhance your skills in using the software package?
☐ Not at all ☐ A little ☐ Moderately ☐ Much ☐ A great deal

11. How long have you been using this software package? Years?__________ Months?_______

12. On average, how many hours per week do you use this software package? __________ Hours/week

13. Please indicate your gender ☐ Female ☐ Male

14. Please identify your position within the overall organization:
☐ Top level management ☐ Middle level management
☐ First level supervisor ☐ Professional employee without supervisory responsibility
☐ Other (e.g., operating personnel).

15. Please indicate the highest degree you have received
☐ High School ☐ Associate ☐ Bachelor ☐ Master ☐ Doctorate

16. I would like to have a copy of the summary report. My e-mail address is: ______________________