Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 1995 Proceedings

International Conference on Information Systems (ICIS)

12-31-1995

The Effects of Knowledge Embeddedness on the Diffusion of Case Technologies within Organizations

Russell Purvis
University of Central Florida

V. Sambamurthy
Florida State University

Robert Zmud
Florida State University

THE EFFECTS OF KNOWLEDGE EMBEDDEDNESS ON THE DIFFUSION OF CASE TECHNOLOGIES WITHIN ORGANIZATIONS

Russell L. Purvis
Department of Management
College of Business Administration
University of Central Florida

V. Sambamurthy
Information and Management Sciences
College of Business
Florida State University

Robert Zmud
Information and Management Sciences
College of Business
Florida State University

Abstract

Systems development in organizations is well recognized as a knowledge-intensive effort. Since the relevant application domain knowledge is thinly spread across an organization, the acquisition, sharing, and integration of knowledge are significant activities during the development process. Advocates of computer-aided software engineering tools (CASE) claim that these tools offer a potentially valuable feature for facilitating such knowledge integration and management activities: the *central repository*, which is a location for storing, retrieving, and maintaining a variety of applications development information. Yet, the effects of the CASE repository on the diffusion of the technology have received limited attention in prior research. This study examines whether the embedding of applications development knowledge within the CASE repository influences the diffusion of the CASE technology across applications projects in organizations. We develop a construct called *knowledge embeddedness*, which refers to the extent to which relevant applications development knowledge is systematically populated within the CASE repository. Based on data gathered from 168 organizations, through a large-sample survey of CASE user groups, we found strong support for the relationship between knowledge embeddedness and diffusion of CASE technology. These results have interesting implications for future research and practice.

1. INTRODUCTION

Systems development in organizations is well-recognized as a knowledge-intensive effort, e.g., "knowledge is the raw material of software design teams" (Walz, Elam, and Curtis 1993). Since the relevant application domain knowledge is thinly spread across an organization (Curtis, Krasner and Iscoe 1987), the acquisition, sharing, and integration of knowledge are significant activities during the development process (Walz, Elam and Curtis 1993). Advocates of computer-aided software engineering tools (CASE) claim that these tools offer a potentially valuable feature for facilitating knowledge integration and management activities: the *central repository* or *encyclopedia*, which is a location for storing, retrieving, and maintaining a variety of applications development information (Martin 1990a; 1990b). McClure (1989) considers the repository to be "the heart of CASE," a mechanism for managing all information concerning a software system. Yourdon (1992) calls the repository the "single most important technological development in the CASE industry...today's CASE environment could be regarded as a number of tools clustered around the repository (p. 137)." Such claims imply that the CASE repository could play a key role in influencing the diffusion of the technology within an organization's systems development projects. Yet, despite the growing volume of research on impacts of CASE (for instance, Banker and Kauffman 1991; Necco, Gordon, and Tsai 1989;

Card, McGarry, and Page 1987; Lempp and Lauber 1988; Norman, Butler, and McElroy 1989; and Vessey, Jarvenpaa, and Tractinsky 1992), the role of the CASE repository has received relatively less attention.

The goal of this study is to explore the relationship between embedding applications development knowledge within the CASE repository and the diffusion of the CASE technology within organizations' systems development projects. We develop a construct called *knowledge embeddedness,* which refers to the extent to which relevant applications development knowledge is systematically populated within the CASE repository. The thesis tested is that greater levels of knowledge embeddedness will increase the value of a CASE tool to an adopting organization and, hence, be significantly associated with greater diffusion of the CASE technology within an organization's portfolio of applications projects. The next section of this paper presents our conceptual ideas leading to the above hypothesis. The following sections present details of our empirical methodology, analysis, and results.

2.0 CONCEPTUAL MODEL

The conceptual model for this research (see Figure 1) borrows its conceptual underpinnings from the "critical mass" theory (Markus 1987), which predicts that the diffusion rate for certain technologies is influenced by the number of people who have already adopted the technology — critical mass is the point at which enough individuals have adopted the technology so as to shift the perceived cost-benefit tradeoff of adoption from negative to positive for individuals in the adoption system (Rogers 1991). In the context of CASE, our model suggests that a critical mass of knowledge must be stored in the repository for its utility to become evident and its adoption to occur. Thus, with higher levels of knowledge embeddedness, we would anticipate greater levels of diffusion of the CASE technology within systems development projects. In addition, our model recognizes the importance of other key factors that could affect the diffusion of the technology.

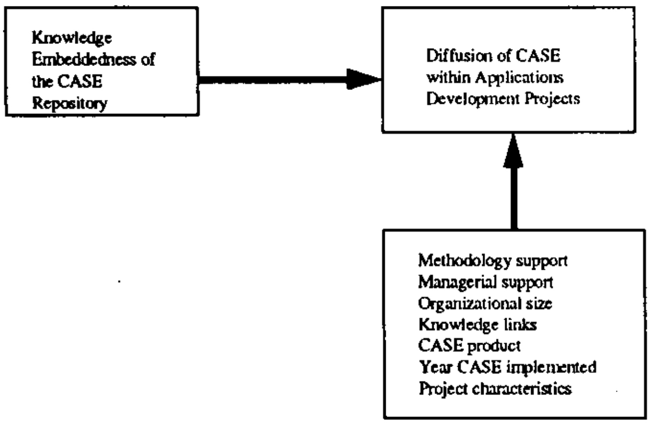

Figure 1. Conceptual Model for this Research

Two caveats are necessary before we elaborate our conceptual model. First, though our model posits an influence from knowledge embeddedness to diffusion, we recognize that the relationship might unfold over time through a process of mutual causation. A critical mass of knowledge embeddedness might be necessary for the initial diffusion to occur. Subsequently, increased levels of knowledge embeddedness would influence greater diffusion of the CASE technology; in turn, higher levels of diffusion would facilitate more knowledge embeddedness within the CASE repository and vice versa. However, given the novelty of the knowledge embeddedness construct, a simpler perspective might be appropriate for this exploratory inquiry. Future research might examine the more complex dynamics, hinted above, through a longitudinal investigation.

A second caveat relates to the distinction between the impacts of knowledge embeddedness and knowledge-in-use. Our perspective of knowledge embeddedness does not capture the manner in which such knowledge is *actually used* on the projects. Investigation of the knowledge-in-use might reveal a variety of rich ways in which the CASE repository affects diffusion. However, before conducting a deeper and richer investigation of the impacts of knowledge-in-use, it might be important to explore whether knowledge embeddedness *does* influence the diffusion of CASE. Subsequent investigations could adopt richer conceptual models and investigate the mediating effects of knowledge-in-use as well.

2.1 Knowledge Embeddedness

An assumption underlying the concept of knowledge embeddedness is that systems development knowledge is codifiable. Codifiability refers to the ability to structure knowledge into identifiable rules and relationships that can be stored within a memory bin (Kogut and Zander 1992; Walsh and Ungson 1991). Some forms of knowledge, such as the behavioral issues handled by a systems analyst, are not amenable to codification. Further, codifiability infers the existence of an implied theory by which knowledge can be identified and symbolically represented (Kogut and Zander 1992). The theory influencing the codifiability of applications development knowledge is based on the systems development life cycle, information engineering, or a derivative thereof.

This research relies upon information engineering as a guide for identifying the relevant domains of knowledge embeddedness within the CASE repository. The justification for this choice stems from the recognized fit between information engineering and the CASE repository.

> The heart of information engineering is an encyclopedia. The encyclopedia is a computerized repository that steadily accumulates information relating to the planning, analysis, design, construction, and later, maintenance of systems. [Martin 1990a, p. 14]

Table 1 Potential Dimensions of Knowledge Embeddedness

Information Systems Planning

This phase is concerned with top management goals and critical success factors, and how technology can be used to create new opportunities or competitive advantages. A high-level overview is created of the enterprise, its functions, data and information needs. The CASE repository stores knowledge on:

- Enterprise mission, objectives, and goals
- Critical success factors
- Market factors
- Organizational structure
- Enterprise data model
- Business processes
- Current information systems portfolios
- Business policies, rules, and events

Business Analysis

This phase is concerned with what processes are needed to run a selected business area, how these processes interrelate, and what data is needed. The repository can store knowledge on:

- Data models including entities and their relationships
- Attributes of each entity
- Process activity models
- Process decomposition diagrams
- Process dependency diagrams

Design

In this phase it is determined how selected processes in the business area are implemented in procedures and how these procedures work. Direct end-user involvement is needed in the design of the procedures. The repository can store knowledge on:

- Screen and report formats
- Data flow diagrams
- Module structure charts
- Module flow charts
- Action diagrams
- User interface specifications
- Data structure diagrams

Construction

Implementation of the procedures using, where practical, code generators, and end-user tools. Design is linked to construction by means of prototyping. The repository can store knowledge on:

- Program structure charts
- Reusable code
- Physical database design and tables
- Stored record formats
- Test libraries and test cases

Project Management

Consists of planning, reorganizing, integrating, measuring, and revising the time, costs, and expectations associated with a project. Information in a repository could include:

- Estimates and schedule of deliverables, tasks, and resources
- Business justification - costs and benefits
- Project priorities and constraints
- On-line public calendars of relevant project dates, etc.
- Unresolved issues

Dixon 1992; IEF 1992; Martin 1990a, 1990b.

Information engineering identifies a variety of knowledge domains that could be stored within the CASE repository: information systems planning, business analysis, design and construction, and project management (Martin 1990a, 1990b). Table 1 illustrates the manner in which these different components of applications domain knowledge could be stored within the CASE repository. Knowledge embeddedness is the extent to which these five types of knowledge are stored within the CASE repository.

2.2 Diffusion of CASE

Based on the traditional definition of diffusion (Rogers 1983), we define diffusion as the spread of CASE technology through the population of systems development projects within an organization. As argued earlier, "critical mass" arguments suggest that growing levels of knowledge embeddedness within the CASE repository present greater opportunities for utilizing the technology to manage interdependencies among an organization's portfolio of applications projects. As more knowledge is stored within the CASE repository, it becomes available not only to members of a particular project team, but to other development teams as well.

Prior research demonstrates that the relative advantage of an innovation is a major factor influencing the diffusion of that innovation (Rogers 1983). Relative advantage refers to the extent to which an innovation is perceived as being better than the idea that it supersedes. Higher levels of knowledge embeddedness could enhance the utility of CASE as a production, coordination, and organizational technology in managing the knowledge integration needs of an organization's portfolio of applications projects (Henderson and Cooprider 1990). Compared to the traditional means of knowledge integration through use of meetings, memos, or documentation, the use of the repository permits leveraging of the power and functionality of advanced information technologies (Huber 1991). Finally, higher levels of knowledge embeddedness increases the compatibility of the CASE technology with the knowledge integration needs of applications development activities; such compatibility has been found to increase the diffusion of innovations in prior research (Tornatzky and Klein 1982; Cooper and Zmud 1990; Rogers 1983).

Collectively, these arguments suggest that

H1: Higher levels of knowledge embeddedness within the CASE repository will be significantly associated with the diffusion of CASE technology within an organization's portfolio of applications projects.

While the primary hypotheses of our study anticipates a significant effect of knowledge embeddedness on diffusion of CASE, another premise of our research is that some knowledge domains may be more influential than others. Given the absence of significant prior research on the effects of the CASE repository, we cannot venture specific hypotheses about the relative importance of the different knowledge domains. Hence, our interest also lies in exploring the relative significance of the different knowledge domains. Thus, we included the following exploratory research question:

RQ1 *What are the relative effects of the different dimensions of knowledge embeddedness (planning, analysis, design, construction, and project management) on the diffusion of CASE within an organization's development projects?*

2.3 Control Variables

A vast stream of prior research on the diffusion of technologies and innovations identifies a variety of other factors that may also play a key role in triggering the diffusion of CASE. Each one of these variables is discussed below.

Methodology support. A methodology is

> a coordinated group of applicable techniques, tasks, and guidelines designed to capture essential business and systems design knowledge and translate this information into an effective computer-based system. [Dixon 1992, pg 97]

It has been argued that the achievement of maximum benefits of CASE technology requires the implementation and use of a systems development methodology (Dixon 1992; Forte and Norman 1992). McClure states,

> because a structured development methodology provides the overall framework for defining and linking together the software development process steps, selecting a methodology must be the first step in implementing CASE. [p. 176]

Methodologies identify where CASE tools can contribute to systems development and the ways in which these tools are used. However, the methodology must also be compatible with the CASE technology so that the two can synergistically bond (McClure 1989; and Vessey, Jarvenpaa and Tractinsky 1992). Thus, methodologies and CASE technology are complementary; methodologies provide engineering discipline and quality improvements, while CASE contributes productivity and reusability benefits (McClure 1989).

Another important element of methodology support is the extent to which the methodology is actively being used. For example, Tannenbaum (1994) suggests that the lack of adherence to a methodology is an active barrier to CASE implementation. She identifies a variety of scenarios where methodologies serve limited roles as "dust collectors" or "rubber stamp methodologies." Hence, even with a compatible methodology, active use of the methodology is important. Prior research has demonstrated that diffusion of a complex technology such as CASE occurs through a process of "mutual adaptation" between the technology and the work processes (Leonard-Barton 1988). When a methodology is being actively used and is compatible with the technology, opportunities exist for iterative cycles of mutual adaptation and growing diffusion of the technology. We anticipate that higher levels of diffusion of CASE will occur when applications developers are actively using a methodology that is compatible with the technology. Hence, in our research, methodology support is viewed as the product of methodology compatibility and level of current use.

Managerial support influences the diffusion of a technology, either by making the decision for the adopter, or by enforcing a decision already made (Kochen and Deutsch 1980). Management can "push" adoption explicitly through expressed mandates, or reward systems and incentives (Leonard-Barton and Deschamps 1988; Moore and Benbasat 1991). Management can also symbolically signal their commitment to the technology or behaviors expected relative to the technology. Finally, management controls access to training and consulting and the physical access to the resources needed to use the technology. The net result is that studies of adoption within organizational settings must include, or control for, managerial support.

Organizational size. Larger organizations are more likely to be adopters of technological innovations (Tornatzky and Fleischer 1990; Rogers 1983). Size is probably a surrogate measure of several factors that influence the diffusion of innovations: total resources, slack resources and organizational structure (Rogers 1983).

CASE Product. Numerous products exist under the label of CASE technologies and offer varying levels of functionality and methodology support (Henderson and Cooprider 1990; Vessey, Jarvenpaa and Tractinsky 1992). Controlling for their effects is thus important in view of these differences across products.

Knowledge Links. Complex technologies, such as CASE, impose a substantial knowledge burden on adopters. In such cases, high knowledge barriers dictate that the extent to which potential adopters have built links with external knowledge sources is an important predictor of adoption behavior (Attewell 1992; Pennings and Harianto 1992a, 1992b).

Year CASE implemented reflects the cumulative organizational experience with the technology. Effective adoption of CASE requires substantial organizational learning and restructuring of work processes associated with applications development (Orlikowski 1993). Organizations that have adopted CASE relatively early could well be farther along the process of mutual adaptation than organizations that have adopted CASE relatively late.

Project characteristics, such as size and complexity, could potentially impact diffusion of the technology. CASE would be considered a complex technology by its own right; the rate of diffusion is expected to be lower for technologies higher in complexity (Rogers 1983). The use of complex technologies on complex tasks could aggravate this effect. Large and complex projects are fraught with uncertainty and equivocality; these characteristics could lengthen the learning curve for project team members as they engage in the process of mutual adaptation and, thus, affect the diffusion of the technology.

3.0 RESEARCH METHODOLOGY

A large-sample questionnaire survey was utilized for our research. We employed a purposive sampling strategy to gather responses from companies that were currently using CASE. Two user groups of CASE technologies (IEF and KnowledgeWare user groups) agreed to participate in the project. For each group, a copy of the survey instrument was mailed to members along with a cover letter from their group coordinator encouraging participation. In all, a total of 494 questionnaire surveys were sent and 168 completed responses obtained. The response rate (34%) compares favorably with other studies of organizational phenomena. Overall, these demographics satisfy us that our respondents were appropriately knowledgeable about the phenomena under investigation, with about 67% of the respondents being CASE or data administrators who had responsibility for the CASE repository.

Prior to the actual study, efforts were targeted at instrument development, testing, and validation. Such efforts involved in-depth exploratory interviews with systems developers who were experienced and knowledgeable with CASE. These interviews were conducted in parallel with a literature review on knowledge elements embedded within the repository (for example, Martin 1990a, 1990b, 1990c; Dixon 1992; IEF 1992). Next, items for knowledge stored within the repository were reviewed by seven CASE experts from the three CASE tool vendors that were used in the study. They verified that their respective CASE repositories offered the ability to store the information items listed in the instrument. Finally, the instruments were pilot tested with five developers at three nearby organizations that had implemented CASE technology. These participants completed the survey in the presence of the researcher and explained how they interpreted the items; these sessions were used to establish and enhance face validity of the items.

3.1 Construct Operationalization

Knowledge embeddedness was measured by having the CASE or data administrators characterize the extent to which different elements of knowledge were stored within the repository. The items capture each one of the dimensions of knowledge discussed earlier. Respondents were asked to indicate (on a 100% scale) the extent to which their organization had embedded each knowledge element within the CASE repository.

Diffusion of CASE was measured by first focussing respondents' attention on the sample of systems development projects within their organization during the preceding one year. Respondents were asked to identify the percentage of projects that used CASE technology for at least 25% of the systems development tasks. We deemed such a measure to be a more conservative estimate of the diffusion level since it eliminated projects that used CASE only in a perfunctory manner. Our conversations with CASE experts and our own knowledge and experience suggest that a 25% usage is an appropriate threshold.

Methodology support was operationalized as the product of (1) methodology compatibility with the CASE technology and (2) the level of current use of the methodology. Compatibility was measured on a five-point Likert scale, whereas level of current use was measured on a seven-point Likert scale.

Other control variables. Management support was measured through items adapted from Ginzberg (1981) and Slevin and Pinto (1987). Knowledge links were measured through four items that tapped common avenues for importing external expertise on CASE: consultants, hiring of employees with CASE experience, joint ventures with companies possessing CASE experience, and special training and support. A five- point Likert scale was used for these items. Subsequent factor analysis revealed two dimensions in our measures: (I) *expertise acquisition*, referring to hiring of employees with CASE experience or formation of alliances with other organizations that possessed CASE expertise, and (ii) *service acquisition*, referring to the use of consulting services that will perform technology transfer functions for the client or customized training and support from the vendor. These two dimensions were separately incorporated as control variables.

Consistent with previous research, organization size was measured as the number of employees in the IS organization (Rogers 1983; Kimberly and Evanisko 1981). Project characteristics were measured through two items: the size and complexity of projects using CASE. For data on CASE products, a categorical scale was used to code CASE products: 1= IEF, 2=KnowledgeWare, and 3=other products.

Responses on various measurement scales were factor analyzed for construct validity and the results were satisfactory. Further, reliability analysis provided assurances about the reliability of the measures.[1]

4.0 ANALYSIS AND RESULTS

Our analysis began with an examination of data on knowledge embeddedness. Our respondents indicated that less than 5% of project management knowledge was stored within the CASE repository. Further analysis showed that the majority of CASE repositories used in this sample did not effectively capture project management information. Therefore, this dimension was dropped from further analysis.

Factor analysis on measures of knowledge embeddedness, using a principle components analysis and a varimax rotation, yielded four factors in a structure that was consistent with our initial conceptualization.[2] Among them, strategic plan and tactical plan knowledge relate to information strategy planning. Strategic plan knowledge (eigen value = 2.86, variance explained = 11%) refers to items such as enterprise mission, goals, and objectives; enterprise CSFs and assumptions; enterprise data model; and the organization structure and hierarchy. Tactical plan knowledge (eigen value = 1.55, variance explained = 6%) refers to items such as business processes, data flows, and policies; rules; and events. Martin (1990b) states that it is appropriate to divide information strategy into two sublayers: "The top sublayer contains the types of planning of most direct interest to top management....The second sublayer contains the modeling of the enterprise and its information" (pg. 13). These two sublayers are reflected in our items describing strategic and tactical plan knowledge.

Business analysis knowledge emerged as a stronger factor in our analysis (eigen value = 8.84, variance explained = 30%). Consistent with our initial expectations, it refers to items such as normalized data model, entity types and their relationships, attributes of each entity type, detailed process/activity models, and process decomposition and dependency diagrams. Finally, although design and construction were conceptualized as two separate dimensions, our results reveal them to be combined into one element of knowledge (eigen value = 11.02, variance explained = 42.4%). This dimension of knowledge refers to items such as data flow diagrams, screen layouts and report formats, data structure diagrams, class definitions, program structure charts, physical database design and tables, and test libraries and test cases. Factor scores were used to generate measures for the four dimensions of knowledge embeddedness (strategic and tactical plan, analysis, and design and construction). Another round of factor analysis was conducted on these factor scores to assess the unidimensionality of the knowledge embeddedness construct. The results revealed the existence of one factor, providing support for our conceptualization. The measures of the four dimensions were aggregated to develop an overall measure of knowledge embeddedness.

However, before hypothesis testing, scores on the items representing each one of the dimensions of knowledge embeddedness were aggregated to develop indexes of the percentage extent to which the four knowledge types were being embedded in CASE repositories. This examination revealed that strategic plan knowledge was embedded to the lowest extent (29.1%), followed by tactical plan (30.1%). This is to be expected when the top portion of strategic planning is not done within organizations that take a shorter term approach to systems development and proceed directly to the business analysis phase of a project (Martin 1990a;

1990b; Stone 1992). Further, it could be argued that much of the strategic plan knowledge, such as enterprise mission, objectives, goals, critical success factors, and assumptions, is guarded by top management teams. They could resist placing this information within the organization's public domain. In contrast, however, analysis knowledge appears to be stored to the largest extent (57.1%), followed by design and construction knowledge (37.5%).

Hypothesis testing was done using regression analysis. Zero-order correlations among the predictors revealed significant correlations, indicating potential multicollinearity problems. Hence, multicollinearity diagnostics recommended by Belsley, Kuh, and Welsch (1980) were employed in the regression models; they revealed that multicollinearity was not a serious problem. A significance level of 0.05 was chosen as the cutoff for hypothesis testing. In the regression model, the order of entry was as follows: control variables (CASE product, organization size, knowledge links, project characteristics, management support, and year implemented), methodology support, knowledge embeddedness. In addition to the overall model being significant ($R^2 = .39$, $F_{9,159} = 11.51$, $p = .000$), knowledge embeddedness was found to be significant as well ($p=.000$, $\Delta R^2 = .05$) in explaining diffusion of CASE. These results support the primary hypothesis of our study. Other significant predictors included organization size ($p=.04$), project characteristics ($p=.038$), and management support ($p=.001$); interestingly, methodology support was not found to be significant.

In order to explore the research question related to effects of different elements of knowledge embeddedness, a second regression model was constructed. Similar to the earlier model, the control variables were entered first; however, instead of the aggregate measure of knowledge embeddedness, the four dimensions of knowledge embeddedness were entered individually. Table 2 illustrates the regression results. In addition to significant effects due to management support, design and construction ($p=.001$) and strategic plan ($p=.0263$) knowledge were found to exhibit significant effects.

5.0 DISCUSSION AND CONCLUSIONS

The goal of this study was to investigate effects of the embedding of relevant applications development knowledge within the CASE repository on the diffusion of that technology within applications development projects. Our research suggests that four different types of knowledge are being stored within CASE repositories: strategic plan, tactical plan, business analysis, and design and construction. Further, we found that knowledge about strategic and tactical plans was not embedded within the repository to the high degree that knowledge about business analysis, design and construction is. This is consistent with Stone (1992), who states:

> CASE is currently used mostly for analysis, design, and construction of information systems, and the role that CASE can play in information system planning is almost universally misunderstood, undervalued, and underused. Indeed most strategic information system planning is still conducted manually, without the aid of CASE, and the overwhelming majority of CASE-based application development projects still begin without the benefit of a tactical plan. [pg. 125]

Business analysis knowledge was found to be embedded to the largest degree within the CASE repository. This knowledge is key in producing models that provide a stronger basis for designing and implementing applications (Stone 1992); further, as discussed in the next sections, it is most significant in influencing the diffusion of CASE.

Consistent with the main hypothesis of our study, knowledge embeddedness was found have a significant association with the diffusion of CASE technology. Further, two components of knowledge embeddedness, strategic plan and design and construction, were found to be significantly related to diffusion. Despite being stored relatively sparsely in CASE repositories, strategic plan knowledge was found to be significant. This suggests that strategic plan knowledge is a powerful force in the diffusion of CASE across the population of projects. Strategic plan knowledge is unique in that it is valuable across projects, whereas other components of knowledge embeddedness mostly offer information about a specific project. Strategic plans provide descriptions of the organization that can be shared and become a public map across several projects.

Design and construction knowledge was the strongest component influencing diffusion of CASE. The extent to which design and construction knowledge is embedded within the repository changes the dynamics of the repository from a passive to an active repository. When low levels of design and construction knowledge exist in the repository, much of the information may have no direct relationship with physical code. At higher levels of knowledge embeddedness of design and construction code, the repository becomes active because it can be directly used in the generation of code. An active repository can be directly usable by any other application.

Our study also supports results of prior research relative to effects of organization size, project characteristics, and management support on the diffusion of CASE. Interestingly, we did not find any effects due to methodology support. On a closer examination, it appears that a richer set of dynamics may be in play with respect to methodology support. First, we discovered that nearly 48% of the organizations in our sample had changed their methodology during the implementation of CASE, reflecting the incompatibility of CASE with previously existing methods. Our operationalization of methodology support thus needs additional reconceptualization. Further, our measures may not have captured all the subtle aspects associated with methodology support. For example, Stone states

Table 2: Regression Results with Dimensions of Knowledge Embeddedness and Control Variables as Predictors

Dependent Variable: Diffusion of CASE across projects within an organization

Variable	Beta	t-statistic	Significance of t	ΔR^2	Significance of ΔR^2
Methodology support	.05	.59	.55	.008	.17
Management support	.30	3.39	.001**	.14	.000**
Organization size	-.12	-1.93	.05	.06	.001**
Knowledge links					
expertise acquisition	-.07	-1.06	.29	.007	.27
service acquisition	-.03	-.42	.67	.016	.09
CASE product	-.03	-.41	.68	.004	.43
CASE year adopted	.05	.75	.45	.015	.055
Project characteristics	-.14	-1.89	.06	.086	.000**
Dimensions of knowledge embeddedness					
Strategic plan	.14	2.24	.026*	.018	.028*
Tactical plan	.06	.89	.37	.003	.37
Business analysis	.12	1.62	.10	.007	.17
Design and construction	.22	3.17	.001**	.04	.001**

$R^2 = .41$, Adjusted R^2 - .36, $F_{12,146} = 9.05$, p = .000**

* $p < .05$
** $p < .01$

> Methodologies in use today are highly variable in how comprehensive and usable they are. Many address the entire applications development cycle, from enterprise-wide strategic planning through maintenance, although not all do. Methodologies also vary in the amount of guidance they provide to application developers, users, and management, as well as in the tools and techniques that they support. [(pg. 43]

Future research should incorporate some of these issues.

5.1 Limitations of the Study

The use of a single respondent to provide information about all key issues is one limitation of our research. In a large sample survey, particularly employing a purposive sampling strategy built around CASE user groups, we had limited access to multiple organizational respondents. Further, the key concerns with single respondents are potential for common methods variance and completeness of their knowledge about issues examined in the study. However, the use of CASE and database administrators in large companies and knowledgeable designers in small organizations provides assurance that the respondents were knowledgeable about the issues. Further, common methods variance would be a less troublesome issue in the context of objective phenomena, such as knowledge embeddedness and CASE diffusion.

The purposive sampling strategy may bias results toward users of specific CASE products examined in this study. However, we deemed it particularly important to control for the type of CASE products and to tap firms that had adopted CASE. A purposive sampling strategy was more appropriate in this instance. Future research could examine other CASE products to replicate our findings. On a related note, the sample was limited to integrated CASE products. Future research could replicate our findings with CASE tools that have been developed for client-server environments and distributed processing. Finally, while diffusion is an important construct in understanding CASE implementation, our research did not examine performance effects of knowledge embeddedness. This could be another topic of future research. Finally, we relied upon the information engineering paradigm for understanding and operationalizing the knowledge embeddedness construct. We acknowledge that a different paradigm, such as object-oriented, might yield a different set of elements for operationalizing knowledge embeddedness. However, at this stage, the dominant CASE products, particularly those used in this study were built around the information engineering paradigm. Therefore, this paradigm is appropriate for our study; future research could replicate the knowledge embeddedness construct within other paradigms of systems development.

5.2 Directions for Future Research

What do these study results imply about the value of CASE repository for knowledge management during systems development practice? The CASE repository can be viewed as a channel for sharing embedded knowledge horizontally and vertically within an organization; this, in turn, spreads the adoption of the technology. Strategic plan knowledge provides information useful *across* systems development projects. On the other hand, design and construction knowledge provides needed detail about specific development efforts *within* a project. The embedding of greater amounts of applications knowledge, particularly strategic plan and design and construction, within the repository enhances utility of the CASE technology across the population of applications development projects. Future research could longitudinally test the "critical mass" implications of our results: at what point does knowledge embeddedness influence the diffusion of CASE? What are the dynamics of the diffusion process beyond this threshold point? Another important research issue would be to examine if knowledge embeddedness also triggers greater levels of infusion within individual systems development projects. Cooper and Zmud (1990; also Kwon and Zmud 1987) identify infusion as another key element of the technology implementation phenomenon. For CASE, infusion could be viewed as the extent to which various CASE functionalities are utilized within individual projects (Henderson and Cooprider 1990). With a focus at the level of individual projects, researchers could examine if knowledge embeddedness increases the level of infusion. Our research raises many exciting research issues around the concept of the CASE repository.

6. REFERENCES

Attewell, P. "Technology Diffusion and Organizational Learning: The Case of Business Computing." *Organization Science*, Volume 3, Number 1, 1992, pp. 1-19.

Banker, R. D., and Kauffman, R. J. "Reuse and Productivity in Integrated Computer-Aided Software Engineering: An Empirical Study." *MIS Quarterly*, Volume 5, September 1991, pp. 375-401.

Belsley, D. A.; Kuh, E.; and Welsch, R. E. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*. New York: Wiley, 1980.

Card, D. N.; McGarry, F. E.; and Page, G. T. "Evaluating Software Engineering Technologies." *IEEE Transactions of Software Engineering*, Volume SE-13, Number 7, 1987, pp. 845-851.

Cooper, R. B., and Zmud, R. W. "Information Technology Implementation Research: a Technological Diffusion Approach." *Management Science*, Volume 36, Number 2, 1990, pp. 123-139.

Curtis, B.; Krasner, H.; and Iscoe. N. A Field Study of the Software Design Process for Large Systems." *Communications of the ACM*, Volume 31, 1987, pp. 1268-1287.

Dixon, R. L. *Winning with CASE: Managing Modern Software Development*. New York: McGraw- Hill, Inc., 1992.

Forte, G., and Norman, R. J. " CASE: A Self-Assessment by the Software Engineering Community." *Communications of the ACM*, Volume 35, April 1992, pp. 28-32.

Ginzberg, M. J. "Early Diagnosis of Mis Implementation Failure: Promising Results and Unanswered Questions." *Management Science*, Volume 27, 1981, pp. 459-478.

Hackathorn, R. D., and Karimi, J. "A Framework for Comparing Information Engineering Methods." *MIS Quarterly*, June 1988, pp. 203-220.

Henderson, J. C., and Cooprider, J. G. "Dimensions of IS Planning and Design Aids: a Functional Model of CASE Technology." *Information Systems Research*, Volume 1, Number 3, 1990, pp. 227-254.

Huber, G. P. "Organizational Learning: The Contributing Processes and Literatures." *Organization Science*, Volume 2, Number 1, 1991, pp. 88-115.

IEF. *Technology Overview*. Texas Instruments Incorporated, 1992.

Kimberly, J .R., and Evanisko, M. J. "Organizational Innovation: The Influence of Individual, Organizational and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations." *Academy of Management Journal*, Volume 24, 1981, pp. 689-713.

Kochen, M., and Deutsch, K. W. *Decentralization Sketches Towards a Rational Theory*. Cambridge, Massachusetts: Gunn and Haen, 1980.

Kogut, B., and Zander, U. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." *Organization Science*, Volume 3, Number 3, 1992, pp. 383-397.

Kwon, T. H., and Zmud, R.W. "Unifying the Fragmented Models of Information Systems Implementation." In R. Boland and R. Hirschheim (Editors), *Critical Issues in Information Systems Research*. New York: John Wiley, 1987.

Lempp, P., and Lauber, R. "What Productivity Increases to Expect Form a CASE Environment: Results of a User Survey." *Productivity: Progress, Progress, Prospects, and Payoff,* *Proceedings of the Twenty-Seventh Annual Technical Symposium.* Gaithersburg, Maryland, 1988, pp. 13-19.

Leonard-Barton, D. "Implementation as Mutual Adaptation of Technology and Organization." *Research Policy,* Volume 7, Number 5, 1988, pp. 251-267.

Leonard-Barton, D., and Deschamps, I. "Managerial Influence in the Implementation of New Technology." *Management Science,* Volume 34, 1988, pp. 1252-1265.

Markus, L. M. "Toward a 'Critical Mass' Theory of Interactive Media: Universal Access, Interdependence and Diffusion." *Communications Research,* Volume 14, 1987, p. 491-511.

Martin, J. , *Information Engineering, Book I: Introduction.* Englewood Cliffs, New Jersey: Prentice Hall, 1990a.

Martin, J. *Information Engineering, Book II: Analysis and Design.* Englewood Cliffs, New Jersey: Prentice Hall, NJ, 1990b.

Martin, J. *Information Engineering, Book III: Design and Construction.* Englewood Cliffs, New Jersey: Prentice Hall, 1990c.

McClure, C. *CASE is Software Automation.* Englewood Cliffs, New Jersey: Prentice-Hall, 1989.

Moore, G. C., and Benbasat, I. "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation." *Information Systems Research,* Volume 2, Number 3, 1991, pp. 192-222.

Necco, C. R.; Gordon, C. L.; and Tsai, N. W. " Systems Analysis and Design: Current Practices." *MIS Quarterly,* 1987, pp. 461-475.

Norman, R.; Butler, G.; and McElroy, D. "CASE Technology Transfer: A Case Study of Unsuccessful Change." *Journal of Systems Management,* Volume 40, Number 5,1989, pp. 33-37.

Orlikowski, W. "CASE Tools as Organizational Change: Investigating Incremental and Radical Changes in Systems Development." *MIS Quarterly,* Volume 17, Number 3, 1993, pp. 309-340.

Pennings, J. M., and Harianto, F. "The Diffusion of Technological Innovation in the Commercial Banking Industry." *Strategic Management Journal,* Volume 13, 1992a, pp. 29-46.

Pennings, J. M.; and Harianto, F. " Technological Networking and Innovation Implementation." *Organization Science,* Volume 3, 1992b pp. 356-382.

Pinto, J., and Slevin, D. "Critical Factors in Successful Project Implementation." *IEEE Transactions on Engineering Management,* Volume 34, Number 1, 1987, pp. 22-27.

Rogers, E. M. "The 'Critical Mass' in the Diffusion of Interactive Technologiės in Organizations." In K. L. Kraemer, (Editor), *Information Systems Research Challenge: Survey Research Methods,* 1991, pp. 245-264.

Rogers, E. M. *Diffusion of Innovations,* Third Edition. New York: The Free Press, 1983.

Slevin, D. P., and Pinto, J. K. "Balancing Strategy and Tactics in Project Implementation." *Sloan Management Review,* 1987, pp. 33-41.

Stone, J. A. *Inside ADW and IEF: The Promise and Reality of CASE.* New York: McGraw-Hill, 1992.

Tannenbaum, A. *Implementing a Corporate Repository: The Models Meet Reality.* New York: Wiley, 1994.

Tornatzky, L. G., and Fleischer, M. "The Deployment of Technology." In L. G. Tornatzky and M. Fleischer (Editors), *The Processes of Technological Innovation.* Lexington, Massachusetts: Lexington Books, 1990.

Tornatzky, L. G., and Klein, K. "Innovation Characteristics and Innovation Implementation: A Meta-Analysis of Findings." *IEEE Transactions of Engineering Management,* Volume 29, Number 1, 1982, pp. 28-45.

Vessey, I.; Jarvenpaa, S. L.; and Tractinsky, N. "Evaluation of Vendor Products: CASE Tools as Methodology Companions." *Communications of the ACM,* Volume 35, Number 4, 1992, pp. 90-105.

Walsh, J., and Ungson, G. R. "Organizational Memory." *Academy of Management,* Volume 16, Number 1, 1991, pp. 57-90.

Walz, D. B.; Elam, J. J.; and Curtis, B. "Inside a Software Design Team: A Look at Knowledge Acquisition, Sharing, and Integration Activities." *Communications of the ACM,* 1993, pp. 1224-1237.

Yourdon , E. *Decline and Fall of the American Programmer.* Englewood Cliffs, New Jersey: Yourdon Press, 1992.

7. ENDNOTES

1. Given the limitations of space, the items and scale reliabilities are not reported here. Copies of the instruments and the reports on reliabilities can be obtained from the first author on request.

2. Analysis was repeated using an oblique rotation method; the resulting factor structures were similar. Details are available upon request from the first author.