DHĀRANA
BHAVAN'S INTERNATIONAL JOURNAL OF BUSINESS
Vol:2, 1 (2008) 3-9 ISSN 0974-0082

An Analytical Framework for Assessing the Interface among Information Systems, Technologies and Organizational Learning

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Abstract

Much of current research investigates the interface between organizational learning (OL) and various types of information systems and technologies (IST). Related literature has focused on the relationships in a rather narrow and piecemeal fashion. What is lacking is an integrated framework that provides a general coherence to IST-OL research. This paper seeks to remedy this situation by providing a holistic and analytical framework that is capable of grounding existing and future research in this area. This study also outlines a research agenda for the field of IST-OL using the developed framework as a foundation.

Key words / phrases: *Information systems, information technology, organizational learning, mental models, research frameworks.*

1. Introduction

The concept of organizational learning (OL) has interested researchers for several decades (Cangelosi and Dill, 1965; Crossan, Lane, and White, 1999), with that interest increasing over the last twenty years (Bhatt and Zaveri, 2002). The reasons for this interest spring from a recognition of the ability of OL to replenish knowledge stocks in the dynamic and ever-changing landscape of today's modern organizations. Directed and purposeful efforts at OL often cost organizations many millions or even billions of dollars. For example, IBM spent more than $US25 billion on research and development efforts between 1988 and 1992 (Boisot, 1998). Croasdell (2001) posits the necessity of rapid learning in organizations due to changes in technology and shifts in demand. The recognition of OL's importance is so sharp that many have begun to regard OL as a major antecedent of organizational success and survival (Achrol, 1991; Garvin, 1993; Slater and Narver, 1995; Lukas, Hult, and Ferrell, 1996). Of utmost importance is the possibility of impacting such organizational outcomes as competitive advantage and knowledge and technology exploitation (Templeton, Lewis, and Snyder, 2002) offered by OL.

As organizations of all types have increasingly come to rely on information systems and technologies (IST), it is little wonder that researchers have recognized the potential of IST to impact or be associated with OL. Much of the literature that specifically deals with IST-OL relationships has come from those interested in the support of OL by collaborative technologies such as group support systems and group decision support systems. Bhatt and Zaveri (2002) have posited the potential of many types of decision support systems to impact or support OL. But this leaves many other types of IST out of consideration. Many organizations, particularly firms that are larger and more geographically dispersed, have invested heavily in boundary-spanning, integrated information systems such as enterprise resource planning and customer relationship management systems. If and when various types of systems are considered in connection with OL, it is done so in an isolated fashion where only a few conceptual factors are considered. What is potentially beneficial for the field of IST-OL research is to understand extant research within a holistic framework and provide a conceptual foundation for future investigations.

This paper seeks to fill the extensive gap in the literature through two contributions. First, this study will provide a generalized, analytical IST-OL framework. Second, this study will outline a research agenda for further study. To this end the paper will be organized as follows. Section 2 will present a model of IST foundational concepts and connect this to OL. Section 3 will synthesize a suitable definition of OL. Section 4 will briefly outline the categories of IST systems and existing IST-OL literature and position them with respect to the desired model. Section 5 will bring together an existing information and knowledge model, and a novel organizational IST framework created by the author to develop a multidimensional IST-OL framework. Section 6 will outline an IST-OL research agenda based on the framework. Section 7 will conclude the contributions of the paper.

2. The IS Nomological Net

We will begin the development of the desired framework by first briefly examining the IS nomological net of Benbasat and Zmud (2003). Figure 1 shows the IS nomological net. Although the nomological net was originally designed to depict the set of phenomena of interest within the IS discipline and as a guide to IS research, we will regard it as a high-level representation of how information systems, and associated IT artifacts are situated within organizations. The various constructs within the net can be described as follows:

- The Information system and IT artifact – The IT artifact will usually consist of some kind of software deployed on one or more computers or servers. The IT artifact is potentially a part of larger Information system which can include people and processes.
- Usage – The IT artifact is designed to support or automate certain tasks that are performed in pursuit of the satisfaction of organizational goals. The performance of these tasks represents Usage.
- Impact – Certain results are expected to accrue as a result of the usage of the system and its artifact. These results could manifest in such outcomes as lower costs, increased efficiencies, or more generalized forms of outcomes such as better decisions or the production of new knowledge. As a result of usage there are direct and indirect as well as intended and unintended impacts on the organization's individuals as well as its teams, groups, work units and the larger organization. In our study this generalized construct can be replaced by OL, as we anticipate OL to be subsequent to Usage.
- Managerial, methodological, and operational practices – These practices are associated with the planning, designing, constructing, and implementation of IT artifacts (software). The practices also relate to directing and facilitating IT artifact usage and evolution.
- Managerial, methodological, and technological capabilities – The capabilities relate to abilities or aptitudes for managing, developing procedures, or leveraging technology and/or know-how.

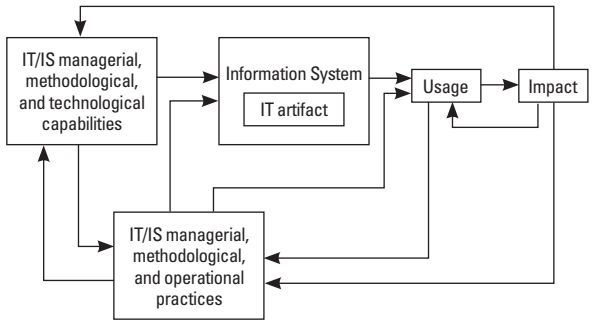

Figure 1 Information systems discipline nomological net (adapted from Benbasat and Zmud, 2003).

A useful way of summarizing the foregoing paper is that IST, the information system and the IT artifact collectively, are designed and developed to address certain needs within organizations. As a result of the usage of IST there are intended and unintended consequences of that use, which can impact the capabilities as well as the practices which influenced the design and development of the system. Thus, IST are embedded within the organization in a feedback loop within which the organizational contexts and structures influence and are influenced by IST.

The nomological net of Benbasat and Zmud (2003) is inadequate to serve as our ultimate model of the relationship between IST and OL, being originally designed as a framework for all types of IS research. Its utility in this study is to provide the notion of embeddedness. This term will be used here to connote the degree to which a technology or information system is an integral part of the social and technological infrastructure of the organization. The shortcoming of the net lies in its inability to relate the social reality of OL. This will become clearer after an adequate definition of OL has been provided.

3. Organizational Learning

Argyris and Schon (1978) identified two types of learning, single loop learning (SLL) and double loop learning (DLL). SLL is defined as the detection and correction of error. In essence, an individual (or organization) notices a discrepancy between

performance and desired goals with corrective action being taken. SLL can be seen as that type of limited learning that tends to maintain an organization relative to its environment. In DLL there is a questioning of the underlying assumptions and goals with a resultant change in both. DLL is of critical importance to organizations and individuals because it enables further learning. Moreover, DLL is transformative, changing informal and formal routines and processes, and sometimes yielding radical change in organizational design.

Ching, Holsapple, and Whinston (1992) argue that organizational learning subsumes learning by entities. Human or non-human entities learn when they adjust the contents of their knowledge systems. A knowledge system may consist of various types of knowledge such as descriptive, procedural, presentation, and linguistic. Organizational learning also involves trans-entity learning. The knowledge system of the organization is more than a simple union of the knowledge systems of its respective entities. This can be explained by the presence of various repositories as well as communication channels. Repositories serve as storehouses of various kinds of knowledge, separate from the organization's entities that can be made accessible for review and use. Communication channels are important for organizational learning because the opening and shifting of communication channels, if used effectively, can create new knowledge. Finally, what makes this characterization of OL important is that the patterns of interaction through communication and coordination give rise to organizational-level knowledge.

These characterizations establish that OL happens throughout the organization, but are not sufficient to provide an understanding of how OL actually occurs. Kim (1993) provides a natural mechanism for the translation of learning from the individual to the organizational level. That mechanism is mental model. A mental model is an internal, mental representation of an aspect of reality. For example, a mental model of a decision problem within a management team might involve the individual's understanding of the people involved and their relationships, the various parameters or variables involved in the choice, the possible set of outcomes, etc. Individuals form mental models in a variety of ways by direct work experience, through the incorporation of information conveyed by word of mouth, directed observation or study, or by intuiting connections between entities or causes and effects. The important point here is that when knowledge is specific to an individual, it has little chance of effecting changes within the organization until it becomes shared. Mental models become shared when they are communicated to other individuals via a process of surfacing and explanation within groups whose members may adopt all or portions of the models.

By integrating the work of Crossan, et. al. (1999) and that of Kim (1993), Balbastre and Moreno-Luzón (2003) have developed a model that integrates the individual, group, and organizational levels. Within this model are six types of learning. Individual single-loop learning occurs when deviations from a desired goal are detected and corrected (Kim, 1993). This is the same SLL as discussed by Argyris and Schon (1978). It is important to note here that there is no update in the mental model of the individual. Individual double-loop learning occurs when an established mental model is called into question and updated to accommodate changing situations or needs. Group single-loop learning occurs when group members improve their performance within their established mental models, that is, error detection and correction without a corresponding change in mental models. Group double loop learning occurs when there is a corresponding change in shared mental models (Balbastre and Moreno-Luzón, 2003). Organizational single-loop learning is similar to SLL by the individual. Deviations are detected and corrected with no corresponding changes in shared mental models. Organizational double-loop learning occurs when mental models become incorporated into the organization through shared mental models.

Against this broad background, we now state a suitable definition of OL. For purposes of this study we choose to frame OL as *the process of developing, refining, and sharing mental models across the levels of the organization; individual, group, and organization*. This definition agrees with the understanding of OL as an impact within the IS nomological net. Thus, OL, as an impact, is a multi-level construct that is influenced or supported through the use of IST. In turn, OL is anticipated to influence the IST-related capabilities and practices of the organization.

4. IST and OL

The literature connecting IST and OL has become, in some senses, moderately extensive. So space will not permit a comprehensive review of all of its various aspects and meanings. We seek only to demonstrate the aptness of the developing framework. The fact that some of the research is focused on some narrow categories of IST, while other areas have remained relatively untouched, and that some research seeks to cast a general and broad net at the IST-OL relationship (Goodman and Darr, 1998; Venugopal and Baets, 1995; Rein, Holsapple, and Whinston, 1993) is evidence of some immaturity of the research stream and evidence for the need of the framework contained in this study.

The early days of the information revolution were characterized by the explosive growth of new information technology and systems that increased individual worker productivity.

Subsequent developments in thin-client, client-server, and distributed, Web-based technologies have sought to make information systems and resources available to masses of individuals. As organizations have sought to harness the power of information and knowledge, many types of IST have been developed. One of the earliest manifestations of this effort were what have come to be known as knowledge-based systems; decision support systems, expert systems, and other supposedly artificially intelligent systems such as neural nets. These systems sought to capture expert, often rule-based knowledge, and make it available to individuals within the organization. As organizations have realized the benefits of the use of groups and teams as well as linking partners, suppliers, and customers together in a growing and efficient *value chain*, the emphasis has moved away from individual computing to collaborative systems and enterprise and distributed systems. Two examples of this are enterprise resource planning (ERP) and customer relationship management (CRM).

Much of the literature on IST and OL comes from the area of decision support systems. Zack (2007) suggests that the integration of computer-based decision support and human-centric approaches is necessary for organizational learning to occur. In particular, IT is better suited for managing uncertainty (not enough information) and complexity (having too much information), while the human-centric approaches are better suited for situations of ambiguity (lack of a conceptual framework) and equivocality (having competing or contradictory conceptual frameworks). IT can also aid in the latter situations by providing a means to make social connections and support face-to-face interactions.

Bhatt and Zaveri (2002) suggest nine general DSS attributes that enable OL. Their list includes efficient access of data, experimentation with variables, generation of alternate models, trend analysis, exploratory and confirmatory models, simulation, justification of solutions, exploration and exploitation of stored data, and idea generation. Although their work does not suggest precisely how these attributes facilitate learning above the individual level, they are in accord with other authors in declaring that a DSS should "be designed to facilitate an understanding among different decision-making participants." In particular they suggest the use of GDSS for information and knowledge sharing.

Group support, in particular, appears to be related to OL. Examination of case and field studies reveal that GDSS and GSS usage generally have a positive impact on such variables as information exchange, communication, number of ideas generated, knowledge, and knowledge sharing (Fjermestad and Hiltz, 2000). Hender, et. al. (2002) examine the relationship between GSS-incorporated idea generation techniques and creativity. Kwok, Ma, and Vogel (2002) investigate the effects of GSS and content facilitation on knowledge acquisition in a collaborative learning environment. Dennis, Tyran, Vogel, and Nunamaker (1997) find that process support and process structure have positive effects on such variables as the production and identification of information, as well as the communication and integration of information. Through integration the existing GSS-OL literature and data analysis, Tomblin (2005) suggests and demonstrates a positive relationship between content and *process support* dimensions of GSS and creation and maintenance of mental models at the individual, group, and organizational levels.

Other literature highlights additional systems such as executive information systems and various knowledge-based systems. Hines and Ghoul (1998) report success in the construction and validation of a knowledge-based organizational learning support system (OLS). Venugopal and Baets (1995) offer a conceptual framework for an integrated intelligent support system for learning. Linger and Burstein (1998) provide a general framework for the construction of an Organizational Memory System (OMS). In their framework, the OMS is not a simple repository. The OMS should support teams whose members are engaged in reflective activity aimed at improving their practice.

The extant literature thins considerably when we consider enterprise-level IST. Other than the research highlighting the necessity of learning during ERP implementation, the author was able to identify only one article associating ERP and OL. This situation provides further credence to the necessity of a more holistic framework for IST-OL relationships. Kidd and Richter (2001) contend that ERP can actually have a negative impact on OL by 'hollowing out' the workforce, through downsizing, thus decreasing organizational slack that can be devoted to generating organizational learning. This situation leaves the question of whether or not ERP has a positive impact on OL unaddressed.

This brief review provides us with the following insight and understanding. Relative to the nomological net, OL is an impact. IST of various forms are related to OL, but only certain IST have received any great attention. The IST-OL relationship manifests itself at the individual, group, and organizational levels. Finally, the mechanism which is aptly able to serve as a mechanism for the creation, transfer, and storage of what is learned, is the mental model. What we now need is a framework within which to understand and relate the various types of IST, levels of learning, and what is learned in the form of mental models and codified knowledge.

5. The Framework

Any framework which purports to fundamentally ground the research into the connection between IST and OL must have certain characteristics. First, it must be able to treat specifics of investigated relationships without being too narrow. It must be inclusive without being so broad as to be meaningless. It must also capture the essence of the constructs being related. Models dealing exclusively with OL certainly exist (Balbastre and Moreno-Luzón, 2003; Kim, 1993). While these are strong on the essence and mechanism of OL, they are weak or silent on the technological aspects. Other investigations that are strong on the technological side (Vandenbosch and Higgins, 1995; Tomblin, 2005) are weak or silent on the social aspects. This is not to say that people need represent a variable or construct within a framework or model.

One way to capture the essence of interaction is to properly frame, within the context of organizational social exchange and collaborative work, the 'object' that is passed between participants. According to the previous OL definition, we will regard the mental model as the fundamental unit of learning. Thus, the mental model serves as a unit of exchange between interacting organizational members. While it may be understood that interaction can occur without exchange, we will ignore those types of interactions and assume that the degree of exchange represents the degree of interaction.

Similar to Boisot (1998) in his treatment of knowledge assets, we will also recognize that mental models, the organization's most fundamental knowledge assets, can be categorized along the dimensions of *codification, abstraction,* and *diffusion*. Codification refers to the degree to which a mental model (knowledge asset) can be given form. That form could be verbal, written, or encoded in some digital medium for exchange, storage, or retrieval. Complete codification of knowledge makes automation of tasks possible. Abstraction refers to the number of categories that need to be drawn upon, when performing a task. The fewer the categories, more the abstraction present in a knowledge asset (mental model). Codification and abstraction give form and structure to mental models and have the joint effect of making knowledge more shareable. Diffusion refers to the proportion of the population of organizational agents (human or computer) that can be reached with information operating at different levels of codification and abstraction. One must take care not to confuse this with the notion of adoption. Diffusion simply refers to availability.

While Boisot (1998) offers some insight into the impact of information technology on knowledge assets, the treatment of technology speaks only to its utility and its use as medium of exchange. To characterize the technology that supports the exchange of mental models we will use the dimensions of *reach, transfer,* and *embeddedness*. Figure 2 shows a three-dimensional model of these constructs that can be used to categorize IST.

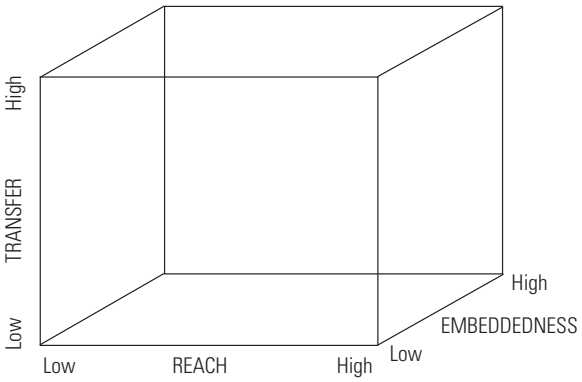

Figure 2 Three dimensional categorization of IST

Embeddedness was encountered earlier and refers to the degree to which a technology or information system is an integral part of the social and technological infrastructure of the organization. Reach refers to the number of people capable of being connected for the purposes of communication or information and knowledge exchange. Transfer refers to the ability or use of the technology to broadcast, exchange, or even store and retrieve information, data, and knowledge. Different types of IST could be realized as points in a three dimensional space along each of the given dimensions. For example, a decision support system utilized by a single individual would have low embeddedness, low reach, and low transfer. An ERP system, on the other hand, will have high reach, high transfer, and high embeddedness. It should also be noted that, with respect to usage, various systems may be able to occupy a multitude of points within the three-dimensional space. This would depend on the number of users for a particular task.

The choice of these particular dimensions for the characterization of IST with respect to mental models seems justified via the reviewed literature. Different technologies are produced or acquired to support a given number of users. Stand-alone decision support systems (DSS), for example, are typically designed for use by only a few users. Thus, they permit little, if any, connection to other users. That is, their reach is low. Stand-alone DSS can be used to store and retrieve information. That is, information can be transferred using these systems. In contrast, group support and group decision support systems, connecting several users assigned to the same task, have high reach. Since many of these systems are connected to various repositories of information

and permit (potentially) the sharing of mental models, their reach is potentially high. These systems would also differ with respect to the degree to which they are fundamental part of the social and technological infrastructure. For example, single-user DSS may represent an ad-hoc or specialized technology with intermittent use (low embeddedness), while group support may be the normal technological means by which groups or teams complete tasks and collaborate in general (moderate to high embeddedness).

Together, Boisot's (1998) knowledge characterization and the IST dimensions given above provide a useful framework with which to characterize IST used in support of OL. Refer to Figure 3. It captures the nature of what passes within organizational social exchanges and includes the technological aspects as well.

Social exchange	Technological
Codification	Embeddedness
Abstraction	Reach
Diffusion	Transfer

Figure 3 IST-OL Frameworks

6. An IST-OL Research Agenda

Given the multitude of possible combinations of constructs within the framework, there are a variety of investigations that could be conducted on IST support of OL. Although mental models give rise to the notion that all knowledge is contained entirely within individual heads, these models are capable of being elicited to one degree or another and subsequently encoded. Future research should focus on the characteristics that promote the technological dimensions with respect to OL. For example, how does high transfer ability support OL? What might inhibit OL support by a technology with high transfer? Future research should also focus on the characteristics of codification, abstraction, and diffusion of information and knowledge, within the context of IST use, that foster OL. For example, how does the use of ICT to enable abstraction support OL.

Another approach to research is to consider how the various dimensions promote or hinder one another during IST use. What is the interplay between the dimensions when a technology promotes abstraction and has high transfer? Still another is to fix the dimensions at some desirable points and then determine how the use of the technology is related to OL at each of the three OL levels, individual, group, and organizational. For example, does ERP with high reach foster individual learning? What is the strength of the relationship of ERP to organizational learning?

The foregoing paper could be regarded as a categorical or even combinatorial approach to the study of the IST-OL relationships. It is similar to the existing research on the selection of a limited mix of constructs for study. While this can yield results, it may still leave the field somewhat fragmented. A more systematic, and potentially more unifying approach, would be to create separate research streams characterized by application type. For example, if we confine our attention to group support systems (GSS), we could develop the following list of researchable propositions:

- (P1): GSS are positively related to individual OL.
- (P2): GSS are positively related to group-level OL.
- (P3): GSS are positively related to organizational-level OL.
- (P4): GSS with low embeddedness are not significantly related to organizational-level OL.
- (P5): GSS with high embeddedness are significantly related to organizational-level OL.
- (P6): There is no significant difference between the strength of the relationship of low-embeddedness GSS and high-embeddedness GSS on organizational-level OL.
- (P7): There is a positive relationship between codification and transfer at the individual, group, and organizational levels during GSS use.
- (P8): At fixed levels of transfer ability, diminishing returns on OL are experienced with increased levels of codification of the mental models.

With such a systematic approach it may be possible to reach certain generalizations, which are the hallmark of empirical and scientific investigations. For example, what can be said, in general, about high reach systems with regard to their ability to support OL at each of the learning levels via the social exchange dimensions?

Given that we have grounded our understanding of IST within the organization using the nomological net (Benbasat and Zmud, 2003), it will also be important to understand the feed-forward and feedback relationships between the Usage and Impact constructs via the framework. For example, the dimensions of embeddedness, reach, and transfer will be experienced within the Usage construct. These will have some relationship to learning at each of the levels of the organization. Will the resultant learning influence the experience of embeddedness, reach, and transfer over time. Answering this question could possibly be approached through the lens of "structuration" (Giddens, 1984).

These are but a few of the research questions that could eas-

ily be turned into testable hypotheses. The current list is by no means exhaustive and others may wish to add to it.

7. Conclusions

The contribution of this paper is twofold. First, the paper has presented the development of a research framework useful for the study of the relationship of IST to OL. The framework was developed using IST foundational concepts, existing OL research, and characterizations of technology and the fundamental units of OL. It is felt that the framework is holistic enough to be useful as a guide for future research. This paper has also offered a brief sketch of a possible research agenda which can be used by other researchers or added to by the same. An empirical assessment should be made that confirms the suitability of the chosen dimensions. This is left for a future investigation.

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