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Studying ComputerAided Software Engineering Diffusion in Organizations: Complementing Classical Diffusion Theory With Organizational Learning Perspective

Srinarayan Sharma
Southern Illinois University, gr4601@siucvmb.siu.edu

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Srinarayan Sharma, Department of Management, Southern Illinois University, Carbondale, IL 62901
Tel: (618) 453-3307
Email: gr4601@siucvmb.siu.edu

Introduction

Computer-aided software engineering (CASE), a relatively recent technological innovation, is viewed by both researchers and practitioners as a potential means to increase the productivity (Banker and Kauffman, 1991; Norman and Nunamaker, 1988; Stamps, 1987; Swanson, et al., 1991) and quality (Howard, 1990) of information systems development activities, reduce costs and time spent in systems development (Feuche, 1989; Martin, 1989), and ease the software development and maintenance burden threatening to overwhelm information systems departments (Bachman, 1988; Banker and Kauffman, 1991; Swanson, et al., 1991). Actual experiences with CASE tools, however, have been mixed. While some studies have reported productivity gains (or perception of such gains) from the use of CASE tools (Banker and Kauffman, 1991; Necco, et al., 1989; Norman and Nunamaker, 1988; Swanson, et al., 1991), many others have found that the expected productivity gains are elusive (Card, et al., 1987; Yellen, 1990), or hampered by inadequate training and experience, developer resistance, and increased design and testing time (Norman, et al., 1989; Orlikowski, 1988, 1989, 1993; Vessey, et al., 1992). These contradictory experiences with CASE tools have been difficult to interpret and have puzzled both practitioners and researchers. The inadequacy of conceptual and theoretical foundation of organizational innovation diffusion, primarily based on the classical diffusion theory first espoused by Rogers (1962), have been cited as a prime reason for the contradictory empirical findings (Fichman, 1992).

The classical diffusion theory, used in most studies of IT diffusion in general and CASE diffusion in organizations in particular, has many shortcomings. First, the theory operates under the assumption of an unchanging innovation (Brown, 1981). In reality, innovation is a continual process whereby the form and function of the innovation are modified throughout its life (LeonardBaron, 1988; Walton, 1989). Second, the theory emphasizes the demand aspect of diffusion, assuming that everyone has an equal opportunity to adopt; the supply side of the innovation is almost ignored (Brown, 1981). In fact, institutions that supply and market innovations determine to a certain extent who adopts them and when. Third, the classical diffusion theory considers the technological adoption decisions of individuals or organizations without taking into account community issues, assuming that individuals adopt innovations for their own independent use (Fichman, 1992). However, there is evidence that the technology can be subject to network externalities (Katz and Shapiro, 1986; Markus, 1987), which means that the value of use to any single adopter will depend on the size of network of other users. Fourth, the classical theory fails to distinguish between two types of communication involved in the diffusion process: signaling versus knowhow or technical knowledge (Attewell, 1991). It assumes that signaling information takes different lengths of time to get to different potential adopters (according to their centrality to communications networks and links to prior adopters), resulting in the early, middle, and late Scurve adopters, and is therefore viewed as central in explaining the diffusion process. However, one may question whether signaling information is a limiting factor in situations where information about the existence of new technologies and their benefits is widely broadcast by manufacturers' advertisements, by specialized business journals, and by trade associations (Burt 1987). The technical knowledge required to use a complex innovation successfully places far greater demands on potential users and on supplyside organizations than does signaling (Attewell, 1992). If obtaining technical knowledge is slower and more problematic, it can be posited that it plays a more important role in the diffusion of complex technologies than does signaling. Finally, most of the studies of supply-side institutions in innovation conceptualize the diffusion process in terms of knowledge transfer. Attewell (1992) argues that such studies treat the movement of complex technical knowledge under a model of communication most appropriate for signaling. Studies have, however, shown that although one can readily buy the machinery that embodies an innovation, the knowledge needed to use modern production innovations is acquired much more slowly and with considerably more difficulty (Arrow, 1962; Dutton and Thomas, 1985, Ray, 1969; Pavitt, 1985; von Hippel, 1988). Absorbing a new complex technology not only requires modification and mastery of the technology, but it also often requires (frequently unanticipated) modifications in organizational practices and procedures (Stasz, Bikson, and Shapiro, 1986; Johnson and Rice, 1987). Thus, implementing a complex technology requires both individual and organizational learning.

Not surprisingly, the findings of past studies of IT diffusion show inconclusive support for the classical diffusion theory in the case of diffusion of complex information technologies (such as CASE) which exhibit user interdependency and impose knowledge burden on users (Fichman, 1992). (When the adoption decision of individuals or organizations depends on the dynamics of community-wide levels of adoption because of network externalities, innovation diffusion is characterized as exhibiting user interdependencies. Similarly, when technologies cannot be adopted as a "black box" solution but rather impose a substantial knowledge burden on potential adopters, innovation diffusion is characterized to exhibit high knowledge burden.) One interpretation of these findings is that classical diffusion variables by themselves may not be strong predictors of adoption and diffusion of complex technologies at the organizational level (Fichman, 1992). Fichman (1992) recommends that future research on IT diffusion at the organizational level consider other than classical or communications perspective, such as market and infrastructure, economic, and organizational learning perspectives, to account for these inconsistencies. In this study we complement the classical diffusion theory with an organizational learning perspective.

Organizational Learning

As a process, organizational learning takes place when individual members of an organization, acting from their images or maps of organization, detect a match or mismatch between outcomes and expectations and embed the resulting discoveries, inventions, and evaluations in organizational memory (Argyris and Schon, 1978). Individual learning involves the distillation of an individual's experiences regarding a technology into understandings that may be viewed as personal skills and knowledge (Attewell, 1992). Organizational learning is built out of this individual learning of members of an organization. Definitions of organizational learning underscore (1) interaction of the organization with the environment, (2) changes in organizational modeling of its environment, and (3) organizational action (McKee, 1992). Individual learning is deemed necessary but insufficient for organizational learning (Argyris and Schon, 1978).

The organizational learning perspective complements the classical diffusion theory in many ways. A good illustration of this complementarity is in the alternative explanations given for the flatness of Scurve's left tail before "takeoff" or bandwagon effect. The communications perspective attributes this to the adopter's innovativeness characteristics or resistance to adoption. The organizational learning perspective attributes it to the existing knowledge barriers about the innovation -- difficulties of obtaining knowledge and skilled personnel and the effort of in-house organizational learning about technologies (Attewell, 1992). The S-curve may be viewed in terms of the changing height of hurdles (both know-how and machinery cost) to in-house adoption. A similar set of explanations is given for the "takeoff" or differences in the rates of diffusion of different innovations. The communications perspective attributes the "takeoff" to the lowering of adopter resistance to adoption to social interaction and other communications and the variance in diffusion rates to different resistance levels for different innovation. The organizational learning perspective attributes it to the lowering of knowledge barriers through the development of a variety of interpersonal, analytic, organizational, and ecological interfacing learning skills and their embedding in the organizational maps and images (McGee, 1992).

Research Model

The research model used in this study draws on both classical diffusion theory and organizational learning theory. Fifteen independent variables are examined in this study for their correlation with two phases of the diffusion process adoption and infusion. The independent variables examined in this study can be classified in five broad categories: characteristics of IS professionals, knowledge acquisition factors, knowledge distribution and sharing factors, organizational factors, and technology characteristics. The characteristics of IS professionals relate to the attributes of the individuals working in the information systems department (ISD) of an organization. Knowledge acquisition factors are concerned with the processes by which knowledge is obtained by organizations, while knowledge distribution and sharing factors relate to the processes by which information from different sources is shared, resulting in new information and understanding. Organizational factors concern both internal and external environments of the organization. Technology characteristics relate to the attributes of the innovation being adopted. These categories and the variables (enumerated below) therein have been chosen to represent both the commonalities (organizational factors) and differences (characteristics of IS professionals, knowledge acquisition factors, knowledge distribution and sharing factors, and technology characteristics of innovation) between these perspectives.

The variables included under the characteristics of IS professionals are the prior experience of IS professionals, career orientation of IS professionals, and the proportion of multiskilled IS personnel in the ISD. The variables studied under the knowledge acquisition factors are training and human resources development, support of mediating institutions, and environmental scanning. The variables examined under knowledge distribution and sharing factors are job/role rotation of IS professionals and media richness of communication channels. The variables studied under organizational factors are IS perception of corporate objectives and simultaneous engineering. The variables studied under technology characteristics are relative advantage, complexity, and stability.

Past research has shown that different diffusion related variables may impact different stages differently (Kwon and Zmud, 1987). Laudon (1985) has shown that factors associated with rational explanations of IT implementations success are more significant for earlier rather than later stages. In that vein Cooper and Zmud (1990) have examined two widely separated diffusion stages (adoption and infusion) in the context of MRP implementation. Their results replicate Laudon's findings. It seemed fitting that we examine CASE diffusion in the adoption and infusion stages for two reasons. First, this will, building on past research (Keen, 1980), help generalize the findings under different contexts and for different technologies. Second, if variables impact different phases differentially, their effects are likely to be more pronounced when the phases are further apart.

The following relationships are hypothesized:

1. The experience of the IS professionals with a compatible methodology will be positively related to the adoption and infusion of CASE tools by ISD.

2. Compatible career orientation of IS professionals will be positively related to the adoption and infusion of CASE.

3. The degree of turnover of IS personnel will be negatively related to adoption and infusion of CASE technology.

4. The proportion of multi-skilled IS personnel in an ISD will be positively related to the infusion of CASE in case of high turnover of IS personnel.

5. The proportion of multi-skilled IS personnel in an ISD will not be related to the adoption and infusion of CASE technology in case of low turnover of IS personnel.

6. The degree of training and human resources development will be positively related to adoption and infusion of CASE.

7. The degree of support of mediating institutions will be positively related to adoption of CASE technology.

8. The degree of support of mediating institutions will not be related to infusion of CASE technology.

9. Environmental scanning for systems development technology will be positively related to adoption and infusion of CASE technology.

10. Degree of job/role rotation of systems development personnel will be positively related to both adoption and infusion of CASE technology.

11. The media richness of communication channels for knowledge sharing about CASE technology will be positively related to the adoption and infusion of CASE.

12. The perceived effectiveness goal will be positively related to CASE adoption and infusion.

13. The perceived efficiency goal will be negatively related to CASE adoption and infusion.

14. The level of simultaneous reengineering of business areas will be positively related to adoption and infusion of CASE tools.

15. The degree of relative advantage of CASE technology over existing systems development technology will be positively related to adoption and infusion of CASE.

16. The perceived complexity of CASE tools will be negatively related to CASE adoption and infusion.

17. The stability of CASE toolset should be positively related to its adoption.

Data Collection Methodology

A national mail survey is being used for data collection. The questionnaire is aimed at the chief information officer or the head of information systems department. Different variables of the research model have been operationalized using Churchill's (1978) procedure. Hierarchical multiple regression and canonical correlation will be used for data analysis.

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