# Technology Acceptance and Performance: An Investigation into Requisite Knowledge

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*Organizations expend large amounts of educational and training resources to improve employee task and job performance. These resources must be allocated efficiently and effectively to increase the probability of organizational success. Information technology (IT) is one organizational area in which education and training are particularly important, largely because IT has redefined the requisite skills for functional competency in the workplace. Through an empirical study, this research investigates how knowledge bases contribute to subjects' attitudes and performance in the use of a CASE tool in database design. The study identified requisite knowledge bases and knowledge base interactions that significantly impacted subjects' attitudes and performance. Based upon these findings, alternatives are provided to management that may help organizations increase the performance benefits of technology use and promote more positive attitudes towards technology innovation acceptance and adoption. By structuring education and training efforts to increase performance and enhance positive attitudes, organizations will be better able to optimize their investments in information technology innovations.*

Improving human performance in organizational tasks remains a primary goal for modern organizations to increase competitiveness. Goldstein [1993] estimated that organizations invest close to $40 billion in training per year. Within the Fortune 500 companies, 44% of their training investment relates to technical training [Goldstein, 1993]. Organizations expend tremendous resources to improve employee task and job performance. Education and training are principal tools used to improve human performance and promote better decision-making. In fact, many scholars argue that education and training are the main issues that need to be studied to understand human decision-making and problem-solving behavior. Indeed, Rouse and Morris [1986] observed:

> To the extent that it is reasonable to characterize any single issue as the central issue, this issue is instruction and teaching. For any particular task, job, or profession, what mental models should people have and how should they be imparted? (p. 357)

This statement suggests two significant implications for organizational success. The first implication acknowledges that individuals must have relevant knowledge bases to perform a work-related task or job competently. The second implication addresses the problem of how to identify these knowledge bases so that organizations can facilitate the necessary knowledge transfer. An individual's knowledge base refers to the mental model or structural representation stored in long-term memory about a specific domain or process. Many of the activities surrounding the completion of a job or task are influenced by the individual's relevant mental models or knowledge bases related to that domain or process [Goldstein, 1993; Shaft and Vessey, 1995; Perrig and Kintech, 1985].

Information technology (IT) is one organizational area in which education and training are particularly important, largely because IT has redefined the requisite skills for functional competency in the workplace [Goldstein, 1993; Zuboff, 1985]. In many cases, knowledge of how to complete the relevant task - task-domain knowledge - is essential, but not sufficient, for an individual to perform well in the workplace. Frequently, the individual must also possess competencies in the use of IT to be successful in modern work environments. It is anticipated that the changes in job competencies resulting from technology shifts (e.g., computer-assisted software

Manuscript originally submitted October 5, 1995; Revised April 18, 1996; September 20, 1999; Accepted October 28, 1999 for publication.

engineering (CASE)) will increase the cognitive complexity for the worker [Goldstein, 1993]. Therefore, in addition to task-domain knowledge, modern workers might also benefit from knowledge bases associated with the use of IT. This study investigates technology acceptance and adoption by examining how an individual's knowledge of a tool, in combination with his task domain knowledge, influences attitudes and performance related to the use of an IT innovation.

Dramatic improvements in IT price-performance ratios have contributed to the enormous impact of IT on organizational success. One aspect of this impact is end-user computing, a phenomenon that is reshaping the way organizational tasks are performed. Most organizations have implemented personal computers (PCs) and expect their managerial and professional staffs to become proficient end users with this new technology. The potential impact of IT, such as CASE, is increasing as organizations become more information intensive and more end users adopt the automated tools. Cheney, et al. [1986], Davis and Bostrom, [1993], Cronan and Douglas [1990], and Sein [1988] indicated that training end users to properly use technology tools to construct their own systems is a critical factor in the successful deployment of IT. This expectation of technology proficiency requires many individuals to rethink their current practices and to learn new methods of task accomplishment [Ryan, 1999]. The acquisition of technology proficiency, of course, can be facilitated through education and training. The rapid pace with which organizations are implementing new IT and the tremendous growth of end-user computing are causing an increasing need for subsequent education and training on IT [Goldstein, 1993]. Sein, [1988], and Bostrom, Olfman and Sein [1988] have noted the importance of a systematic training program to promote successful end-user computing with respect to systems development.

However, there has been very little, if any, study into what should be the focus of this education and training, especially in the use of IT tools that automate substantial portions of work processes like computer-assisted software engineering (CASE), computer-aided design (CAD), computer-assisted instruction (CAI), and expert systems (ES). With IT tools such as these, much of the knowledge about the job requirements (e.g., software engineering in CASE) are embedded in the technology itself. As noted by Goldstein [1993] and Howell and Cooke [1989], increases in technology and machine responsibility may result in increased cognitive demands on people. In such cases, the question becomes "What knowledge is needed by the user to accomplish his or her task while utilizing a process-automating tool like CASE, CAD, CAI, or ES?" Is task-domain knowledge necessary, and if so, what level of proficiency is sufficient? Or is knowledge associated with the systems model and operational procedures of the automated tool required for user satisfaction and enhanced performance? Galliers and Swan [1997] propose that effective IS design must integrate both formal and informal knowledge to promote project success. Goldstein [1993] stated that a systematic instructional program must include training needs assessment based on the related knowledge, skills, and abilities necessary to perform the task.

The purpose of this exploratory study is to identify requisite knowledge bases and skills that contribute to positive attitudes and improved performance when using an automated IT tool, CASE, to accomplish an organizational task. CASE is a broad group of software technologies that together support the automation of information systems (IS) development and can reduce the programming backlog that has long plagued corporate IS [Loh and Nelson, 1989]. The potential impact of CASE is increasing as organizations become more information intensive and the use of CASE technologies becomes more pervasive throughout the organization. Identifying and understanding how knowledge bases support individuals' IT use will allow organizations to focus educational and training resources more effectively to enhance technology acceptance and adoption [Zmud and Lind, 1985; Hartog and Herbert, 1986; Decker et al., 1984]. Specifically, the research question addressed is: How do particular knowledge bases and skills of users contribute to their attitude and performance in the use of a CASE tool in designing a database for a business application?

## THEORETICAL BACKGROUND

In considering the knowledge associated with the use of an automated IT tool like CASE, researchers have identified at least two distinct knowledge bases that are possible [Sein, 1988; Bostrom, et al., 1988; Pei and Reneau, 1990]. One is a conceptual model that constitutes much of the theoretical foundation underlying the use of the automated tool involved. This conceptual model is closely connected to the methodology embedded in the tool [Hackathorn and Karimi, 1988; Henderson and Cooprider, 1990]. In contrast, the step-by-step operating procedures related to the use of the IT tool constitute another possible knowledge base or skill-set for an individual [Goldstein, 1993]. Past research has provided evidence that, given a sufficiently complex task, knowledge of the tool's conceptual model facilitates superior learning compared to operational knowledge of the IT tool [Borgman, 1986; Eylon and Reif, 1984; Halasz and Moran, 1983]. In many cases, the conceptual model is hypothesized to provide an organizational structure for scheduling and controlling the operational procedures related to the tool.

In the Davis and Bostrom [1990] study, contextual knowledge was deemed essential for an individual to achieve meaningful learning. Davis and Bostrom [1990] found that interface designs that are more similar to the user's conceptual model were both easier to learn and more productive. Investigating training needs for end users, Davis and Bostrom found that the ability to acquire new knowledge was strongly influenced by previously established knowledge. They stated that technology-related cognitive demands that are anchored to pre-existing knowledge structures are more meaningful, reliable, and retrievable. In a related study, Gasson [1999] found that the form used to represent task domain knowledge was critical to system effectiveness. Knowledge representation in forms using terms with meanings more familiar to the user is proposed as a superior design methodology approach. Zigurs and Buckland [1998] develop a framework for investigating group support system effectiveness based in part on task/technology fit.

Shaft and Vessey [1995] investigated the role of application knowledge on computer program comprehension. They found that programmers more knowledgeable in the task domain used a top-down decomposition approach. Programmers who were less knowledgeable in the application domain showed a tendency to assemble their understanding of the program in a bottom-up fashion. The ability to use abstract representations (top-down) is theorized to be associated with a more complex task-domain knowledge base. In an investigation of information requirements determination, Vessey and Conger [1993] found performance improvements among novice analysts with higher levels of task domain knowledge. The tendency of individuals with higher levels of task domain knowledge to use a more abstract representation scheme suggests a more elaborately organized task view. Performance improvements of these individuals may be, in part, their ability to rely on a more elaborately organized task view.

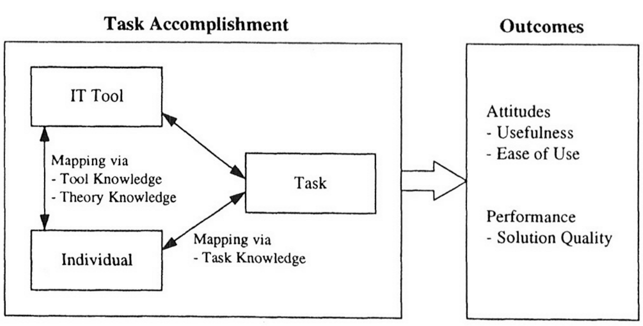
The importance of task knowledge as a critical component of IT learning and task performance has recently been addressed in the literature. Pei and Reneau [1990] used production rule-based ESs to investigate the impact of memory structure on human problem-solving performance. They considered the users' mental models (i.e., their knowledge bases) of the IT and their task domain-specific knowledge together as essential components in understanding how IT contributes to decision performance and fosters individual learning. Pei and Reneau [1990] explicitly identified knowledge transfer (learning), such as in computer-based training (CBT) systems, as one example of how IT and users' mental models are both critical to understanding complex problem solving. In CBT applications, Pei and Reneau noted that the users' understanding of the ES's meta-knowledge is critical to knowledge transfer. Pei and Reneau [1990] investigated the consistency between the structure of the rule-based ES and the users' mental models of the task domain as a moderator of technology-facilitated learning. They acknowledged the pedagogical importance of the consistency between the cognitive aspects of the man-machine interface and prior training (i.e., knowledge base) in the application task domain.

From Pei and Reneau's [1990] study, it is evident that at least two types of knowledge bases, or as they referred to them, mental models, are associated with the use of IT in completing an organizational task. The first is task-domain knowledge, which is a combination of mental structures about the domain itself and the ability to devise problem-solving strategies for that domain [1990]. The second, which is directly associated with the use of IT, is the need to develop a mental representation of the automated system to be able to understand and control its behaviors [1990]. Hackathorn and Karimi [1988], Henderson and Cooprider [1990], and others have identified the importance of the conceptual model embedded in the tool as well as the operational characteristics associated with the tool. Davis and Bostrom [1993] found that, in sufficiently complex tasks, reference contextual knowledge supports higher levels of performance. Thus, the most effective cognitive process in using automated IT tools is most likely to be the combination of task-domain knowledge along with the conceptual and operational knowledge associated with the utilization of the computer technology.

Bostrom, et al. [1988] established an IS research framework that has been used to investigate constructs such as learning theory, conceptual models, mental models, interface effectiveness and teaching methods as they relate to technology attitudes and performance [Davis and Bostrom, 1993; Sein, 1988]. In this investigation, the Bostrom, et al. [1988] model provides a foundation for studying the impact of particular knowledge bases and skills on the use of a target system during task accomplishment. The discussion identified at least three relevant knowledge bases germane to the use of an automated IT tool like CASE: (1) knowledge about the task, or *task-domain knowledge*; (2) conceptual knowledge about the theory behind the methodology of the tool, or IT theory knowledge; and (3) knowledge about the procedural steps taken in the use of the tool, or *IT tool knowledge*. This study investigates these three knowledge bases to determine if knowledge levels are related to positive attitudes and increased performance during task accomplishment. The following figure presents the research model.

The attitudinal constructs of perceived usefulness and perceived ease of use utilized in this experiment have been associated with IT innovation acceptance and adoption [Davis, Bagozzi, and Warshaw, 1989]. Davis, Bagozzi, and Warshaw [1989, p. 985] defined perceived usefulness as "the prospective user's subjective probability that using a specific appli-

*Figure 1. Research Model*



cation system will increase his or her task performance within an organizational context." They also defined perceived ease of use as "the degree to which the prospective user expects the target system to be free of effort" [1989, p. 985]. Davis, Bagozzi, and Warshaw found that these two constructs affect the acceptance and use of IT. Both perceived usefulness and ease of use were found to be significant factors in people's intent to use computer applications. Their findings were in agreement with those of previous researchers [Barrett, Thornton, and Cabe, 1968; Schultz and Slevin, 1975; Malone, 1981]. In fact, Davis, Bagozzi, and Warshaw [1989] argued persuasively that many computer satisfaction variables are closely related to the perceived usefulness and perceived ease of use constructs.

The performance variables in this study are measures that are directly associated with the task at hand, that of the logical specification of a database design. The task involved the development of a conceptual schema of a database for a particular application domain. Three of the more important steps in the development of a conceptual schema are: (1) the determination of the primary key or identifier for each entity; (2) the specification of the relevant attributes for each entity; and (3) the specification of the relationship or association between two or more entities [Ahrens and Sankar, 1993].

A primary key, or identifier as it is referred to in this article, is an attribute of an entity by which the entity can be uniquely referenced or identified. For example, a student's social security number often serves as the identifier for the student entity in a university database. Attributes are other named properties or characteristics that sufficiently describe an entity. For example, attributes of a student entity other than social security number might be name, address, GPA, and classification. The values of these attributes may or may not be unique among the students in the database. An association is a relationship between two entities in a database. Using a university database as an example, there is a many-to-many association between the student entity and the class entity. A student may have zero, one, or more classes and a class may have zero, one, or more students.

The IT tool in the experiment is a CASE tool designed to be used by both end users and IS professionals [Dewitz and Olson, 1994a, 1994b]. Expertise related to design methodology and CASE technology have been projected as two of the most critical skills to be possessed by IS personnel in the future [Leitheiser, 1992]. The use of a CASE tool seems especially appropriate for this study because past research supports the notion, as previously discussed, that users may employ the three knowledge bases (task-domain, theory, and tool) when using CASE. Henderson and Cooprider [1990] began their development of a functional model of CASE technology for IS planning and design by citing the importance of technology being functionally oriented. Hackathorn and Karimi [1988], Welke and Konsynski [1980], and Henderson and Cooprider [1990] considered the delineation of methodology and technology tools as paramount to measuring the functionality of design-aid technology. In their view, methodology provides the logical disciplines or *theory* underlying IS design, and technology tools support the *usage behaviors or procedures* performed during application development. Sprague and McNurlin [1993] reported that the organizational benefits and user acceptance of CASE are dependent upon the integration of the methodology and technology, that is, upon the theory and procedures.

Baldwin [1993] criticized current CASE tools for failing to include the user's mental model of the application task. Gasson identified the importance of a methodology that supports both a user's view and a technology view [1999]. Adelson and Soloway [1985] found that the designer's formulation of a mental model of the application and the mental simulation of that model is a critical component in the successful development of a computer application. A clearly defined mental model is reported to significantly impact the designer's ability to deal with the application at different levels of abstraction. In addition to methodology (theory knowledge) and technology (tool knowledge), Vessey and Conger [1993], Glass and Vessey [1992], Sein [1988], and Fichman and Kemerer [1993] have identified application (task-domain) knowledge as a critical component of successful CASE tool deployment.

Based on the cited research and the above discussion, this study employs a laboratory experiment to examine task-domain, theory, and tool knowledge as determinants of attitudes and performance when using one type of automated IT, a CASE tool. This investigation into determinants of CASE attitudes and performance is justified, in part, by the potential contribution of CASE technology to IS and organizational success [Cheney, et al., 1986; Zmud and Lind, 1985], and the current lack of sufficient theory to guide management in decisions concerning resource allocations to promote greater CASE acceptance and adoption [Goldstein, 1993].

## RESEARCH METHODOLOGY

The study utilized a laboratory experiment to address the research objectives. Subjects provided demographics via a questionnaire before receiving a training lecture on a database design CASE tool (Salsa). The Salsa CASE tool, based on semantic data modeling principles [Hammer and McLeod, 1981; Kroenke, 1994], is being developed by a commercial software company with the intention of supporting IS professionals and end users. Semantic data models were developed with the goal to facilitate "the database designer to naturally and directly incorporate more of the semantics of the database into the schema" and provide the database designer and intended user a "natural application modeling mechanism to capture and express the structure of the application environment in the structure of the database" [Hammer and McLeod, 1981, p. 352]. Two of the more prominent semantic models are Chen's entity relationship (ER) and Kroenke's semantic object (SO) [Bock and Ryan, 1993]. The semantic object modeling method used in this research consists of identifying: 1) logical objects relevant to the users; 2) attributes that sufficiently describe the logical objects; and 3) associations between objects [Kroenke, 1994]. For greater depth of information on the semantic data modeling CASE tool used in this study, see Dewitz and Olson [1994a, 1994b].

### Hypotheses

Each hypothesis was analyzed first for interaction effects; in the absence of significant interaction effects, an analysis of main effects was performed. Although the research is exploratory in nature, main effects for tool, task and theory knowledge were all hypothesized *a priori* to be positive, in the absence of interaction effects. In essence, an increase in either tool, task, or theory knowledge was anticipated to have a positive effect on attitudes and performance. In the presence of interaction effects, there were no *a priori* research hypotheses. Therefore, attitudes and performance (dependent variables) were hypothesized to be, in part, a consequence of the positive effects of an individual's knowledge bases (independent variables).

### Experimental Procedures

The experiment was held in a dedicated instructional computer laboratory. Participants provided demographic data via a questionnaire at the beginning of the experimental session. After a sufficient time for completion of the demographic questionnaire, the subjects participated in a training session on the CASE tool. The length of the training session was approximately one hour. The training session included material on the theory of the design methodology, the application of the design methodology (CASE tool), an example case using the design methodology, and a short tutorial addressing the database CASE tool used in this study.

Each participant was provided a hardcopy of the case scenario specifying the database design requirements. The subjects were provided ample space to make notes as they used the CASE tool to design their interpretation of the information requirements. During the experiment, subjects were not allowed to consult with each other nor were they able to seek the assistance of the researchers present in the laboratory. Each subject's database design was stored on the computer and was not available to other participants. As a subject completed the database design task, the researcher provided a questionnaire for collecting attitudes regarding database design, the CASE tool, and the design methodology used in the study. In addition, this section of the questionnaire assessed each subject's knowledge of the task domain, IS theory, and CASE tool. The total time required to attend the training lecture, complete the database design task, and provide the personal data was approximately 2 hours. During the course of the experiment no subjects withdrew from the study.

*Table 1: Theoretical Model of Research Variables*

| Research Variable | Research Variable Surrogate | Variable Type |
|---|---|---|
| Task Knowledge | Application Task Comprehension | Independent |
| Technology Knowledge | IT Tool Competency | Independent |
| Theory Knowledge | IT Theory Knowledge | Independent |
| Attitudes Related to IT | Attitudes of Perceived Usefulness and Ease of Use when Using a CASE Tool | Dependent |
| Performance Related to IT | Performance on Database Design when Using a CASE Tool | Dependent |

### Subjects

The experimental subjects were graduate and undergraduate business students at a major university. Participation in the study was voluntary with incentives of class credit offered to the subjects to increase their motivation. The graduate students were MIS and MBA students enrolled in an MIS course involving end-user computing. The undergraduates were MIS students with varying levels of formal IS education. The research design qualifies as a convenience sample implying limitations on generalizability beyond the present study. It was anticipated that the subject pool represented a wide variety of IS skill sets. Based on the current research objectives, it was appropriate that these differences exist.

### Variable Measurement

The laboratory experiment had three independent variables representing theory, tool, and task knowledge, and two classes of dependent variables, attitudes and performance (see Table 1). The independent variables represent knowledge deemed germane to using a CASE tool to perform database design. Attitudes represent a subject's attitudes and beliefs regarding technology usefulness and ease of use. Performance represents the subject's ability to satisfy the information requirements of the design task scenario with an appropriate logical database model.

The independent variables represent the subject's mental model of database design using a CASE tool to perform a database design task. The independent variables measure knowledge of database *theory* as a contributor to performance, CASE *tool* competency required to perform the task, and *task* recall as a surrogate of task-domain knowledge. The knowledge bases were measured through a series of questions. Theory knowledge was measured by the use of nine multiple-choice questions that had been used on examinations in past database classes. Therefore, these questions had been qualified before being used in this study as appropriate items for assessing theory knowledge of database design. The theory questions included topics such as data integrity, domain constraints, and functional dependencies.

Tool knowledge was also measured with nine multiple-choice questions on the operations of the Salsa database design product, the CASE tool used in the experiment. The tool questions addressed the functional competencies required to utilize the CASE product. Tool knowledge questions included operational issues such as system actions required for achieving a specific objective, CASE system function identification (e.g., model validation and attribute grouping), and definitional terms used to express the formalisms inherent in the CASE system.

Task knowledge was assessed by measuring task recall through a series of questions. In task knowledge assessment, subjects were provided with several questions regarding specific facts presented in the database design scenario and were required to identify the correct answer to the question or whether the content of the question was beyond the scope of the scenario. Other task questions required the subject to use free memory recall in identifying specific elements presented in the task. There were a total of nine questions measuring task knowledge.

A subject's scores over the three assessed knowledge bases had a possible range from zero to nine each. These scores correspond with the number of questions that a subject answered correctly on the respective set of questions. For example, if a subject answered no questions correctly in responding to the assessment of theory knowledge, his or her score was a zero for theory knowledge. If someone answered five questions correctly on the tool knowledge set of questions, his or her score on tool knowledge was five, and so on.

Procedures performed to assure the psychometric qualities of the knowledge assessment component of the instrument (theory, tool, and task knowledge) included evaluations by a panel of MIS researchers and a comparable subject pool of students. Items not acceptable to the expert panel were eliminated, while items were added to adequately represent any constructs identified as lacking in items. The measure of the understandability of the items was assessed using a comparable subject pool. In this manner, evaluating each item on the instrument for clarity and understandability contributed to the validity of the knowledge assessment items. Using ANOVA procedures, items that the comparison group did not consider understandable (i.e., neutral, unclear, or very unclear as opposed to being considered as clear or very clear) with a significance level less than or equal to .039 were eliminated from the instrument.

The attitude measures of usefulness and ease of use were each measured with a set of five-point Likert questions. Appendix A gives the questions that were used to measure each one of the constructs. These questions were adopted from the study by Davis, Bagozzi, and Warshaw [1989] with very small modifications (i.e., each of these items was modified to make reference to the specific Salsa CASE tool used by the subjects in the experiment). The Cronbach alphas for the usefulness and ease of use constructs were .935 and .901, respectively.

Performance was operationalized as identifier, attribute, and association specification on the logical level as opposed to the physical level that references the data definition within the database dictionary. The identifier assessed the ability of a subject to specify a logical object and an identifier appropriate for referencing the object. Attribute specification included the attribute by name and its cardinality constraints. The association metric represents the subject's ability to identify relationships between logical objects and specify the necessary cardinality constraints.

Subjects' performance on the database design task was graded on completion. Essentially, task performance represents the designer's achievement of a database schema design free of certain classes of anomalies. A subject's performance was computed for the individual task facets of specifying object identifiers, attributes, and associations. Solution correctness included degree on all task facets (i.e., minimum and maximum cardinality), and appropriate connectivity for the association facet.

The objective grading scheme was designed to provide maximum consistency of scoring. The scheme, as developed in previous research [Batra, Hoffer, and Bostrom, 1990; Bock and Ryan, 1993], classifies errors as fatal, major, medium, and minor for multiple task facets. The grade on a facet ranged from 0 to 4 points, 0 being the lowest grade, or a fatal error and 4 being the highest, or no error. Grades on facets with medium or minor faults were given scores of 2 and 3, respectively. As examples, the omission of an association was scored as a fatal fault resulting in zero points, the incorrect connectivity between objects would be scored as a medium error for 2 points, and the incorrect specification of the minimum cardinality of an association would be classified as a minor error for 3 earned points. Since there was a recommended solution containing six objects (and therefore six identifiers), the highest score on performance for the identifier component was 24 (4 times 6). The total number of attributes in the recommended solution was 19, resulting in a total score of 76. Lastly, the total number of associations in the recommended solution was 30 (including minimum and maximum cardinalities) which leads to a high end score of 120.

The task facets were based on the specific methodology used by the CASE tool [see Dewitz and Olson, 1994a, 1994b; Kroenke, 1994]. A subject's database design task performance quality was assessed by a trained database researcher and was checked for reliability by consensus agreement between one of the authors and the grader on randomly selected cases. The assessments by the author and grader were the same in almost all cases. Jarvenpaa and Ives [1990] previously used this approach as a means of assuring inter-rater reliability. In comparison to the Jarvenpaa and Ives [1990] study, which was less structured in that the grading was content assessment, the present study is more systematically objective and subject to fewer validity threats. Extending beyond the sampling procedures as described, the researchers used a double-blind grading system, which resulted in a minimum 97% agreement between graders.

### Task

Subjects were asked to provide a database design suitable to satisfy the information requirements of the presented task scenario. The experimental task had been used in previous research studies investigating database design. The task contained a narrative description and several example reports representing an engineering firm's need to manage project-engineer assignments. Additionally, the task requirements addressed aspects such as firm suppliers and engineer skill certification. The database design task (see Appendix B), although artificial in nature, was deemed a realistic surrogate for practicing database designers based on its use in previous research studies and the specific adaptations made for this study [Batra, Hoffer, and Bostrom, 1990; Bock and Ryan, 1993]. The dynamics of the task content provided a variety of challenges to the participants and included advanced concepts such as supertype-subtype relationships and referential integrity constraints. Prior to the experiment, none of the subjects had been exposed to the database design task. A recommended solution to the database design task was agreed upon by several database researchers prior to the experimental sessions and included the constructs of identifier, attribute, and association specification.

## FINDINGS

### Data Analysis

Of the 99 participants in the experiment, 53 percent of the subjects had more than one year of business-related job experience. Forty-four percent of the participants reported 1-4 years of previous computer use and 56 percent reported more than four years of computer use experience. Twenty percent of the participants classified themselves as graduate students. Based on Rainer and Harrison's [1993] classification scheme for end users, 26 of the subjects classified themselves as novice users (category 1), 51 classified themselves as moderately sophisticated end-users (categories 2 and 3), and 20 of the subjects reported being highly sophisticated end-users (categories 4 and 5). There were four unusable responses with incomplete questionnaires not included in the analysis, resulting in 95 complete and usable responses.

The study used a series of multiple regression analyses to examine the relationships between the independent variables (tool, task, and theory knowledge bases) and the dependent variables related to attitudes and performance. The multiple regression analysis for each dependent variable was hierarchical, with main effects being introduced first and the marginal contribution of interaction effects examined second. There was no evidence of serious multicollinearity among the main effects. Further, deviation transformations [Neter, Wassermann, and Kutner, 1990, pp. 315-329] of the independent variables reduced any multicollinearity induced by interaction and other higher-order terms. Residual analysis did not reveal any significant departures from model assumptions for any of the models but, in the case of perceived usefulness, indicated a curvilinear component for tool knowledge.

### Attitudes

Table 2 summarizes the hierarchical development of the final multiple regression model for perceived usefulness and Table 3 contains the sample regression coefficients and their respective individual p-values. Note that in Table 3, the coefficients are in terms of the original independent variable values while the p-values correspond to the transformed variables, thus reducing the potential masking effect of multicollinearity introduced into the model by the higher-ordered terms. The final model includes all terms investigated in the hierarchical process because all smaller models were of diminished quality according to both the $C_p$ and adjusted $R^2$ criteria [Neter, Wassermann, and Kutner, 1990, pp. 446-450]. There is strong evidence of interaction effects among the three independent variables in their relationship with perceived usefulness.

As an aid in understanding the nature of the interaction among the independent variables on perceived usefulness, Figure 2 contains an interaction plot similar to that proposed in Peters and Champoux [1979]. It appears from this figure that, on average, perceived usefulness increases with tool knowledge for individuals with a match between task and theory knowledge (either having *both* low task and low theory knowledge (Curve A) or *both* high task and high theory knowledge (Curve B)). In considering these two groups, those with high task and high theory knowledge (Curve B) evidence higher average perceptions of usefulness than those with low task and low theory knowledge (Curve A).

When there is a mismatch between task and theory knowledge, however, it cannot be said that tool knowledge has a

*Table 2: Hierarchical Analysis for Dependent Variable Usefulness*

| Level | Variables | Marginal p-value | Overall $R^2$ | Overall p-value |
|---|---|---|---|---|
| I | Tool | | | |
| | Task | | | |
| | Theory | 0.00001 | 0.2403 | 0.00001 |
| II | Tool*Task | | | |
| | Tool*Theory | | | |
| | Task*Theory | | | |
| | Tool*Task*Theory | 0.5436 | 0.2654 | 0.0002 |
| III | $Tool^2$ | 0.0160 | 0.3115 | 0.00003 |
| IV | $Tool^2$*Task | | | |
| | $Tool^2$*Theory | | | |
| | $Tool^2$*Task*Theory | 0.00012 | 0.4570 | < 0.00001 |

*Table 3: Regression Results for Usefulness*

$R^2$ = .4570    Adjusted $R^2$ = .3883    Overall p-value < .00001

| Independent Variable | Sample Coefficient | Two-tailed p-value |
|---|---|---|
| Tool | -3.050 | 0.3843 |
| Task | -2.476 | 0.1248 |
| Theory | -0.822 | 0.2049 |
| Tool*Task | 1.233 | 0.9539 |
| Tool*Theory | 0.536 | 0.4438 |
| Task*Theory | 0.393 | 0.0039*** |
| Tool*Task*Theory | -0.204 | 0.0459** |
| $Tool^2$ | 0.363 | 0.0084*** |
| $Tool^2$*Task | -0.136 | 0.0347** |
| $Tool^2$*Theory | -0.065 | 0.0074*** |
| $Tool^2$*Task*Theory | 0.023 | 0.0014*** |

Legend: *** = p-value < .01, ** = p-value < .05

positive effect on perceived usefulness. For the group with low task coupled with high theory knowledge (Curve C), average perceived usefulness is high at low levels of tool knowledge but does not appear to improve as tool knowledge increases. On the other hand, for the group with high task and low theory knowledge (Curve D), perceived usefulness appears to increase with tool knowledge to a maximum point and then diminishes beyond that.

Table 4 contains regression results from the main effects model for ease of use. Regression analysis for ease of use produced no evidence of significant interaction. Consistent with the preliminary hypotheses, all sample regression coefficient signs are positive. Further, task and theory each have a significant positive main effect on ease of use.

### Performance

*Figure 2. Interaction Plot for Perceived Usefulness*

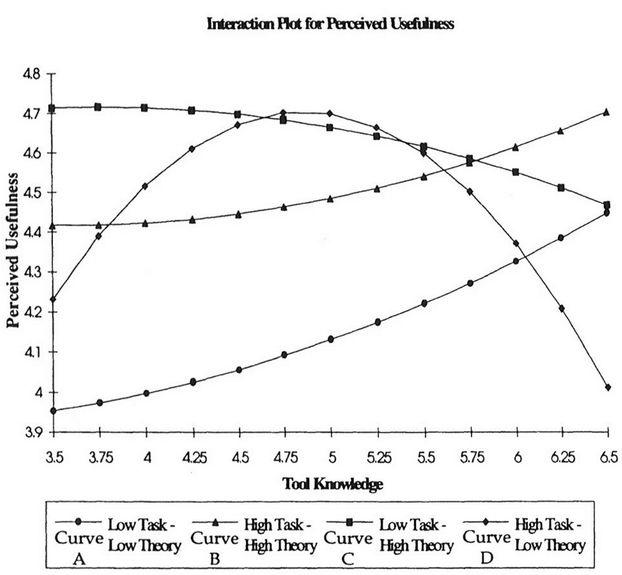



Table 5 summarizes the main effects of the regression results for all three performance variables: identifier, attribute and association performance. There were no significant interaction effects in any of these models. In each case, all sample coefficients are positive, and theory has a significant positive main effect. It is interesting to note that in these models which incorporate main effects of tool, task and theory knowledge, theory emerges as consistently significant across all performance facets (identifier, attribute, and association). Also, while not statistically significant, a marginal positive effect of task knowledge is evidenced across the performance metrics. With respect to identifier specification, tool knowledge was marginally significant.

## DISCUSSION

Users' perception of technology as useful is based on the interacting combination of tool, task, and theory knowledge. Davis, Bagozzi, and Warshaw [1989] identified usefulness as the primary indicator of the acceptance and adoption of technology by individuals, so the findings on this construct are especially important.

As a research construct, perceived usefulness was designed to assess a variety of extrinsic motivators closely related to task performance [Davis, Bogozzi, and Warsaw, 1992]. Finding knowledge interaction for usefulness is congruent with the original premise that perceived job performance is a consequence of multiple extrinsic factors and is therefore a complex phenomenon. Usefulness, as a construct, requires that an individual have the appropriate level of theory to formulate the task solution strategy and the complementary competency to use the tool to execute the strategy. When there is a consistent fit between theory and task knowledge (i.e. both high or both low), increasing tool competency increases perceived usefulness. Individuals with strong knowledge profiles in this combination should have receptive attitudes toward the usefulness of a particular technology in accomplishing their tasks. When there is an inappropriate fit between theory and task knowledge (i.e., one knowledge base

*Table 4: Regression Results for Ease of Use*

$R^2$ = .1698    Adjusted $R^2$ = .1436    Overall p-value = .0005

| Independent Variable | Sample Coefficient | One-tailed P-value |
|---|---|---|
| Tool | 0.059 | 0.0980 |
| Task | 0.073 | 0.0164** |
| Theory | 0.071 | 0.0071*** |

Legend: *** = p-value < .01, ** = p-value < .05

*Table 5: Regression Results for Performance Variables*

**Identifier Performance: $R^2$ = .1181 Adjusted $R^2$ = .0891**
**Overall p-value = .0093**

| Independent Variable | Sample Coefficient | One-tailed p-value |
|---|---|---|
| Tool | 0.821 | 0.0664 |
| Task | 0.564 | 0.0720 |
| Theory | 0.575 | 0.0410** |

**Attribute Performance: $R^2$ = .1259 Adjusted $R^2$ = .0971**
**Overall p-value = .0064**

| Independent Variable | Sample Coefficient | One-tailed p-value |
|---|---|---|
| Tool | 1.423 | 0.1506 |
| Task | 1.278 | 0.0950 |
| Theory | 1.979 | 0.0094*** |

**Association Performance: $R^2$ = .1391 Adjusted $R^2$ = .1107**
**Overall p-value = .0033**

| Independent Variable | Sample Coefficient | One-tailed p-value |
|---|---|---|
| Tool | 2.391 | 0.1820 |
| Task | 2.559 | 0.0853 |
| Theory | 4.228 | 0.0045*** |

Legend: *** = p-value < .01, ** = p-value < .05

is high while the other knowledge base is low), increasing tool competency has a dysfunctional effect on perceived usefulness. Instances where the individual possesses high task knowledge without the matching level of theory knowledge are most susceptible to decreasing perceptions of usefulness. This decrease in perceived usefulness may be an indication that the individual lacks the knowledge to develop and apply an overall strategy to solve the robustly perceived task using the IT tool. Instances where the individual possesses high theory knowledge and low task knowledge also showed decreasing levels of perceived usefulness. Individuals in this class may not perceive the task as robust enough to require the IT support tool (i.e., these individuals may perceive themselves as capable of solving the task without the intervention of technology support).

When considering perceived usefulness as an indicator of innovation acceptance and adoption, organizations should strive to establish the appropriate knowledge fit. Organizations should focus their education and training efforts on creating the appropriate knowledge bases sufficient for individuals to perceive technologies as useful in their work. Recognizing the more complex nature of perceived usefulness, organizations must simultaneously consider both theory and task knowledge. Organizational education efforts, such as internal and external continuing education courses, professional educational requirements or certifications, and support for advanced degrees, could be targeted at increasing IT theory knowledge bases. Training efforts such as seminars, hands-on tutorials, and the utilization of information centers could be aimed at increasing tool competencies and task comprehension.

Increasing an individual's task and theory knowledge, on average, increases perceived ease of use. Individuals with high task and/or theory knowledge have the ability to employ the technology with perceived ease of use. In Vessey and Galleta, [1991] and Perrig and Kintech, [1985] problem-solvers are hypothesized to induce their mental models based on the task and/or the problem representation. In these findings, users with sufficient task and/or theory knowledge were able to operate the tool without expending great effort. When compared to usefulness, there is a more simple relationship between ease of use and the supporting knowledge bases. Organizational efforts that focus on either of these knowledge bases can be applied to enhance perceived ease of use. Rotating job responsibilities, work groups or teams, employee empowerment, and increased education and training on the task will contribute to increased task knowledge. Organizations may choose the alternative of heightening task knowledge as a basis for creating higher levels of perceived ease of use of IT in instances where there are obstacles to education and training efforts for IT theory.

It is prudent, however, to note that some amount of training in the technology is still a requisite for perceived ease of use. With reference to the specific CASE tool used in this study, this training would be minimal because the semantics of the task are embedded in the semantic data model. Perceived ease of use as a function of task knowledge may be an indication of the transparency of the tool. That is, the effort to employ the tool is minimal for individuals who are more knowledgeable in the task domain. Tool transparency, such as this, suggests that the technology has effectively simplified the man-machine interface such that the cognitive effort may be associated with the task requirements alone. In essence, the tool provides a feeling of naturalness or intuitiveness for individuals well versed in the task domain. Theory knowledge as it supports ease of use suggests that individuals who understand the systems model of the tool may have a greater ability to use the tool without significant effort. Technology innovations where perceived ease of use is associated with task-domain and theory knowledge may require less training than other technology-based tools demanding more tool-specific knowledge for ease of use. In these instances, technology transparency lessens the educational and training effort focusing on tool operations.

Users' performance is significantly improved by increasing theory knowledge. The ability of an individual to specify the identifier facet of database design is positively related to theory knowledge. Attribute and association facets are also supported by similar knowledge profile requirements. The data suggest that individuals with higher theory knowledge perform better on these facets. The CASE tool in this instance may be more intuitive and feel more natural to individuals with sufficient theory knowledge. As a research construct, theory knowledge represents the individual's understanding of the technology's underlying systems model. This is in agreement with findings where performance advantages are associated with the ability to use abstract representation schemes. In these findings there is evidence that increasing theoretical knowledge bases improves the average performance of individuals with a given level of tool and task knowledge. Without evidence of interaction effects or multiple main effects on performance, there is less support for simultaneous training in knowledge bases beyond theory. Again, pragmatically it is necessary that individuals have some level of knowledge in tool and task domains to support adequate performance.

In general, based on these findings, organizations may want to focus their educational and training programs to be more effective by making sure that IT theory knowledge is included in any educational and training program. When considering acceptance and adoption attitudes, organizations should recognize that perceived usefulness requires an appropriate fit between knowledge bases, including IT theory knowledge. Although with perceived ease of use and performance the mix of knowledge bases are not as clear, it is clear that IT theory knowledge should be part of that mix. With these findings, organizations can set attitudinal and performance objectives and design their education and training programs accordingly. Individuals who are well versed in IT theory (knowledge of database in this study), on average, can be expected to perform better on facets related to CASE tool usage and, probably, similar automated IT tools. In fact, this finding implies that knowledge of the procedural operations of CASE or other automated IT innovations may not be sufficient to heighten performance. Based on the findings in this study, users of automated IT innovations (e.g., CASE, CAD, CAI, ES) may develop more positive attitudes and experience performance benefits from knowledge in the methodology and theory embedded in these tools.

## CONCLUSION

Individual learning is critical for organizational success. Consequently, organizations must invest in efficient and effective education and training methods for their employees to facilitate the learning process and increase organizational chances for success. These methods should not only present the opportunity for employees to gain new knowledge, but should leverage their current knowledge. If organizational education and training methods are sound, individual learning will result in improved attitudes and competencies.

The alternatives presented in this study should enable organizations to assess new information technologies more accurately. In addition, organizations should be able to more effectively focus on knowledge that promotes positive attitudes and higher levels of technology competencies. The improved attitudes will result in increased acceptance and adoption of new technologies and the enhanced competencies will result in improved performance.

One of the most critical findings in this study was the emergence of the importance of IT theory knowledge in the use of the CASE tool. Casual observations of the educational and training practices of most companies give the impression that they are mainly concerned with imparting knowledge about the work task and knowledge about procedural aspects of IT tools. Rarely, it seems that education and training in companies concentrate on cultivating the IT theory knowledge of workers. The trend toward embedding many of the functions of IT development and use in the IT tool itself is accelerating. This trend is not only for CASE, but also for many common office IT products like spreadsheets. With such automation, there might be a tendency now to avoid the theory behind these IT functions. This study indicates that to ignore the theory behind these IT functions in educational and training programs is a mistake. Whether these IT functions are integrated within an IT tool or not, it is still important for users to understand the theory behind them if acceptance and performance are to be optimized.

Other research that has been reported on—using automated tools, such as expert systems, in education and training—shows that automated tools cannot simply be made available to the end users and learning will occur [Clancy, 1983]. To create an effective learning environment, other components are necessary. This study found that one of those components is the theory behind the methodology embedded in automated IT tools like CASE. Future research should continue the line of investigation developed in this study so the potential for successful deployment of IT (e.g., CASE) will be improved.

## Appendix A

**DEPENDENT VARIABLES**

**ATTITUDES**

**Useful**

The SALSA tool would allow me to work more quickly.
The SALSA tool would increase my job performance.
The SALSA tool would increase my productivity.
The SALSA tool would make me more effective in my job.
The SALSA tool would make my job easier.
I would find the SALSA tool very useful.

**Ease of Use**

The SALSA tool is easy to learn.
The SALSA tool is controllable.
The SALSA tool is clear and understandable.
The SALSA tool is flexible to interact with.
The SALSA tool is easy to use.
It is easy to become skillful on the SALSA tool.

**PERFORMANCE**

**Identifier**: Primary key specification of primary and secondary keys for logical object reference.

**Attribute**: Specification of properties that adequately describe the logical object. Includes minimum and maximum cardinality.

**Association**: Specification of relationships that adequately describe the associations between logical objects. Includes minimum and maximum cardinality.

**INDEPENDENT VARIABLES**

**Theory Knowledge**: Assessment of theoretical database knowledge.

**Tool Knowledge**: Assessment of CASE tool comprehension and functional competency.

**Task Knowledge**: Comprehension of task scenario describing application information requirements.

## Appendix B: DATABASE DESIGN CASE

**Engineering Services Inc.**

Engineering Services Inc. is an engineering firm with approximately 500 employees. A database is required to keep track of all employees, employee skills, employee department assignments, and supply vendors for departments.

Every employee has a unique number assigned to them by the firm. It is also necessary to store their name and date-of-birth. Each employee is given a current job title (e.g., engineer, administrator, foreman, etc.). Additional information recorded for engineers only includes their type of degree (e.g., electrical, mechanical, civil, etc.), certification date, and certification expiration date (Exhibit A). Information recorded exclusively for administrators includes typing speed (Exhibit A).

There are 11 departments and each department has a unique phone number. Employees are assigned to only one department and departments usually have many employees. Each department deals with many vendors (Exhibit B). Typically, a vendor deals with more than one department (Exhibit B). Storage of the name and address of each vendor is also required. The date of the last meeting between a department and a vendor also is required to be stored.

An employee can have many skills (e.g., drafting, project estimation, safety inspection, etc.). Each skill category has at least one employee capable of providing that service. Skill information consists of a skill code and a short skill description.

**Department Vendor Contact Report**
**For the Month of: July, 1993**

| Department | Supply Vendor | Contact Date |
|---|---|---|
| Electrical | Johnson Supply Co. | 7/1/93 |
| | Interstate Wholesale Inc. | 7/11/93 |
| Mechanical | Pipe Fabricators | 7/2/93 |
| | Commercial Supply | 7/8/93 |
| | Interstate Wholesale, Inc. | 7/11/93 |
| | Hi-Vac Mfg. | 7/23/93 |
| Drafting & Design | | |
| Repair & Maintenance | Interstate Wholesale, Inc. | 7/11/93 |
| | Parts Inc. | 7/23/93 |

**Employee Report As of July 31, 1993**

| EmployeeID | Name | Date-of-birth | Job Title | Specific Data | |
|---|---|---|---|---|---|
| 123 | Jack Shuster | 12/03/65 | Engineer | Civil | Cert. 1991, Expires 1994 |
| 611 | James Bloch | 11/23/68 | Engineer | Mechanical | Cert. 1988, Expires 1994 |
| 1212 | Jay Smith | 01/01/44 | Engineer | Mechanical | Cert. 1978, Expires 1995 |
| 1310 | Jay Spence | 09/22/77 | Administrator | 55 WPM | |
| 1677 | Sid Galloway | 02/23/67 | Administrator | 44 WPM | |
| 2121 | Jackson Titus | 03/31/73 | Engineer | Electrical | Cert. 1989, Expires 1996 |
| 3001 | Rob News | 04/22/76 | Foreman | | |
| 3010 | Peter Hardway | 05/09/74 | Engineer | Electrical | Cert. 1990, Expires 1995 |

**Summary Vendor Contact Report**

| Vendor Summary | Department |
|---|---|
| Johnson Supply Co. | Electrical |
| Interstate Wholesale, Inc. | Electrical |
| | Mechanical |
| | Repair & Maintenance |
| Pipe Fabricators | Mechanical |
| Commercial Supply | Mechanical |
| Hi-Vac Mfg. | Mechanical |
| Parts Inc. | Repair & Maintenance |

## References


Adelson, B. and E. Soloway (1985).. "The role of domain experience in software design." *IEEE Transactions on Software Engineering*, SE-11, 11, 1351-1360.

Ahrens, J.D. and Sankar, C.S. (1993). "Tailoring database training for end users." *Management Information Systems Quarterly*, 17, 4, 419-439.

Baldwin, Dirk (1993). "Applying multiple views to information systems: A preliminary framework." *Data Base*, 24, 4), 15-30.

Barrett, G.V., Thornton, C.L., and Cabe, P.A. (1968). "Human factors evaluation of a computer based storage and retrieval system." *Human Factors*, 10, 431-436.

Batra, D., Hoffer, J.A., and Bostrom, R.P. (1990) "Comparing representations with relational and EER models." *Communications of the ACM*, 33, 2, 126-139.

Bock, D.B. and Ryan, T.(1993) "Accuracy in modeling with extended entity relationship and object oriented data models." *Journal of Database Management*, 4, 4 , 30-39.

Borgman, C.L. (1986). "The user's mental model of an information retrieval system: An experiment on a prototype on-line catalog." *International Journal of Man-Machine Studies*, 24, 1, 47-64.

Bostrom, R.P., Olfman, L., and Sein, M.K.(1988). "End-user computing: a framework to investigate the training/ learning process", in J.M. Carey (ed.). *Human Factors in Management Information Systems*, Ablex Publishing Corporation: Norwood, NJ , 221-250.

Bostrom, R.P., Olfman, L. and Sein, M.K. (1990) "The importance of learning style in end-user training." *Management Information Systems Quarterly*, 14, 1, 101-119.

Clancy, W.J.(1983). "The epistemology of a rule-based expert system: A framework for explanation." *Artificial Intelligence*, 20, 3 , 215-251.

Cheney, P.H., Mann, R.I., and Amoroso, D.L. (1986). "Organizational factors affecting the success of end-user computing." *Journal of Management Information Systems*, 3, 1, 65-80.

Cronan, T. and Douglas, D.(1990). "End user training and computing effectiveness in public agencies: An empirical study." *Journal of Management Information Systems*, 6, 4 , 21-40.

Davis, F.D., Bagozzi, R.P, and Warshaw, P.R. (1989). "User acceptance of computer technology: A comparison of two theoretical models." *Management Science*, 35, 8 , 982-1003.

Davis, S.A. and Bostrom, R.P. (1993). "Training end users: an investigation of the roles of the computer interface and training methods." *Management Information Systems Quarterly*, 17, 1, 61-85.

Decker, P.J. (1984). "The effects of different symbolic coding stimuli in behavior modeling training." *Personnel Psychology*, 35, 711-720.

Dewitz, S. and Olson, M. (1994a). Semantic Object Modeling with SALSA: A Casebook. McGraw-Hill: New York.

Dewitz, S. and Olson, M. (1994b). Semantic Object Modeling with SALSA: A Tutorial. McGraw-Hill: New York.

Eylon, B. and Reif, F. (1984). "Effects of knowledge organization on task performance." *Cognition and Instruction*, 1, 1 , 5-44.

Fichman, R. G. and Kemerer, C.F. (Winter 1993). "Adoption of software engineering process innovations: The case of object orientation." *Sloan Management Review*, 7-22.

Galliers, R.D. and Swan, J. (1997). "Against Structure Approaches: Information Requirements Analysis as a Socially Mediated Process." *Proceedings of the Thirtieth Hawaii International Conference on System Sciences*, Information Systems Track, IEEE. Computer Society Press: Los Angeles, CA , 179-187.

Gasson, Susan (1999). "The Reality of User-Centered Design." *Journal of End User Computing*, 11,4, 5-15.Glass, R.L. and I. Vessey (1992). "Towards a history of software applications domains." *Journal of Systems and Software*, 16, 189-199.

Goldstein, I.L. (1993). *Training in Organizations Needs Assessment, Development, and Evaluation,* 3rd ed, Brooks/ Cole Publishing Company: Pacific Grove, CA.

Hackathorn, R.D. and Karimi, J.(1988). "A framework for comparing information engineering methods." *Management Information Systems Quarterly*, 12, 2, 203-220.

Halasz, F.G. and Moran, T.P. (1983). "Mental models and problem solving using a calculator." In A. Janda (ed.), *Human Factors in Computing Systems: Conference Proceedings of the ACM*, Special Interest Group on Computer and Human Interaction (SIGCHI). Association for Computing Machinery: New York.

Hammer, M. and McLeod, D. (1981). "Database description with SDM: A semantic database model." In *Transactions on Database Systems*, 6, 3.

Hartog, C. and Herbert, M. (1986). "1985 opinion survey of MIS managers: key issues," *Management Information Systems Quarterly*, 10, 4, 351-361.

Henderson, John C. and Cooprider, J.G. (1990). "Dimensions of I/S planning and design aids: A functional model of CASE technology." *Information Systems Research*, 1, 3, 227-254.

Howell, W.C. and Cooke, N.J. (1989). "Training the human information processor: A review of cognitive models." In I.L. Goldstein (ed.) *Training in development and organizations*, Jossey-Bass: San Fransisco.

Jarvenpaa, S.L. and Ives, B. (1990). "Information technology and corporate strategy: a view from the top." *Information Systems Research*, 1, 4, 351-376.

Kroenke, D.M. (1995).*Database Processing*, 5th ed., MacMillan: New York.

Leitheiser, Robert (1992). "MIS skills for the 1990s." *Journal of Management Information Systems*, 9, 1, 69-92.

Loh, M. and Nelson, R. (1989)."Reaping CASE harvests." *Datamation*, July 1, 31-33.

Malone, T.W. (1981). "Toward a theory of intrinsically motivating instruction." *Cognitive Science*, 4, 333-369.

Neter, J., Wasserman, W., and Kutner, M. H (1990). *Applied Linear Statistical Models,* Irwin: Homewood, IL,.

Pei, B.K.W. and Reneau, J.H. (1990). "The effects of memory structure on using rule-based expert systems for training: A framework and an empirical test." *Decision Sciences*, 21, 2 , 263-286.

Perrig, W. and Kintech, W.(1985). "Propositional and situational representation of text." *Journal of Memory and Language*, 2, 4, 503-518.

Peters, W. S. and Champoux, J.E. (1979). "The Role and Analysis of Moderator Variables in Organizational Research," in Mowday, R. T. and Steers, R. M. (eds.) *Research in Organizations: Issues and Controversies.* Goodyear Publishing Company: Santa Monica, CA, 239-253.

Rainer, Jr., R.K. and Harrison, A.W. (1993). "Toward development of the end user construct in a university setting." *Decision Sciences*, 24, 3, 1187-1202.

Rouse, W.B. and Morris, N.M. (1986) "On looking into the black box: Prospects and limits in the search for mental models." *Psychological Bulletin*, 100, 349-363.

Ryan, Sherry D.(Oct.-Dec. 1999). "A Model of the Motivation for IT Retraining." *Information Resources Management Journal* , 24-32.

Schultz, R.L. and Slevin, D.P. (Eds.) ( 1975). *Implementing Operations Research/Management Science*. American Elsevier, New York,.

Sein, M.K. (1988). "Conceptual Models in Training Novice Users of Computer Systems: Effectiveness of Abstract vs. Analogical Models and Influence of Individual Differences." University Microfilms International: Ann Arbor, MI.

Shaft, T.M. and Vessey, I.(1995). "The relevance of application domain knowledge: the case of computer program comprehension." *Information System Research*, 6, 3, 286-299.

Sprague, R. and McNurlin, B.C. (1993). *Information Systems Management in Practice*, 3rd Edition. Prentice-Hall: Englewood Cliffs, NJ.

Vessey, I. and Conger, S.(1993). "Learning to specify information requirements." *Journal of Management Information Systems*, 10, 2, 203-225.

Vessey, I. and Galetta, D.(1991). "Cognitive fit: an empirical study of information acquisition." *Information System Research*, 2, 1, 63-84.

Welke, R.J. and Konsynski, B.R. (1980). "An examination of the interaction between technology, methodology, and information systems: A tripartite view." *Proceedings of the First International Conference on Information Systems*, Philadelphia, PA (December 8-10, 1980), 32-48.

Zigurs, Ilze and Buckland, Bonnie K.(1998). "A Theory of Task/Technology Fit and Group Support Systems Effectiveness." *Management Information Systems Quarterly* (September), 313-334.

Zmud, R.W. and Lind, M.R. (1985). "Linking mechanisms supporting end-user computing." *Proceedings of the 12th Annual Conference of ACM SIGCPR/SIGDBG*, Minneapolis, MN, 74-80.

Zuboff, S. (1985). "Automate/Informate: The two faces of intelligent technology." *Organizational Dynamics*, 14, 2 , 5-18.

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