# The Management of End-User Computing: Status and Directions

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The development of computing applications by the people who have direct need for them in their work has become commonplace. During the 1980s, development of applications by "end users" accelerated and became a key management and research concern. Known as "end-user computing," the phenomena and research associated with this trend cross a variety of disciplines. This article critically surveys the published literature on end-user computing (EUC) management according to a comprehensive research model. The article introduces the EUC management research model, identifies prior research contributions, and offers guidelines for the future. The focal points of the model are two EUC management components which represent two different levels of theorizing found in the literature. The first level focuses on the organization factors of strategy, technology, and management action. The second level focuses on the individual factors of end user, task, tool, and end-user action. The remainder of the model includes factors typically investigated as the antecedents (context) and consequences (outcomes) of EUC. More than 90 English-language articles published from 1983–1990 are mapped into the model. Specific variables for each factor are identified; research streams are interpreted; findings are synthesized; and gaps in our knowledge are highlighted. We then raise a number of substantive and methodological issues that need to be addressed and suggest two themes we envision as important for EUC management research in the 1990s: EUC as an extension of organizational computing and EUC as a social learning phenomenon. Guidance is offered for using these themes to inform future research.

Categories and Subject Descriptors: H.4.1 [**Information Systems Applications**]: Office Automation; K.6.1 [**Management of Computing and Information Systems**]: Project and People Management

General Terms: Human Factors, Management

Additional Key Words and Phrases: Desktop computing, end-user computing, information center, information technology management, personal computing

## 1. INTRODUCTION

In the past, most computing technologies were based on centralized architectures. Due to economies of scale and scarcity of expertise, the individuals responsible for developing, operating, and maintaining systems were located in centralized departmental units. These centralized arrangements required that computers be segregated from the people who needed to apply them in their work. With the advent of distributable computing, these arrangements began to change [King

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1983]. Today, computer applications are increasingly developed by the people who have direct need for them in their work. Development of applications by "end users" is a particularly widespread phenomenon in at least two vital fields of computing application: scientific/technical computing where information technologies have been placed directly in the hands of researchers, designers, and engineers; and business/commercial computing where information technologies have been placed directly in the hands of clerks, analysts, and managers. During the 1980s, pressures toward distribution accelerated and became a key management and research concern. Known as "end-user computing" (EUC), the phenomena and research associated with this trend cross a variety of disciplines.

The growth of EUC provides challenges for both computer science (CS) and information systems (IS) researchers. Within the CS research community, the changing nature of computer users has fueled the development of interface designs which provide a richer and more flexible communication channel aimed at supporting learning among novice users. Similarly, the changing nature of software development has fueled the development of tools which provide access to standardized design models aimed at making it easier to generate customized applications.

Within the IS research community, the distribution of computing resources has fueled the development of new management practices aimed at supporting and controling EUC. This body of research provides the focal point for our survey. The published research on EUC management grew from a few seminal articles between 1979 and 1981 to more than 90 conceptual and empirical studies between 1983 and 1990. Despite this volume of research, scholars still are not in agreement on how to manage end-user computing. For example, within a two-year period, five approaches to EUC management strategy were published: the managed free-economy approach [Gerrity and Rockart 1986], the contingent strategic-perspective approach [Henderson and Treacy 1986], the PC management discipline approach [Pyburn 1986–1987], the technology assimilation approach [Alavi et al. 1987–1988], and the expansion/control approach [Munro et al. 1987–1988]. These five approaches are not mutually exclusive, but none directly acknowledges another. One reason for this situation is that some of the investigations were undertaken simultaneously. Nevertheless, to the readers of these articles, no progress toward a cumulative body of knowledge is evident.

The purpose of this article is to critically survey the published research on

EUC management to determine what we know and what we do not know about managing end-user computing. The goal is to help direct future research into potentially fruitful channels. If properly directed and channeled, continued research can contribute to knowledge of whether or not, as well as how, new information technologies can be effectively introduced and managed. EUC researchers can contribute to knowledge about the most effective approaches to the management task. This is important because information technology assimilation is projected to have a continuing major impact on organizations [McKenney and McFarlan 1982; Straub and Wetherbe 1989; Hartmanis and Lin 1992].[1]

### 1.1 Definition of End-User Computing Management

A variety of definitions for end-user computing exists in the literature [Hackathorn and Keen 1981; Lehman 1985; Bullen 1986; Leitheiser and Wetherbe 1986; Panko 1987; Cotterman and Kumar 1989; Sipior and Sanders 1989]. For this study, *end-user computing* is defined as *the adoption and use of information technology by personnel outside the information systems department to DEVELOP software applications in support of organizational tasks*. The software applications may be used by the developers or their coworkers and may range in complexity from relatively simple financial models to comprehensive information systems. The organizational tasks may be personal, departmental, or multidepartmental in scope. Examples of EUC studies which fall outside this definition include those which (1) address only the use of applications developed by IS professionals or (2) address clerical office automation activities utilizing only word processing, desktop publishing, or electronic communication software.

*Management* is defined in terms of the traditional processes of planning, organizing, staffing, directing, and controling organizational activities (for example, Harrison [1978]). Additionally, these management processes are viewed in light of findings that contemporary management is fast paced, communication intensive, support oriented, and coordination based (for example, Mintzberg [1973]). The *management of end-user computing* is defined as *planning, organizing, staffing, directing, controling, supporting, and coordinating the adoption and use of information technology by end users to develop software applications in support of organizational tasks*.

### 1.2 Scope of Literature Survey

While forms of end-user computing can be traced back to the early 1970s, it is not until the end of that decade that the concept begins to receive attention in research and practice. McLean [1979], Canning [1981a; 1981b], and Martin [1982] popularize the notion that application development by end users is a viable solution to growing organizational problems with traditional systems development. End-user computing is envisaged as a way to reduce the applications development backlog and overcome the shortage of qualified professionals.

From 1979–82, EUC management research is predictive and prescriptive in nature, with awareness of the phenomenon a primary goal. McLean [1979], for example, prescribes the role of end users as application developers but warns that applications developed should be limited in scope. Hammond [1982] prescribes the use of the information center as the ultimate vehicle for managing end-user computing in a mainframe environment. Benjamin [1982] predicts that end users will dominate the consumption of corporate computing cycles by the 1990s. The few empirical publications at this time typically offer one or two case descriptions as exemplars.

[1] The only other known EUC management review is based on published and unpublished sources dating up to 1986 [Amoroso 1988]. Since 1986, the number of published EUC research articles has increased almost fourfold.

In 1983 two broad-based field studies appear in the literature. Rockart and Flannery [1983] introduce a widely cited taxonomy of end users, the concept of a shared IS/user environment, and key issues for EUC management. Benson [1983] describes the transition from mainframe to micro-based EUC technology and relevant management issues based on interviews with IS managers and end users. Both articles investigate the growth of end-user computing and legitimize the IS executive's role in managing EUC.

Given the seminal nature of these 1983 contributions, this literature survey is based on the research published from January 1983 through December 1990. Nine top journals were surveyed: *Communications of the ACM*, *Data Base*, *Harvard Business Review*, *Information and Management*, *Information Systems Research*, *Journal of Management Information Systems*, *Management Science*, *MIS Quarterly*, and *Sloan Management Review*. These journals are considered to be among the primary publishers of computing management research [Hamilton and Ives 1982a; Vogel and Wetherbe 1984; Alavi et al. 1989]. Additionally, since high-quality refereed conference proceedings often form the basis for articles later appearing in research journals, selected papers from the proceedings from several North American conferences are also included. Specifically, recent papers presented at the *International Conference on Information Systems* and *Hawaii International Conference on System Sciences* are included, as are selected papers from a recent meeting of the International Federation of Information Processing Workgroup 8.2 devoted to EUC topics. Finally, the survey includes a few noteworthy articles published in journals with primarily practitioner audiences or in a special journal issue devoted to EUC management. No attempt is made to provide bibliographic coverage of related unpublished papers, unpublished dissertations, trade journals, newsletters, general conference proceedings, or books.

### 1.3 Organization of the Article

The article is organized as follows. Section 2 introduces our research model for EUC management and our classification of the literature. In Sections 3–6 we map the literature into the four components of the model, assess research contributions, and offer guidelines for building on relevant prior literature. Lists of variables associated with the model are also provided. In Section 7 we present substantive and methodological issues that need to be addressed in future research, and we also suggest some new directions we believe EUC management research should take. Finally, in Section 8 we discuss the limitations of the survey and highlight some major conclusions.

## 2. RESEARCH MODEL

To organize the prior research and to provide guidance for future efforts, we developed a comprehensive EUC management research model. We employed an iterative combination of deductive and inductive reasoning to formulate the research model. Initially, we began with a rough outline of the key factors which had surfaced from our less formal reviews of the EUC literature. The initial model took the form of a traditional *A-B-C* model encompassing *a*ntecedents, *b*ehavior and *c*onsequences, where "behavior" is a phenomenon of interest to the research community. As our literature analysis progressed, two levels of theorizing on EUC management emerged (organization and individual); new factors were added; and existing factors were rearranged. After many iterations of modification and enhancement, the research model presented in Figure 1 emerged.

The model is useful for several reasons. First, it provides a framework for identifying concepts which have been addressed in previous conceptual and empirical studies. Second, it provides a structure for surveying the prior research and determining what we know and do not know about EUC management. Third, it serves as a guide for de-

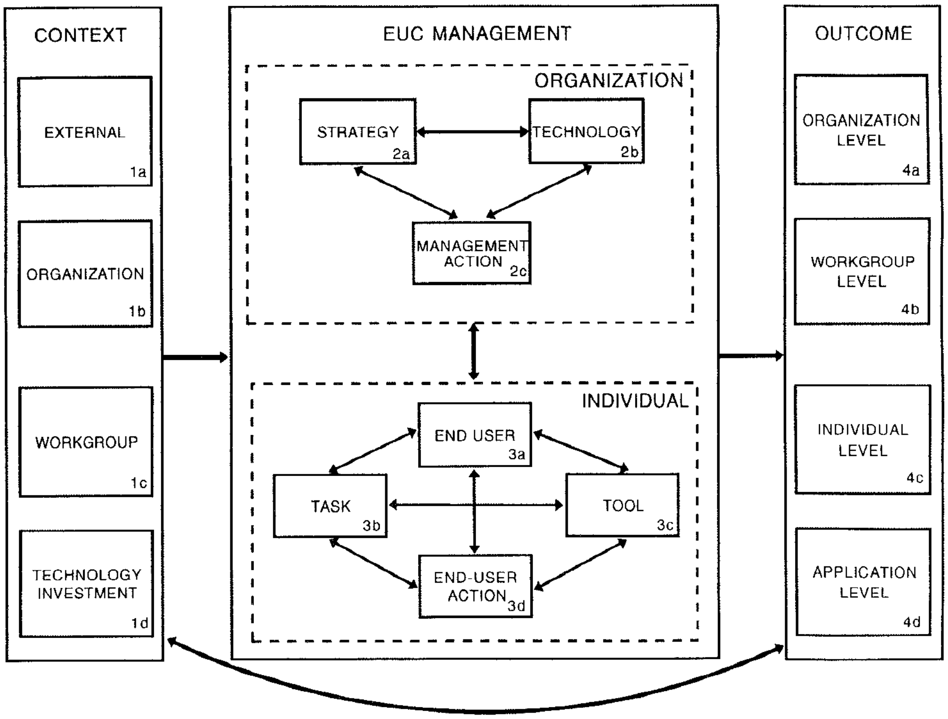


**Figure 1.** EUC management research model.

signing future research by clarifying levels of analysis, identifying important variables, and facilitating the accumulation of knowledge.

### 2.1 EUC Management Research Model

The EUC management research model in Figure 1 consists of four major components: (1) context, (2) organization EUC management, (3) individual EUC management, and (4) outcome. These components are subdivided into factors, each representing a class of variables relating to the management of end-user computing.[2] Arrows between components and between factors include some of the typical relationships explored in previous research. While most EUC management research has been conducted under the assumption of one-way linear causation, the double-headed arrows shown in Figure 1 suggest that these relationships are reciprocal and interactive in nature (this is discussed in more detail in Section 7). Since the research model is necessarily drawn at a high level, all relationships are not shown. For example, relationships between different factors within the organization and individual components are *summarized* by a single arrow joining the two components. Additionally, relationships between variables within a single factor are *encapsulated* within the factor.

The focal point of the research model is labeled "EUC management." This part of the model contains factors which the literature identifies as crucial to the man-

[2] We refer to the elements of our research model as components, factors, and variables, Each component is made up of several factors, and each factor is made up of several variables.

agement of end-user computing. Its two components represent the organizational and individual levels of theorizing: external control and organizational action versus self-control and individual action. The model is linked conceptually to the definition of EUC management provided in Section 1. The organization component represents the planning, organizing, staffing, directing, controling, supporting, and coordinating functions. Here, the literature identifies strategy (2a), technology (2b), and management action (2c) as critical factors. The individual component represents the adoption and use of information technology by users to develop software applications in support of organizational tasks. Here, the literature identifies end user (3a), task (3b), tool (3c), and end-user action (3d) as critical factors. The double-headed arrow connecting the organization and individual components depicts the reciprocal linkage between the two levels of theorizing (and two levels of action). The specific variables associated with each factor in the organization and individual components are discussed in Sections 3–5 and summarized in Figures 3 and 5.

The remainder of the model represents those factors typically investigated as the antecedents (context) and consequences (outcomes) of EUC. The context component includes one external factor (1a) and three internal factors: organization (1b), workgroup (1c), and technology investment (1d). The variables associated with these factors are typically viewed as antecedent variables in EUC management research. These include industry, company size, innovativeness, development backlog, and many others. The outcome component contains four factors with each corresponding to a different level of analysis: organization level (4a), workgroup level (4b), individual level (4c), and application level (4d). The variables associated with these factors serve as typical criterion variables in EUC management research. These include perceived effectiveness, number of adopters, user satisfaction, and many others. The specific variables associated with the context and outcome components of the research model are discussed in Section 6 and summarized in Figures 8 and 9.

By design, some redundancy exists in the model. For example, a technology factor exists in each of the four major components. In the context component, the technology investment factor (1d) might serve as a measure for the size of investment in information technology (IT) or the stage of IT growth within an organization. In the organization EUC management component, the technology factor (2b) is more narrowly defined to include only EUC-related technology investments and EUC maturity. In the individual EUC management component, the tool factor (3c) encapsulates perceptions about specific tools from the perspective of end users. Finally, in the outcome component, the application-level factor (4d) includes technology-based outcomes such as changes in the quality of user-developed applications. Additional redundancy exists for selected context and outcome factors.

While the model is based on published EUC management research, the overall framework and categorization of variables also reflect our knowledge of the IS management literature and relevant reference theories. So while the model has roots in the past, it looks forward toward further development of EUC management research.

### 2.2 Classification of the Literature

An essential step in conducting this survey was to classify the over 90 research reports selected for analysis. To support this effort, coding sheets were developed and revised as the research model evolved. Each article was classified after a careful reading by one or both of the authors. In many cases, studies were reexamined and reclassified as our review progressed. Thus the literature classification was an iterative process.

Figure 2 classifies the published research on EUC management included in the survey. The content of each article is represented in two ways. First, the re-

| STUDY | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS (1) Context | (2) Org-Level | (3) Indiv-Level | (4) Outcomes | METHOD | SAMPLE |
|---|---|---|---|---|---|---|
| Benson (1983) | | technology, action | | | field study | 20 companies<br>69 IS managers<br>67 users |
| Rockart & Flannery (1983) | | strategy, technology, action | user, task | | field study | 7 companies<br>50 IS managers<br>200 users |
| Keen & Woodman (1984) | | strategy, action | | | conceptual | |
| Rivard & Huff (1984) | | | | org, workgroup, individual | field study | 10 companies<br>10 IS, IC managers |
| Alavi (1985) | | technology, action | tool | organization | field study | 31 IS managers |
| Alavi & Weiss (1985-86) | | action | action | application | conceptual | |
| Brancheau et al (1985) | | action | user | organization | field study | 5 companies<br>5 IC managers<br>53 users |
| Rivard & Huff (1985) | | | user, task, action | individual, application | field study | 10 companies<br>272 users |
| Wetherbe & Leitheiser (1985) | | strategy, technology, action | action | organization | field study | 25 IC managers |
| Cheney et al. (1986) | org, workgroup | action | task, action | organization | conceptual | |
| Couger (1986) | | strategy, action | | organization, workgroup | field study | 17 companies |
| Gerrity & Rockart (1986) | | strategy, action | | | conceptual | |
| Guimaraes & Ramanujam (1986) | | action | | organization | field study | 173 IS managers |
| Henderson & Treacy (1986) | | strategy, technology, action | | organization | conceptual | |
| Laudon (1986) | | technology, action | action | application | field study | 25 companies |
| Lee (1986) | | action | user, task, tool, action | individual | field study | 12 companies<br>311 users |

(a)

**Figure 2.** Published research on EUC management.

| | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS | | | | | |
|---|---|---|---|---|---|---|
| **STUDY** | **(1) Context** | **(2) Org-Level** | **(3) Indiv-Level** | **(4) Outcomes** | **METHOD** | **SAMPLE** |
| Leitheiser & Wetherbe (1986) | workgroup | technology, action | action | | conceptual | |
| Porter (1986) | workgroup | strategy, action | task | organization, individual | conceptual | |
| Pyburn (1986-87) | | strategy, technology, action | action | individual | field study | 8 companies<br>58 users |
| Zmud & Lind (1986) | organization, workgroup | action | | organization | field study | 21 companies<br>21 IS managers |
| Alavi et al (1987-88) | | strategy, technology, action | | | conceptual | |
| Amoroso & Cheney (1987) | | | user, task, tool, action | individual | field study | 18 companies<br>260 users |
| Behestian & Van Wert (1987) | | action | | | case study | 1 company |
| Carr (1987) | | action | | workgroup | field study | 20 companies<br>20 ICs |
| Christy & White (1987)<br>also White & Christy (1987) | | strategy, action | | | field study | 6 ICs |
| Gattiker & Paulson (1987) | | action | user | | lab experiment | 120 students |
| Harrison & Dick (1987) | | action | | | field study | 100 companies<br>100 PC managers |
| Hackathorn (1987) | | action | user, tool, action | organization application | field study | 150 companies<br>239 managers |
| Moore (1987) | organization, workgroup | | user, task, tool, action | | conceptual | |
| Munro et al. (1987-88) | | strategy, technology, action | | | field study | 37 companies<br>37 IS/IC managers |
| Necco et al. (1987) | organization, workgroup | action | action | | field study | 97 IS managers |
| Nelson & Cheney (1987) | | action | user, action | | field study | 20 companies<br>100 users |
| O'Donnell & March (1987) | | strategy, action | | | conceptual | |
| Panko (1987) | | strategy, technology, action | task, action | | conceptual | |

(b)

| STUDY | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS (1) Context | (2) Org-Level | (3) Indiv-Level | (4) Outcomes | METHOD | SAMPLE |
|---|---|---|---|---|---|---|
| Raymond (1987) | org, workgroup, investment | | | organization | field study | 34 companies<br>34 IS managers |
| Sein et al. (1987) | workgroup | action | user, task, action | | conceptual | |
| Sumner & Klepper (1987a) also Sumner & Klepper (1987b) | investment | action | user, task, action | application | field study | 8 companies<br>31 users<br>62 applications |
| Watson & Carr (1987) | | action | | | conceptual | |
| Bergeron & Berube (1988) | | strategy, action | user | individual | field study | 31 companies<br>31 IS managers<br>212 users |
| Brancheau & Wetherbe (1988) | | action | user | individual | field study | 4 companies |
| Carlsson (1988) | | action | tool, action | individual | field study | 1 company<br>3 users |
| Corman (1988) | investment | | | application | conceptual | |
| Huff et al. (1988) | | strategy, technology, action | | application | conceptual | |
| Lederer & Spence (1988) | | action | | | conceptual | |
| Magal & Carr (1988) | organization | technology, action | | organization | field study | 311 IC managers |
| Necco & Tsai (1988) | | technology, action | action | | field study | 15 companies<br>15 IS managers |
| Rivard & Huff (1988) | workgroup | action | user, tool | individual | field study | 10 companies<br>272 users |
| Saaksjarvi et al. (1988) | | strategy, action | user | organization, individual | field study | 16 companies<br>16 IS managers<br>151 users |
| Saarinen et al. (1988) | | strategy, technology, action | | organization | field study | 4 companies<br>4 IS managers |
| Amoroso (1989) | | | action | | field study | 2 companies<br>43 executives |
| Brancheau & Wetherbe (1989) | | strategy, technology, action | user, action | | conceptual | |

(c)

**Figure 2.** Continued

| STUDY | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS (1) Context | (2) Org-Level | (3) Indiv-Level | (4) Outcomes | METHOD | SAMPLE |
|---|---|---|---|---|---|---|
| Brown & Bostrom (1989a) | organization | strategy, technology, action | | workgroup | field study | 4 companies<br>4 IS managers |
| Brown & Bostrom (1989b) | organization | strategy, technology, action | | | conceptual | |
| Cotterman & Kumar (1989)<br>also Kumar & Cotterman (1990) | | | user, task, action | | conceptual | |
| Doll & Torkzadeh (1989) | | | task, action | individual | field study | 44 companies<br>618 users<br>250 applications |
| Ghani & Al-Meer (1989) | | | task, tool, action | individual | field study | 85 users |
| Igbaria et al (1989) | | | user, task, action | | field study | 471 users |
| Kwan & Curley (1989) | organization | technology, action | | | field study | 115 companies<br>67 IS professionals<br>48 users |
| Lepore et al (1989) | workgroup | action | | workgroup | field study | 10 companies<br>38 workgroups |
| Lind et al (1989) | organization | technology, action | | organization | field study | 21 companies<br>21 IS managers |
| Magal (1989) | | technology, action | user | | field study | 311 companies<br>311 IS/IC managers |
| Pentland (1989) | workgroup | action | user, task, tool, action | individual | field study | 7 divisions<br>1110 users<br>1851 audit cases |
| Rainer et al (1989) | | action | | | field study | 85 companies<br>205 IC managers, staff |
| Raymond (1989) | organization, workgroup | strategy, technology | user, task | | conceptual | |
| Vijayaraman & Ramakrishna (1989) | | | action | individual<br>workgroup | field study | 10 companies<br>10 IC managers<br>238 users |
| Watson et al (1989) | | action | | workgroup | field study | 55 companies<br>55 DSS groups |

(d)

| STUDY | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS (1) Context | (2) Org-Level | (3) Indiv-Level | (4) Outcomes | METHOD | SAMPLE |
|---|---|---|---|---|---|---|
| Amoroso et al. (1990) | | | task | | field study | 21 companies<br>394 users |
| Alavi et al (1990) | | action | | individual, application | lab experiment | 59 students |
| Bergeron et al (1990) | | action | | individual | field study | 19 companies<br>19 IC managers<br>172 users |
| Bostrom et al (1990) | | action | user, task, tool | individual | lab experiments | 150 students<br>61 employees |
| Brancheau & Amoroso (1990) | | strategy, technology, action | | | field study | 18 companies<br>19 ICs |
| Brancheau & Wetherbe (1990) | workgroup | | user, task, tool, action | | field study | 18 companies<br>380 users |
| Brown & Wynne (1990) | organization | strategy, technology, action | | organization, individual | case study | 1 company<br>5 IS managers<br>29 users |
| Carlsson (1990) | | action | user, tool, tool, action | | case study | 1 company<br>3 users |
| Cronan & Douglas (1990) | workgroup | action | user | individual | field study | 1 division<br>83 applications |
| Davis & Davis (1990) | | action | user, task, tool, action | individual | lab experiment | 91 students |
| Ein-Dor & Segev (1990) | external org, workgroup, investment | strategy, technology, action | tool | organization, individual | field study | 2 countries<br>21 companies<br>108 IS managers |
| Frank & Shamir (1990) | workgroup | action | user, task, action | | field study | 12 companies<br>70 users |
| Galletta & Heckman (1990) | | | task | workgroup | conceptual | |
| George et al. (1990) | workgroup | action | action | workgroup | field study | 3 companies<br>4 workgroups |
| Gogan (1990a) | | action | task, action | | conceptual | |
| Gogan (1990b) | | | task, tool, action | | field study | 4 companies<br>36 users |

(e)

**Figure 2.** Continued.

| STUDY | EUC MANAGEMENT RESEARCH MODEL COMPONENTS & FACTORS | | | | METHOD | SAMPLE |
|---|---|---|---|---|---|---|
| | (1) Context | (2) Org-Level | (3) Indiv-Level | (4) Outcomes | | |
| Gurbaxani & Kemerer (1990) | workgroup | action | action | workgroup | conceptual | |
| Igbaria & Nachman (1990) | workgroup | | user, task, tool, action | individual | field study | 6 companies<br>104 users |
| Klepper (1990a) | workgroup | strategy, action | user, task, action | application | conceptual | |
| Klepper (1990b) | org, workgroup | action | | | conceptual | |
| Klepper & Sumner (1990) | | | user, task, action | workgroup, application | field study | 8 companies<br>51 applications |
| Mawhinney & Lederer (1990) | | | user, task, tool, action | individual | field study | 105 managerial users |
| Raymond (1990) | org, workgroup | strategy, technology | user, task | | conceptual | |
| Robey & Zmud (1990) | external, org, workgroup | action | | | conceptual | |
| Smithson & Hirschheim (1990) | external, org, workgroup | action | user, tool | individual | conceptual | |
| Sein & Bostrom (1990) | | action | user | | lab experiment | 106 students |
| Vijayaraman & Ramakrishna (1990) | | action | | individual, workgroup | field study | 10 companies<br>10 IC managers<br>238 users |

(f)

**Figure 2.** Continued.

search coverage of the article is mapped into the EUC management research model. The specific factors for each component investigated are listed for each study. Second, the research method is identified. Each research article is identified as belonging to either an empirical or conceptual category [Hamilton and Ives 1982b]. The empirical articles are classified according to their research strategy (i.e., case study, field study, field experiment, lab experiment). For each empirical study, characteristics of the sample are also listed.

Figure 2 leaves certain questions unanswered: what relationships among components, factors, and variables have been investigated, and what are the accumulated findings? Sections 3–6 discuss these questions. Each section analyzes published research by factor, while concurrently introducing relevant variables, reviewing key findings, evaluating contributions, summarizing knowledge, and highlighting gaps in our knowledge. The total space devoted to a given article varies considerably. More space is allocated to conceptual studies that propose a theoretical framework or model and empirical studies that identify new relationships or confirm hypothesized relationships. Researchers are encouraged to use the classification of the literature in Figure 2 and the variable listings for each component in Figures 3, 5, 8, and 9, which extend beyond our discussion as roadmaps for their own scanning and synthesizing efforts.

## 3. LITERATURE ON THE ORGANIZATION COMPONENT

The organization component of the model embodies the management processes of planning, organizing, staffing, directing, controling, supporting, and coordinating end-user computing. The research model in Figure 1 incorporates these management processes into three factors: strategy (2a), technology (2b), and management action (2c). A list of variables associated with each organization factor is provided in Figure 3.

### 3.1 Strategy (2a)

The strategy factor embodies the management process referred to as planning—that is, those management activities concerned with establishing a course of action. Although early studies prescribe use of a strategic plan to help managers determine the appropriate balance between support and control actions (for example, Benson [1983], Keen and Woodman [1984], Bullen [1986], and Couger [1986]), few examples of a formal EUC strategy are found in the field (for example, Rockart and Flannery [1983], Gerrity and Rockart [1986], Guimaraes and Ramanujam [1986]). A lack of practitioner consensus about the "best" directional objectives for EUC management is also reported in studies from the mid-decade [Alavi 1985; Pyburn 1986–1987]. Gerrity and Rockart surmise the three predominant EUC strategies to be the Monopolist, Laissez-Faire, and Information Center approaches based on the EUC management actions (tactics) they observed in the field. They recommend instead a "Managed Free Economy" approach which emphasizes "end-user needs" over IS efficiency and control objectives.

Several other authors prescribe an evolutionary approach to EUC management [Henderson and Treacy 1986; Pyburn 1986–1987; Munro et al. 1987–1988; Alavi et al. 1987–1988]. Most of these studies are based on the assumption that an organization's strategy should change over time to maximize movement along an S-shaped growth curve for EUC, an idea that has its conceptual roots in both the Nolan stage growth model [Gibson and Nolan 1974] and McKenney and McFarlan's [1982] technology assimilation model. In contrast, Munro et al. [1987–1988] argue that a strategy aimed at restraining the pace of EUC growth is also a valid approach. The pursuit of a low growth objective is empirically supported by other researchers [Saarinen et al. 1988; Brown and Bostrom 1989b; Brancheau and Amoroso 1990]. Additional models which relate strategy to

**STRATEGY (2a)**
- **Strategic Plan**
  - Master plan
    - existence
    - integration with IS plan
  - Evolutionary Plan
  - Objectives
    - growth pace, direction

**TECHNOLOGY (2b)**
- **EUC Investment**
  - End-User platforms
    - degree PCs are networked
    - link to mainframe
    - dedicated mainframe
  - Number of PCs or terminals
  - Number and range of software packages
  - Ratio end users to workstations
  - Size investment ($, % of IS budget)
- **EUC Maturity**
  - Time since EUC introduction
  - Number or % of end users
  - Stage of growth of EUC
    - application maturity
    - implementation phase
  - Host database access
  - Overall functionality

**MANAGEMENT ACTION (2c)**
- **Support Services**
  - Formal training
    - methods, availability, frequency
  - Consulting
  - Troubleshooting
  - Product research
  - Acquisition support
    - vendor contacts, financial subsidies
    - installation, maintenance
  - Custom user manuals
  - Development of end-user software
  - Application maintenance
  - Documentation of end-user software
  - Backup/recovery on PCs
  - Data transfer/extract
  - Walk-in center
  - Software resource directory
- **Control Policies/Procedures**
  - Equipment/software standards
  - Acquisition policies/procedures
  - Service level agreements
  - Service evaluation procedures
  - Application review/certification
  - Application risk management
  - Corporate data access
  - Chargebacks (equipment, services)
- **Information Center (& other integrating units)**
  - Placement in organization
    - central vs local units
    - reporting level
    - integration with (other) IS units
  - Staffing level/ratio
  - Staff characteristics
    - technical vs business knowledge
    - communication skills
  - Life cycle
  - Critical success factors
- **Linking Mechanisms**
  - Task force/standing committees
    - steering committee
    - user groups
    - quality assurance groups
  - Liaison positions
    - local consultants, data stewards
    - hot line/help desk
  - Other formal mechanisms
    - open houses
    - newsletter
  - Informal mechanisms
    - local experts
    - informal communication networks
- **Structural Form**
  - Centralization of decision making
    - IS vs user department authority
    - degree of partnership between IS/user
    - extent end-user participation
  - Formalization of tasks
    - degree of rules & procedures
    - extent justification for acquisitions
    - restrictiveness of standards
  - Specialization of roles
    - extent of division of labor
    - reliance on IS professionalism
  - Organic vs Mechanistic

**Figure 3.** Variables associated with organization component.

management action are discussed in Section 3.4 below.

At the end of the decade, several authors begin to emphasize the importance of integrating strategic planning for EUC with overall IS planning. Bergeron and Berube [1988] report that it is not just the existence of a "microcomputer plan" but the incorporation of that plan into the overall IS plan that is correlated with user satisfaction. Within the organizational context of small business, Raymond [1990] further points out that EUC should be recognized as both a complement to and an alternative for organizational computing.

### 3.2 Technology (2b)

The technology factor includes variables which characterize an organization's investment in equipment, software, networks, and data for end-user computing, as well as measures of the extent of EUC proliferation within a given organization. Given the rapid pace of change during the 1980s, one concern of EUC researchers has been to document the end-user technological environment—from mainframe query and report-writing tools, to personal computers, to the networking of different platforms (for example, Benson [1983], Wetherbe and Leitheiser [1985], Bullen [1986], and Hackathorn [1987]). Technology investment variables are often reported as demographic statistics for a given population sample but seldom examined in detail.

Among the EUC maturity variables, even the earliest studies point out the difficulty of relying solely on IS manager reports to measure the number of PCs in an organization due to diffused responsibilities for (and knowledge of) equipment acquisitions (for example, Benson [1983]). Actual counts of end users are utilized as an EUC maturity or stage measure by later researchers based on data from end users [Brancheau and Wetherbe 1989]. A more complex measure of the maturity of the organization's portfolio of user-developed applications—based on the "interconnectedness" of the applications—is proposed by Huff et al. [1988]. Other researchers propose a dichotomous implementation phase measure (initial versus integrated) which incorporates the Huff et al. measure [Brown and Bostrom 1989b].

### 3.3 Management Action (2c)

Figure 3 presents five categories of management action variables. The first two (support services and control policies/procedures) include what have been commonly referred to as the support and control actions for managing the development of software applications by end users.[3] The next two categories capture how the responsibilities for these actions are delivered—via an information center or other formal and informal linking mechanisms (steering committees, local experts, etc.). The final category addresses the structural form of the EUC management infrastructure (locus of decision-making authority, division of labor, etc.).

Many of the descriptive studies document an overall lack of EUC support services and control policies/procedures in the field (for example, Benson [1983], Alavi [1985], and Pyburn [1986–1987]). This absence of both support and control actions is characterized as a Laissez-Faire approach by Gerrity and Rockart [1986] and several conceptual modelers [Henderson and Treacy 1986; Alavi et al. 1987–1988; Munro et al. 1987–1988]. However, given the documented absence of strategic plans (see Section 3.1 above), this "approach" is more likely the result of organizations having no strategy for managing the EUC phenomenon. Other field studies published by mid-decade point to a growth in policies for PC acquisitions and equipment/software standards (for example, Couger [1986] and Guimaraes and Ramanujam [1986]). An increasing number of support services as responsibilities of a separate organizational unit is also reported (for example, Brancheau et al. [1985]).

The initial dissemination of the information center (IC) concept is usually attributed to Hammond's [1982] normative model, which includes prescriptions for support services, control policies/procedures, IC/user staffing ratios, IC job descriptions, and organization design

[3] We use the labels "support" and "control" from a more neutral posture than some authors. For example, we recognize that a given support service can be used to "control" end-user actions from an IS perspective, and that a procedure for controling computer acquisitions could include no IS-imposed constraints while providing central assistance and "support." Here we label the variables as support or control, based on the way they are used by most EUC management researchers.

guidelines. Among the studies that compare the normative model to ICs in the field, Christy and White [1987] find the control policies/ procedures in the field to be "quite primitive," and Carr [1987] reports significant differences in IC management issues.

In the ensuing years, the IC label is applied to any formal organizational unit responsible for delivering EUC support services and monitoring control policies/ procedures. From the perspective of IC managers, support staffing and services are reported to be critical for success [Wetherbe and Leitheiser 1985; Magal and Carr 1988; Rainer et al. 1989]. Effective characteristics of IC support staffing and services are also documented from the perspective of end users [Brancheau et al. 1985; Brancheau and Wetherbe 1989]. Researchers report positive correlations between end-user satisfaction measures and various IC support services [Bergeron and Berube 1988; Bergeron et al. 1990; Vijayaraman and Ramakrishna 1990], but negative correlations between end-user satisfaction measures and the number of EUC control policies/procedures (for example, Bergeron and Berube [1988]). If satisfaction is a surrogate for effectiveness (as commonly assumed in the literature), the IC may be more effective for supporting end-user computing than for controling it.

The existence of a life cycle for the IC has also been suggested, although the critical success factors for IC management are reported to be stable over time [Magal and Carr 1988; Magal 1989]. No empirical studies are found which investigate why some organizations abandon the IC approach, although several theoretical perspectives for studying the presence or absence of an IC are proposed [Klepper 1990b; Robey and Zmud 1990].

Formal EUC-linking mechanisms independent of the IC context are addressed in very few studies. For example, Lind et al. [1989] find lateral mechanisms (steering committees, liaison positions, user groups, etc.) to be significant predictors of the number of microcomputers within an organization. Within the literature that focuses on alternatives for decision support system (DSS) support, a convergence of DSS and EUC support mechanisms is reported [Watson and Carr 1987; Watson et al. 1989]. Unfortunately, there are too few data to compare the effectiveness of different linking mechanisms.

Informal mechanisms receive slightly more attention. The importance of an informal communication network as an EUC support mechanism is reported in surveys of end users (for example, Brancheau et al. [1985], Lee [1986], Bergeron and Berube [1988]). George et al. [1990] find that workgroups without a formal organizational subunit to provide support services develop an informal network, and that workgroups with a formal subunit turn first to an informal network.

Examining the literature addressing the structural form of the EUC management infrastructure, some researchers measure the locus of decision authority as a dichotomous choice between corporate IS department authority or business unit authority [Guimaraes and Ramanujam 1986; Pyburn 1986–1987]. Other researchers introduce the idea of IS/user partnerships for the EUC management infrastructure as a whole [Gerrity and Rockart 1986], as well as for specific management actions [Kwan and Curley 1989]. Lepore et al. [1989] find evidence that groups with both end-user participation in EUC management decisions (a "grassroots" process) and adequate support services (training and support) have the most improved quality of work life. Finally, Brown and Bostrom [1989a; 1989b] define the mechanistic and organic forms of EUC management actions, depending on their centralization, formalization, and specialization. Shared IS/user decision making and user participation are among the characteristics of the (de)centralization variable of the organic form.

Although essentially all of the studies that investigate the organization component have included the management action factor, the research is heavily focused on IS department actions. The evidence indicates that IS-directed information centers are not completely effective from an end user's perspective. We have little knowledge about the effectiveness of management actions by user department managers or senior executives outside the IS department. We also have little knowledge about the effectiveness of specific formal and informal linking mechanisms when implemented outside the IC context. Recent research provides some evidence of IS/user partnerships for EUC management and the existence of management actions directed at service and quality rather than efficiency and control.

### 3.4 Relationships Among Organization Factors

Although a perusal of the organization component column of Figure 2 suggests that quite a few studies have addressed all three organization factors, a relatively small number actually address relationships among two or more of these factors. And, as will become apparent in the following discussion, more conceptual than empirical studies have focused on these linkages.

Looking first at the conceptual studies, three evolutionary models independently developed during the mid-1980s [Henderson and Treacy 1986; Pyburn 1986–1987; Alavi et al. 1987–1988] are more alike than different due to their conceptual underpinnings [Gibson and Nolan 1974; McKenney and McFarlan 1982]. All three of these models prescribe support and control actions and/ or structural mechanisms that change to match a sequence of four stages. All three suggest not implementing a full set of control actions until the penultimate stage. Additionally, Henderson and Treacy [1986] propose that the criticalness of four EUC management "infrastructures" (support, technology, data, and evaluation/justification) changes over time, while Pyburn advocates differing support and control actions for a "mature" stage contingent on the scope of the application (personal, departmental, organizational). The key concept underlying all these models is that EUC management actions must vary with the level of EUC maturity in the organization.

The $2 \times 2$ model of Munro et al. [1987–1988] which was cited in Section 3.1 differs from the above evolutionary models in that a high control approach is proposed as appropriate for organizations in an early stage of EUC maturity. Field data from both the U.S. and Scandinavia support the validity of the organizational choices between (1) a low level of support services with high control actions under a "Containment" strategy and (2) a high level of support services and low number of control actions under an "Acceleration" strategy [Saaksjarvi et al. 1988; Saarinen et al. 1988; Brown and Bostrom 1989b; Brancheau and Amoroso 1990]. Saaksjarvi et al. also report that the impact of the IC as a delivery structure is most beneficial (from an end-user perspective) under an Acceleration strategy. However, Brancheau and Amoroso find additional evolutionary sequences not predicted by the model. Unfortunately, these validation studies suffer from small sample sizes ($n < 20$). Munro and Huff have also proposed a five-stage model [Huff et al. 1988] with support and control actions that change over time to match the "maturity" of an organization's portfolio of EUC applications (see Section 3.2 above). They argue that the four strategies of their $2 \times 2$ grid will impact the rate and form of the development of a firm's application maturity. No validation study is known.

Building on several of the prior evolutionary models, as well as portions of a prior innovation management model, Brown and Bostrom [1989b] focus on the structural form of the EUC management infrastructure. The choice of an organic versus mechanistic form is modeled as being contingent on both the organization's technology (EUC maturity) and its strategic plan (EUC growth objectives). Only preliminary validation of the model

| Study/Model | Empirical Validation/Findings |
|---|---|
| Hammond (1982)<br>Normative Information Center Model | Support for 23 of 46 derived propositions (Carr 1987) Field implementations comparatively "quite primitive" (White & Christy 1987) |
| Rockart & Flannery (1983)<br>Third Shared Environment | None reported |
| Alavi & Weiss (1985-86)<br>EUC Control Framework | None reported |
| Guimaraes & Ramanujam (1986)<br>Factors Impacting PC Success | None reported |
| Henderson & Treacy (1986)<br>Different Perspectives for Managing EUC | Support for portions of two later stages (Brown & Wynne 1990) |
| Laudon (1986)<br>Hypothesis tests only | Organization actions and end-user actions related to technology stage |
| Pyburn (1986-87)<br>Evolution of PC Management Discipline | None reported |
| Alavi et al. (1987-88)<br>End-User Computing Strategies | Support for portions of model (Brown & Wynne 1990) |
| Munro et al (1987-88)<br>Four Strategies for End-User Computing (Revision of Expansion-Control Framework in Munro & Huff 1985) | Partial support for evolutionary model (Brancheau & Amoroso 1990) Support for Acceleration and Containment strategies (Saarinen et al 1988, Brown & Wynne 1990) |
| Huff et al (1988)<br>Growth Stages of End User Computing | None reported |
| Magal & Carr (1988) | Importance of CSFs for IC remain the same over time. |
| Brown & Bostrom (1989b)<br>Model of EUC Management Effectiveness (Applied Theory: Innovation Management) | Partial support for model by same authors (Brown & Bostrom 1989a) |
| Magal (1989)<br>Stages of IC Growth | Support for benchmark variable descriptions for 3 of 4 stages by author |
| Klepper (1990a)<br>Establishment of Information Center (Applied Theory: Agency Theory | None reported |
| Raymond (1990)<br>Organizational Postures of Small Business | None reported |
| Robey & Zmud (1990)<br>Rise and Demise of Information Center Applied Theory: exemplars from organization science | None reported |

**Figure 4.** Findings for organization component

by the same authors has been published [Brown and Bostrom 1989a].

Other studies address relationships among two or more of the organization factors, but do not assume an evolutionary approach (i.e., that management actions must vary over time). For example, in their widely cited article, Rockart and Flannery [1983] prescribe separate IS and user management responsibilities for a new "shared" end-user environment. Panko [1987] expands on this idea and proposes five environments with delegated development versus end-user development on one axis, and application size on the other. Similarly, Leitheiser and Wetherbe [1986] prescribe different management actions for differing hardware, software, and database needs. Among the empirical studies that do not assume an evolutionary approach, Laudon [1986] provides support for the contingency hypothesis that more control policies and centralized decision making are found in organizations with more sophisticated EUC technology.

### 3.5 Summary of Organization Component Findings

Figure 4 summarizes the studies which provide conceptual models or frameworks, or contain hypothesis testing, for factors in the organization component.

Among the models/frameworks identified, four of these are evolutionary models independently developed during the same time period [Henderson and Treacy 1986; Pyburn 1986–1987; Alavi et al. 1987–1988; Munro et al. 1987–1988]. More recent studies apply theory from innovation management [Brown and Bostrom 1989b], agency theory [Klepper 1990a], and representative theories from the organization sciences [Robey and Zmud 1990].

As shown in Figure 4, portions of only six of the models have undergone some form of validation within the literature surveyed, and only three validation studies include hypothesis testing by researchers who were not the original modelers [Carr 1987; White and Christy 1987; Brancheau and Amoroso 1990]. Due to both the small number of validation studies and the small research samples in these studies, there is too little empirical evidence to make a definitive argument for either adopting or discarding any of these models in their entirety.

Nevertheless, the literature analyzed here provides several insights into the factors that are important for the management of EUC. Four major points can be made. First, while the characteristics of the typical microcomputer and mainframe EUC environments of the early 1980s have changed, research still supports the idea of planning an infrastructure to match characteristics of the current EUC investment. The calls for an increased focus on strategic planning in the EUC literature parallel with the concerns of the IS strategic-planning literature of the same time period. By the late 1980s, field data support the importance of integrating the EUC plan with the overall IS plan.

Second, there is considerable evidence that a contingency approach is appropriate. All of the evolutionary models [Henderson and Treacy 1986; Pyburn 1986–1987; Alavi et al. 1987–1988; Huff et al. 1988] suggest that management actions need to change over time in response to the level of EUC maturity or learning. However, there is also evidence that the entire range of strategy/action options may not be totally understood. This may be due in part to the fact that most of the evolutionary EUC management models were conceptualized on the basis of field observations from the early to mid-1980s, well before the mixed environment of micro–mainframe linkages or networked micros is reported as the norm. The aspects of EUC which are greatly impacted by this dynamic environment may not be well accounted for in these models. Further, earlier concerns about risk management policies and procedures directed at user-developed applications may not be as important in the EUC technological environment of the 1990s. Increased reliance on networked platforms that cross functional boundaries, for example, would appear to constrain an earlier range of choices for the locus of authority for some technology-decisions.

The paucity of validation studies for the evolutionary models is understandable given the methodological requirements: testing models of this complexity requires large samples, validated measurements, and longitudinal designs. Nevertheless, we encourage EUC management researchers to test the validity of these models so that we know what to retain and what to discard. Researchers not in a position to embark on such projects should be encouraged to work on increasing our understanding of the variables at the factor level within a contingency framework. For example, many stage models have been proposed, but we have no validated measures of EUC maturity stages. Today we have the opportunity to study organizations that are far along the EUC growth curve, whereas earlier researchers report having found no such examples in the field. We also have the opportunity to extend these prior models to account for technological changes such as those cited above.

Third, there is a strong evidence that the "normative model" described by Hammond is an inappropriate yardstick for evaluating current EUC management actions implemented under a central unit such as an information center. ICs are not uniformly designed organizational units. They are introduced and then molded within the context of the organization's current EUC strategy and level of EUC technology investment. For ICs located within an IS department, relationships with other IS units, as well as other EUC-linking mechanisms, need to be explored. The abandonment of an IC unit by some organizations has been highlighted in the practitioner press (for example, Brzezinski [1987]), but not well researched. Robey and Zmud's [1990] litany of organizational theories that might explain the "rise and demise" of the IC provide considerable food for thought for interested researchers.

Fourth, and not totally reflected in Figure 4, research on the EUC management infrastructure has usually taken too narrow a view and failed to address the full range of formal and informal mechanisms that can be applied (with and without formal integrating units such as an IC). There is strong evidence that *informal* mechanisms are heavily relied on by end users. Further, mechanisms such as user groups can be established from top-down mandates, as well as from bottom-up concerns, but we know little about differences in their structure and effectiveness.

## 4. LITERATURE ON INDIVIDUAL COMPONENT

The individual component of the model encompasses the adoption and use of IT by end users to develop software applications in support of organizational tasks. The research model in Figure 1 includes four factors for this component: end user (3a), task (3b), tool (3c), and end-user action (3d). A list of variables associated with the individual EUC management component is provided in Figure 5.

### 4.1 End User (3a)

Given that EUC is a relatively new phenomenon, a key research issue concerns learning more about those individuals who develop software applications. Early studies report descriptive data on the background of end users and the source of their computer education [Benson 1983; Lee 1986; Pyburn 1986–1987]. Depending on the population sampled, researchers find that end users have relatively little experience [Lee 1986] or a great deal of experience with computers [Rivard and Huff 1985]. Another study reports descriptive data on changes in end-user characteristics over time [Klepper and Sumner 1990]. They note that user developers tend to be more experienced than typically acknowledged by the literature. Additionally, they observe that user managers increased their efforts to hire personnel with computer experience over the study period.

Other studies attempt to organize their observations about end users into various classification schemes [Rockart and Flannery 1983; Rivard and Huff 1985; Brancheau and Wetherbe 1989; Cotterman and Kumar 1989]. The most widely cited classification scheme is the typology of Rockart and Flannery. Based on field observations, they categorize individuals from "nonprogramming users," who only access computers with software provided by others, through "IS programmers," who develop sophisticated applications. One of their more interesting types is "functional support personnel." This type of individual is highly skilled with EUC tools and supports other users (and in some cases entire departments) through the development of software applications.

As is typical with field-based classification schemes, the Rockart and Flannery [1983] typology implicitly incorporates several dimensions. The dimension of tool skill (low to high) is well incorporated while functional reporting relationships (user or IS department) and application scope (individual to organizational) are incorporated less completely. Typologies such as this are useful but can hide potentially important concepts. More recently developed classification schemes may prove to offer a stronger basis for future research.

A typology based on innovation diffusion theory classifies end users by the

**END USER (3a)**
- **Personal**
  - Age
  - Cognitive traits
    - cognitive complexity, locus of control
  - Motivational traits
    - motivation toward security & control
  - Computer anxiety
  - Behavioral intention
    - attitude toward adopting
  - Communication behavior
    - media exposure
    - external participation
    - channel usage
- **Education/Experience**
  - Education
  - IS education/knowledge
    - number of systems developed
  - Prior tool experience
  - Time since adoption
  - Tool training/skills/ability
    - computer-related skill
    - accurate mental model
  - Task/domain knowledge

**TASK (3b)**
- **Position**
  - Functional area
  - Position level
  - Autonomy
  - Number of subordinates
  - Role characteristics
    - job role, role clarity
- **Specific Task**
  - Task type
  - Scope (individual, workgroup, org, interorg)
  - Data requirements (source, volume)
  - Interdependence (pooled, seq, reciprocal)
  - Task centrality/criticality
  - Structuredness (specificity)
  - Repetitiveness (routine, nonroutine)

**TOOL (3c)**
- **Computing Environment**
  - Equipment access
    - availability (proximity, uncertainty)
  - Software access
    - functionality
  - Network access
    - corporate data access
  - Perceived direct cost to user
  - User-system interface
    - command vs. direct manipulation
- **Perceived Characteristics**
  - Relative advantage
  - Complexity (ease of use)
  - Compatibility
  - Trialability
  - Observability
    - visibility
    - result demonstrability
  - Image
  - Voluntariness

**END-USER ACTION (3d)**
- **Tool Utilization**
  - Adoption (no, yes)
  - Amount (frequency, length of use)
  - Diversity (number functions, tools)
  - Reliance (information inclusion)
  - Proficiency (skill level, sophistication)
- **EUC Support Options**
  - Access to IC services
  - Access to outside consultants, vendors
  - Access to informal communication network
- **Development Process**
  - Likelihood of EUC development (vs. IS)
  - Methodology
    - weak vs. strong
    - use of accepted practice
    - involvement of other users

**Figure 5.** Variables associated with individual component.

length of time it takes them to adopt EUC tools [Brancheau and Wetherbe 1989]. In this classification scheme, pioneers and early adopters are the first to adopt, with the majority and laggards the last to adopt EUC tools. Theory suggests that individuals tend to be systematically different across adopter categories. Empirical support for these differences is found in the adoption of spreadsheet software [Brancheau and Wetherbe 1990].

The "user cube" typology of end users is based on an analysis of prior conceptual work [Cotterman and Kumar 1989; Kumar and Cotterman 1990]. The user cube classifies users based on the dimensions of operation, development, and control. The resulting $2 \times 2 \times 2$ cube highlights eight ideal types ranging from pure consumers of information, with no hands-on use and no control over development, to highly involved users who operate, develop, and control their own computing applications. This typology should prove useful for researchers needing a multidimensional profile of the nature and extent of EUC in a given research setting. User cube profiles can also be aggregated to support research at the workgroup and organization levels of analysis. Measures need to be developed and validated for this typology to gain broad acceptance.

### 4.2 Task (3b)

Early studies of task focus on descriptive data with the position and function of the end-user common areas of inquiry. These studies find most end users located in the major staff areas of a company with professionals outnumbering managers by a three-to-one margin [Rockart and Flannery 1983; Pyburn 1986–1987]. Several reports indicate that staff functions such as finance and accounting have the highest proportion of end users [Pyburn 1986–1987; Brancheau and Wetherbe 1988; Amoroso et al. 1990]. It seems doubtful, however, that these trends will hold as EUC continues to expand within organizations.

Galletta and Heckman [1990] base their analysis of the EUC task environment on role theory. Role theory is concerned with the degree to which behavior is constrained by social structure. The authors use the theory to formulate a scheme for classifying user development roles. Their role matrix is based on the dimensions of tool use/development activity (user only, provider only, both user and provider) and organizational position (clerk, manager, professional). Each role is seen as a cluster of norms and expectations which interact with other roles to influence end-user action and EUC outcomes. Describing an individual's position in the role matrix can help researchers and managers better understand that individual's attitude and behavior, and might help predict EUC outcomes. The authors suggest a number of propositions for research, but no empirical data are reported.

Another perspective is concerned with the specific task for which a user develops software applications. In this view, task type and task scope (individual, workgroup, organizational) are important. Several studies find that most EUC tasks involve queries, reports, and simple analyses [Rockart and Flannery 1983; Rivard and Huff 1985; Lee 1986]. Depending on the types of users sampled, the scope of these tasks is quite broad. One study of functional support personnel finds most applications to be departmental in scope, with a significant minority of applications multidepartmental [Sumner and Klepper 1987a; 1987b]. It also finds that functional support personnel tend to build applications that rely on extracts from corporate databases, with personal databases taking on a minor role. Due to the interdependence of EUC tasks, several studies find that a large proportion (30–50%) of user data are rekeyed from paper [Rockart and Flannery 1983; Pyburn 1986–1987; Amoroso et al. 1990]. Other studies find that many (31%) user-developed applications receive input directly from other information systems, but that a smaller portion (16%) create output for other systems [Klepper and Sumner 1990]. These findings highlight the growing interdependence among user-developed applications.

### 4.3 Tool (3c)

Studies of tool use provide descriptive evidence for the popularity of mainframe timesharing tools [Rockart and Flannery 1983; Lee 1986] and personal computers [Lee 1986; Pyburn 1986–1987; Hackathorn 1987]. These studies often report on the types of software packages employed by users. They suggest that programming languages are most popular within the mainframe environment while spreadsheets are most popular within the PC environment [Lee 1986; Sumner and Klepper 1987a; Klepper and Sumner 1990]. A few studies point to different outcomes from the use of mainframe versus PC tools (for example, Ghani and Al-Meer [1989]). Unfortunately, most studies ignore the specific characteristics of tools employed by end users. This may be due to the assumption that standard tool characteristics are well known. Given the diversity and rate of change of EUC tools, however, this assumption is questionable.

Innovation diffusion theory suggests that tool characteristics are important determinants of adoption and subsequent end-user action. Thus a user's perception of the relative advantage, complexity, compatibility, trialability, and observability of a tool are proposed to impact end-user action and EUC outcomes [Moore 1987]. While empirical support exists in the reference literature, by 1990 no empirical support is reported in the EUC literature.

### 4.4 End-User Action (3d)

Research on end-user action often takes the form of descriptive studies of EUC tool utilization. These studies help catalogue the amount of time end users utilize specific types of equipment and software [Rockart and Flannery 1983; Rivard and Huff 1985; Lee 1986; Pyburn 1986–1987; Hackathorn 1987] and the diversity of the functions they employ [Rivard and Huff 1985; Lee 1986]. Diversity of function is suggested as an important measure of end-user sophistication [Lee 1986]. A more recent study finds that tool utilization is multidimensional and includes frequency of use, time spent, number of applications, information inclusion, and level of sophistication [Igbaria et al. 1989]. These studies illustrate the growing numbers of hours users spend developing applications and the broad range of functions employed, but they do not provide a clear measure of utilization level or its rate of increase. Despite its importance in IS research (for example, Trice and Treacy [1988], no progress has been made toward developing valid and reliable measures of utilization.

Several confirmatory studies investigate the linkage between tool utilization and other individual factors. One empirical study investigates relationships between various end-user characteristics and five dimensions of microcomputer utilization [Igbaria et al. 1989]. A positive relationship with prior computer experience and a negative relationship with computer anxiety are reported. A study of public accountants examines the link between perceived tool availability and tool utilization [Gogan 1990b]. The study finds that user uncertainty concerning PC availability exerts a major influence on the level of utilization and that both location and portability are important dimensions of availability. Another empirical study examines the relationship between end-user characteristics and tool adoption [Brancheau and Wetherbe 1990]. The study finds age, education, media exposure, and opinion leadership related to year of spreadsheet adoption. Thus, certain types of individuals are more likely to adopt EUC tools than other types of individuals. The study also finds that interpersonal communication channels are highly influential in the tool adoption process.

Cheney et al. [1986] propose that task structuredness, repetitiveness, and interdependence are positively related to successful tool utilization. However, empirical evidence is not supportive of one aspect of the model: task *independence* is found to more likely lead to successful utilization than task interdependence (for example, Lee [1986] and Pentland [1989]). One study cites the fit between the types of professional work found in accounting, finance, and marketing and the capabilities of PC software as an important reason for PC use [Lee 1986]. Another study cites the lack of fit between personal workstation tools and clerical tasks as an explanation for the lack of enthusiasm for tool adoption among clerical personnel [Moore 1987]. Carlsson's [1990] exploratory study of the nonadoption of spreadsheet software provides empirical evidence that an inappropriate task/tool fit can lead to nonadoption of EUC. Finally, Mawhinney and Lederer [1990] propose a comprehensive model of four groups of variables with antecedent relationships with the tool utilization variable. Partial support for end user, task, and tool items is reported for two different samples. Taken together, these studies suggest that PC availability, fit with task, prior computer experience, education, and interpersonal communication behavior work to increase tool adoption and utilization. This is important because tool adoption and use are preconditions for the development of software applications.

Another line of inquiry investigates end-user access to specific support options. Descriptive data indicate that end users look to colleagues for support more frequently than any other source and that the "informal network" is also their most important source of support (for example, Lee [1986], Brancheau and Wetherbe [1988], and George et al. [1990]). IS-provided support ranks a distant second in both frequency of use and importance. Vendor-provided services are utilized even less frequently than IS support and are still less important. As discussed in Section 5 below, these data support the idea that the establishment of formal support mechanisms may not always be the best use of resources.

Alavi and Weiss [1985–1986] draw attention to the parallel nature of IS department and end-user application development processes. The authors suggest that failure to follow accepted computing practices leads to unfavorable outcomes. Necco and Tsai [1988] report that IS managers recommend that end users employing high-level languages adopt the same standards and procedures as IS personnel employing procedural languages, especially for system documentation. An empirical examination of the end-user development process finds that users typically do not follow standard systems development practices despite their development of operationally and strategically important systems [Sumner and Klepper 1987a]. This finding is discussed in Section 6 in terms of its implications for application quality.

### 4.5 Summary of Individual Component Findings

Taken together, the studies reviewed in Section 4 give us some insight into individual EUC activities. Field data suggest that levels of technology education and experience among users are on the rise and that computing expertise is often sought when new employees are hired. These data also suggest that professionals in staff positions using spreadsheet software represent the prototypical situation by the mid-1980s. They also suggest that the scope and interdependence of typical user-developed applications are increasing. Field data indicate that users are the most frequent and most important source of support for EUC. Initial findings suggest that user developers do not necessarily follow accepted practices relating to the development and hygiene of software applications. Given the increasing scope and interdependence of EUC applications, there may be reason for concern about this problem. It is not yet known, however, to what extent this deviation from accepted practice differs from similar deviations by professional developers found in many IS departments. Given the rapid pace of change in the EUC environment, the published descriptive studies on tool characteristics are too old and too disconnected to provide a clear basis for accurately describing the present or projecting into the future. What is needed are more broad-based descriptive studies not biased toward interesting applications and leading organizations. Benjamin's [1982] early study of the Xerox Corporation provides an example of the type of work needed.

The limited evidence available suggests that some types of users are more likely to adopt and utilize EUC tools than others and that these users must be reasonably certain that the tool will be available when it is needed. Similar to the situation for IS research in general, tool utilization is a complex and poorly understood construct. Progress in understanding utilization will be slow until im-

| **Study/Model** | **Empirical Validation/Findings** |
|---|---|
| Rockart & Flannery (1983)<br>Classification of End Users | None reported |
| Rivard & Huff (1985)<br>Taxonomies of Users and Applications | None reported |
| Moore (1987)<br>Innovation Decision Model<br>(Applied Theory: Innovation Diffusion, Reasoned Action) | None reported |
| Cotterman & Kumar (1989)<br>User Cube: Taxonomy of End Users | None reported |
| Doll & Torkzadeh (1989)<br>Discrepancy Model of User Involvement | Support for 8 of 9 contrasting pairs by same authors. |
| Brancheau & Wetherbe (1990)<br>Models for Adopter Distribution, Adopter Categories, Individual Adoption Process<br>(Applied Theory: Innovation Diffusion) | Support for portions of all three models by same authors including S-shaped adopter distribution, differences between adopters, and differences in channel usage. |
| Galletta & Heckman (1990)<br>Information System Role Matrix<br>(Applied Theory: Role Theory) | None reported |
| Gogan (1990b)<br>A General Framework of Individual IT Use | Qualitative support for relationship between tool availability and tool utilization by same author |
| Mawhinney & Lederer (1990)<br>Model of PC System Utilization | Support for 7 of 19 hypotheses by same authors. |

**Figure 6.** Findings for individual component.

proved definitions and measures are developed. Since 1990, progress is evident in developing valid and reliable measures of perceived tool characteristics (for example, Moore and Benbasat [1991]), but similar efforts need to be made for other important constructs.

Although Rockart and Flannery's [1983] seminal article offered a starting point for the important definitional area of end-user role classification in 1983, progress in this area has been slow. To date, the only end-user typology which anyone has attempted to validate is the adopter classification scheme borrowed from innovation diffusion theory. Today, many researchers still profile their samples in terms of the Rockart and Flannery classification scheme and conduct research which fails to distinguish between end users who develop systems and those who just use applications developed by others. Future researchers need to be more careful to profile their research samples in ways that facilitate comparison with other studies. The user cube offers one approach. Other less complex constructs such as tool skill or computer self-efficacy (for example, Murphy et al. [1989]) should also prove useful in efforts to profile end users.

Figure 6 summarizes the studies which provide conceptual models or frameworks, or contain hypothesis testing, for factors in the individual component. Among the nine models or frameworks we identified, only three are explicitly theory based [Moore 1987; Brancheau and Wetherbe 1990; Galletta and Heckman 1990]. End-user role classifications are investigated in four studies [Rockart and Flannery 1983; Rivard and Huff 1985; Cotterman and Kumar 1989; Galletta and Heckman 1990]. The remaining models focus on end-user actions. The more recent studies include some empirical validation by the modelers. Among the studies in Figure 6 that contain hypothesis tests, three are model validation studies by the authors of the models.

Two conclusions can be drawn from the individual component studies. First, the scope and interdependence of EUC applications are increasing. Even though recent studies have not focused on the EUC environment, enough descriptive data are available to suggest that end-user-developed applications are broad in scope. The modest evidence which exists indicates that increasing numbers of applications are being linked electronically. More descriptive data are needed to determine the extent of this trend toward interconnectivity.

Second, innovation diffusion theory appears to provide a viable basis for future research at the individual level. Based on empirical evidence in the reference literature and initial tests in the EUC context, it appears that end users differ markedly across the adoption curve. It also seems clear that interpersonal channels are more influential than mass media channels in the adoption and utilization process. The perceived characteristics of tools also appear to be influential in the adoption process. Other components of innovation diffusion theory should prove useful for understanding end-user computing, but additional empirical tests are needed.

## 5. LITERATURE ON ORGANIZATION/ INDIVIDUAL LINKAGE

This section surveys the literature that addresses relationships between the organization and individual components, as represented by the double-headed arrow between these components in Figure 1. This aspect of the model is crucial since it captures the type and degree of impact that management strategy and tactics for EUC have on end-user development activities and vice versa.

### 5.1 Organization / Individual Linkage

The majority of studies linking the organization and individual components investigate the relationship between management action (2c) and end-user action (3d), and many of these focus on EUC training. For example, Nelson and Cheney [1987] report that better training (technique and amount) leads to greater computer-related ability, which in turn is related to higher EUC tool utilization. Pentland [1989] finds that for training to improve effectiveness, the time delay between training and on-the-job use must be minimized. Sein et al. [1987] argue that the long-run success of learning is highly dependent on the existence of supportive elements in the user's workgroup environment, including integrating units such as an IC and designated local consultants. Thus, the available evidence supports the notion that training can be a positive force in EUC management, but it must be appropriately timed and combined with ongoing support.

Focusing on cognitive aspects of training. Sein and Bostrom [1990] find that the effectiveness of various types of mental models developed in EUC training depend on both individual differences and the intended use of the model. For example, while analogical models may be useful for introducing EUC to novices, abstract models may be more useful once a user gains experience. Davis and Davis [1990] find evidence for human information-processing style as a moderating variable in the relationship between training method and learning performance, while Bostrom et al. [1990] find similar support for their learning style variable. These studies suggest that there is no one best way to train end users, and an organization's approach to training may need to evolve as user skill levels increase.

Other studies not focusing specifically on training address the need to realign organization factors with characteristics of the end-user population over time. For example, Brancheau and Wetherbe [1989] describe end users in terms of a four-part typology of EUC adopters and prescribe ways for managers to leverage the strengths of different adopter categories over time. Magal [1989] profiles end users over time in terms of their growing diversity and demands for IC services. In contrast to the studies reported in Section 3, these studies suggest contingent management approaches based on end-user characteristics.

Returning to studies which investigate

relationships between management action and end-user action, several researchers propose guidelines for management actions to minimize the risks of end-user application development. For example, Alavi and Weiss [1985–1986] propose EUC controls based on systems development life cycle (SDLC) stages. Pyburn [1986–1987] proposes stronger controls for applications with broader scope. Porter [1986] proposes a model in which IS and user management actions are dependent on the perceived benefit and beneficiary (individual versus organization) of the EUC activity. Similarly, Gogan [1990a] proposes management actions contingent on the opportunity/risk profile of the application. Taken together, these primarily conceptual studies suggest a set of task-based contingencies for EUC management action.

Additional empirical studies suggest that management actions alone may not always be effective in influencing end-user computing practices. In a study examining PC security-related behavior, Frank and Shamir [1990] find that informal norms are related to end-user action, but formal policies are not. Brancheau and Wetherbe [1990] also find no relationship between management action (IC contact with user) and the adoption of spreadsheet software by end users. They call for studies which address the reciprocal relationship between end-user and management actions.

Finally, two studies argue for the utility of applying economic theory to EUC management studies. Gurbaxani and Kemerer [1990] describe the growth of EUC from an agent-theoretic perspective in which EUC is an alternative to centralized application development, and actions may be shaped as much by competition as by cooperation. Klepper [1990a] takes a transaction cost perspective in proposing a model in which key individual variables (use experience, task characteristics) combine with organization and internal context variables to determine the likelihood of end-user development. No empirical tests of the agency or transaction cost perspective are known.

### 5.2 Summary of Organization/Individual Findings

Figure 7 summarizes the studies which provide conceptual models or frameworks, or contain hypothesis testing, for relationships between organization and individual factors. Of the ten models identified, only three have been subjected to validation studies, and none of these are by independent authors. Some of the more recent models apply innovation diffusion theory [Brancheau and Wetherbe 1989] and agency or transaction cost theory [Gurbaxani and Kemerer 1990; Klepper 1990a]. The remaining two empirical studies are laboratory experiments that test hypotheses on end-user training.

Several conclusions can be drawn from this group of studies. First, conceptual work as well as field data suggests that to be effective, EUC management actions need to be contingent on several factors other than strategy and technology, as discussed in Section 3. These other factors include task-based contingencies (e.g., application scope and opportunity/risk analyses) and user-based contingencies (e.g., personal traits and tool skill level).

Second, the existing evidence does not confirm the efficacy of formal management actions for controling end-user actions. Specifically, control policies/procedures alone do not appear to be effective. There is, however, strong evidence that informal networks (operating through peer groups) exert a potent influence on individual tool adoption decisions, computing ability, tool utilization, and PC security-related behavior.

Third, of the various management actions examined in the published research, training appears to be the most influential. There is a substantial evidence that training leads to increased tool utilization and competency. This in turn should lead to favorable outcomes for individuals, workgroups, and organizations. But even training actions are found to be more efficacious when timed to coincide with task demands, supple-

| Study/Model | Empirical Validation/Findings |
|---|---|
| Cheney et al (1986)<br>Variables That Affect EUC Success | None reported |
| Porter (1986)<br>Benefit vs Beneficiary Grid | None reported |
| Pyburn (1986-87)<br>PC Management Strategy based on Application Type | None reported |
| Nelson & Cheney (1987)<br>Descriptive Model for Organizational Learning and Acceptance of IS Technologies | Support for 2 of 3 relationships by same authors finding that training leads to greater ability and higher tool utilization. |
| Sein et al. (1987)<br>End-User Training Framework | Partial support for model by same authors (Bostrom et al 1990, Sein & Bostrom 1990) finding analogical models more effective for novices and abstract models more effective for experienced users. |
| Brancheau & Wetherbe (1989)<br>An Overall Strategy for Introducing New Technology (Applied theory. Innovation Diffusion) | None reported |
| Frank & Shamir (1990)<br>Model of Factors Influencing PC Security-Related Behavior | Support for 3 of 6 relationships by same authors including the influence of user ability and informal norms on PC security-related behavior |
| Gogan (1990a)<br>Assessment of End-User Application 1) Opportunities and 2) Risks | None reported |
| Gurbaxani & Kemerer (1990)<br>End-User Computing Management Applied Theory: Agency Theory | None reported |
| Klepper (1990a)<br>Model for End-User vs. IS Development (Applied Theory: Transaction Cost) | None reported |
| Davis & Davis (1990)<br>Hypothesis tests only | Human information processing type moderates effect of training method |
| Gattiker & Paulson (1990)<br>Hypothesis tests only | EUC teaching methods impact students with different levels of academic performance differently |

**Figure 7.** Findings for organization-individual linkage.

mented with posttraining support, and encouraged by workgroup norms.

## 6. LITERATURE ON CONTEXT AND OUTCOME COMPONENTS

This section analyzes the literature for both the antecedent and consequence components of our research model. A list of variables associated with the factors in these components is provided in Figures 8 and 9.

### 6.1 Context Component

The research model includes contextual factors internal and external to a given organization. In Figure 1 we model one external factor (1a) and three internal factors: organization (1b), workgroup (1c), and technology investment (1d). Although a perusal of the context column in Figure 2 suggests considerable attention to context factors, many of these studies include context variables only as research controls. We actually have little knowledge about relationships between context factors and the EUC management factors.

Only one EUC management study explicitly investigates the external context factor (1a). EinDor and Segev [1990] examine the socio-cultural category by comparing a sample of end users from U.S. companies with a sample from Israel. Among their five sets of variables—which include internal context, EUC organization, and individual factors—the only statistically significant differences are for technology (2b) and tool (3c) variables. The study finds that packaged software is more dominant in the EUC environ-

**EXTERNAL (1a)**
- **Socio-Cultural**
  - National culture
  - Language(s)
- **Technology Availability**
  - Existing technology architecture
  - External adoption level
  - Vendor support
  - Rate of change in computer industry

**ORGANIZATION (1b)**
- **Enterprise**
  - Sector (public, private)
  - Planning horizon
    - short, medium, long
  - Industry
    - rate of technological change
  - Information intensity
  - Company size, slack
    - revenues, number employees, profitability
  - Life cycle, stage of growth
- **Cultural**
  - Innovativeness
  - Readiness for change
  - Top management support for EUC
- **Structure**
  - Structural configuration
    - degree divisionalized
  - Structural form
    - centralization of decision making
    - organic vs mechanistic
    - degree of professionalism

**WORKGROUP (1c)**
- **Information Systems Function**
  - IS budget
    - EUC budget, overall budget
  - Number IS employees
  - Staff characteristics
    - technical vs. business knowledge
  - IS effectiveness
    - credibility, responsiveness
  - IS culture, norms
    - innovativeness, readiness for change
    - IS management support for EUC
    - goal congruence
  - IS organizational power
  - Structural design
    - reporting location
    - subunit organization
  - Structural form
- **User Department/Workgroup**
  - Budget for EUC resources
  - Number of end users
  - Number of employees
  - Characteristics of employees
  - Informal communication network
    - gatekeepers, opinion leaders
  - Culture, norms
  - Structural design
  - Structural form

**TECHNOLOGY INVESTMENT (1d)**
- **Technology Architecture**
  - EDP stage and computer resources
  - Existing technical architecture
    - platforms, databases
  - Size investment ($, % of IS budget)
  - Degree system development automation
- **System Application Portfolio (current & future)**
  - Application types
  - Size, complexity
  - Strategic nature
  - System development backlog

**Figure 8.** Variables associated with context component.

ment of the U.S. than in Israel, where IS-developed software is more of a factor. Unfortunately, the two national samples also differ in industry sector and firm size, so these findings may not be generalized beyond the research sample.

Within the organization context factor (1b), top management support for EUC is recognized early on as an important variable (for example, Benson [1983]). Management support is also found to be a critical success factor for ICs [Magal and Carr 1988]. Another study suggests that firms of small organizational size have a different set of EUC success factors than firms of large size [Raymond 1990]. Several other empirical studies control for organization variables such as sector, industry, information intensity, and/or size by the sampling method (for example, Rivard and Huff [1988], Pentland [1989], Lepore et al. [1989], and Brancheau and Wetherbe [1990]).

Within the IS workgroup (1c), effectiveness variables such as credibility and responsiveness and cultural variables such as readiness for change and management support are conceptualized as important antecedents for the organizational component (for example, Rockart and Flannery [1983], Pyburn [1986–1987], Rivard and Huff [1988], and Klepper [1990b]). Within the user department/ workgroup (also part of factor 1c), the informal communication network is repeatedly found to be an important mechanism for EUC-related support (see Section 3) and a critical communication channel for the individual end-users's adoption decision process (see Section 4)

Regarding the technology investment factor (1d), a late EDP stage and the existence of systems development automation tools are reported as correlates of information center implementation [Necco et al. 1987]. Larger IT equipment investments and more complex application portfolios are found to correlate with increased levels of EUC within a sample of small manufacturing firms [Raymond 1987]. The potential relationships between the strategic nature of an organization's application portfolio and either the management action or end-user action factors are proposed but not empirically supported [Sumner and Klepper 1987a]. The size of the system development backlog continues to be conceptualized as an antecedent of IC formation (for example, Cheney et al. [1986], and Klepper [1990b]) and an important variable for predicting end-user action [Klepper 1990a], but backlog reduction is not an empirically supported outcome variable (for example, Rivard and Huff [1984]).

### 6.2 Outcome Component

As shown in Figure 1, the outcome component is partitioned into four factors based on the unit of analysis: organization (4a), workgroup (4b), individual (4c), and application (4d). A list of variables associated with each of the factors is provided in Figure 9. Although a perusal of the outcome column in Figure 2 suggests considerable attention to this component, most of these variables are referenced in conceptual studies; few have been investigated empirically.

Several early studies focus on the general benefits and risks of end-user computing from the perspective of IS managers [Alavi 1985; Alavi and Weiss 1986–1987; Guimaraes and Ramunujam 1986; Couger 1986] and end users [Pyburn 1986–1987]. Benefits cited for end-user computing include: (1) better and more timely access to information, (2) improved quality of information, (3) improved decision making, (4) improved control by users, (5) improved information systems department/user relationships, and (6) lower systems development costs. In Figure 9, the first three of these are included as individual variables (4c); the second three are workgroup (4b) and application (4d) variables.

The risks of end-user computing cited by the above authors include: (1) unreliable systems due to lack of quality assurance procedures, (2) incompatible systems due to lack of standardized interfaces, (3) threats to data integrity, security, and privacy (4) use of private information systems when organizational systems would be more appropriate, (5) ineffective use of monetary resources, and (6) inefficient use of human resources. In Figure 9, the first four of these are included as application variables (4d); the next two are organization (4a) or workgroup (4b) variables. Unfortunately, convincing empirical evidence to document these benefits and risks is lacking.

Most studies that include criterion variables investigate outcome variables at the individual level of analysis. The majority of these examine different forms of user satisfaction, but a few noteworthy studies focus on the harder-to-measure outcomes of end-user computing literacy and productivity.[4] In their exploratory analysis, Rivard and Huff [1985] link user development of applications with three

[4] Our research model classifies "tool utilization" as an EUC management factor even though it is often employed as a dependent variable in published research. Due to our broader perspective on EUC management, the outcome variables specified in Figure 9 go beyond computing activity and encompass the actual impact of that activity.

**ORGANIZATION LEVEL (4a)**

- **EUC Adoption by Organization**
  - Number of end users
  - EUC technology investment
  - Organizational learning
- **Structure**
  - Structural configuration
  - Structural form
    - centralization of decision making
    - organic vs. mechanistic
- **Effectiveness**
  - Perceived effectiveness
  - Operating expense (IT, EUC)
  - Revenue
  - IT innovativeness of organization
  - IS/user communication

**WORKGROUP LEVEL (4b)**

- **Information Systems Function**
  - Demand for IS services
    - EUC support services
    - computer resources
    - system development backlog
    - % maintenance
  - Responsiveness to users
  - Organizational power
  - IS organizational characteristics
  - IS productivity
  - Perceived effectiveness (IC, overall IS)
- **User Department/Workgroup**
  - Number of EUC adopters
  - Independence from IS
  - Organizational characteristics
  - Workgroup productivity
  - Perceived effectiveness

**INDIVIDUAL LEVEL (4c)**

- **Satisfaction**
  - Overall user satisfaction
  - Autonomy (from IS, overall)
  - EUC activities, IC services
  - Tool satisfaction
  - Information access
  - Information satisfaction (UIS)
  - Quality of work life
- **Effectiveness**
  - Decision quality
  - Perceived effectiveness
    - symbolic, image, credibility
  - Productivity of employee
- **End User**
  - Personal
    - cognitive complexity
  - Education/experience
    - skill, ability

**APPLICATION LEVEL (4d)**

- **Maturity**
  - Connectedness
  - Scope of application
    - individual/workgroup/org/interorg
  - Opportunity/risk profile
- **Quality of Application**
  - Security controls
  - Documentation
  - Reliability
  - Maintainability
  - Machine efficiency
  - Data integrity
  - Ease of use
- **Effectiveness**
  - Perceived effectiveness
  - Time to develop
  - Cost to develop
  - Useful life

**Figure 9.** Variables associated with outcome component.

individual-level outcomes: improved productivity (subjective estimate), high satisfaction, and independence from the IS department. Later, Rivard and Huff [1988] report finding workgroup context (IS readiness for change), management action (degree of IS push), end user (prior computing experience and attitude toward EUC), and tool variables (friendliness, environmental setup) statistically linked to overall user satisfaction with EUC.

Several other studies provide evidence that management actions which include support services delivered by workgroup mechanisms, or which offer a degree of autonomy in the development process, are related to higher end-user satisfaction. For example, Lee [1986] finds that greater use of colleagues for EUC support correlates with greater satisfaction with personal computers. Doll and Torkzadeh [1989] report significantly higher satisfaction for users doing their own development compared with users depending on others for development. Ghani and Al-Meer [1989] identify a positive correlation between PC utilization and job satisfaction when an end-user's job contains tasks with broad scope. Finally, Alavi et al. [1990] find that outcome-based controls lead to more self determination, and more satisfaction with the development process, while behavior-based controls lead to better application hygiene (quality), but more personal stress.

Two other studies [Carlsson 1988; Pentland 1989] offer compelling support for the notion that tool use can have both positive and negative impacts on individual productivity. With a rigorous approach to measurement, Pentland examines the impact of end-user characteristics (age, prior experience, time with PC), end-user action (tool utilization and appropriateness for task), and management action (type training, gap between training and use) on individual productivity. The study finds that "marginal" tool use (i.e., inappropriate for the task) is related to reduced personal productivity. In one of the few longitudinal EUC studies, Carlsson [1988] tracks three end users' utilization of spreadsheet software and the resultant changes in their domain-specific cognitive structure over time. The study finds a positive relationship between spreadsheet use and integrative complexity which—based on empirical support in the reference literature—is deemed to lead to increased effectiveness in decision tasks.

Several studies focus on application-level outcomes. Related to the potential risks of EUC identified earlier, Alavi and Weiss [1985–1986] argue that a mismatch between tool and task can lead to ineffective and poor quality applications. Rivard and Huff [1985] link user development of applications with improved development timeliness but also with poorer documentation and reduced machine efficiency. Alavi et al. [1990] find that behavior-based control of EUC leads to enhanced application hygiene in terms of documentation, testing, and backup procedures. Despite these reports, Klepper and Sumner's [1990] two-wave field study of 51 user-developed applications with departmental scope finds that most (70%) applications required only evolutionary changes over the 18-month study period. Only 30% of the applications sampled had structural changes due to abandonment or merger with other systems. While not necessarily representative due to sample characteristics, this study suggests that some of the dire predictions for user-developed applications may not be warranted.

### 6.3 Summary of Context and Outcome Findings

Our analysis in Section 6.1 suggests that the relationships between context factors and variables in the EUC management components have not received much attention. This is not totally unexpected since IS management research has not always been successful at identifying significant relationships. Our analysis suggests that we have a modest amount of knowledge about outcomes at the individual and application levels, but even less empirical knowledge of outcomes at the organization and workgroup levels. The variables receiving the most attention belong to the end-user satisfaction category. Again, this situation is similar to the IS literature where most attention has been directed at developing valid and reliable measures for user information satisfaction.

Figure 10 summarizes the results of the literature which specifically tested a hypothesized relationship between either a context or outcome variable. Only ten studies are found which meet our criteria: three for context factors and seven for outcome factors. Among the three context studies identified in Figure 10a, two find support for relationships with the organization, workgroup, and technology investment factors, and the third finds modest support for relationships with the socio-cultural aspects of the external factor. Unfortunately, all three studies have potential design flaws: the first two utilize size measures for both independent and dependent variables (organization size, presence, or number of end users), and the third does not

**A: CONTEXT FINDINGS**

| Study | Empirical Findings |
|---|---|
| Raymond (1987) | 5 of 10 context characteristics related to existence of EUC. |
| Lind et al. (1989) | Organization size and number of linking mechanisms predict total number microcomputers. |
| Ein-Dor & Segev (1990) | EUC technology and tool characteristics significantly different in two national samples. |

**B: OUTCOME FINDINGS**

| Study | Empirical Findings |
|---|---|
| Bergeron & Berube (1988) | High end-user satisfaction associated with 1) overall IS plan including EUC, 2) IC, and 3) hot line support. |
| Rivard & Huff (1988) | End-user satisfaction with IS services and independence from IS are determinants of overall user satisfaction |
| Lepore et al. (1989) | Decentralized decision-making, adequate support correlate with high QWL. |
| Pentland (1989) | Task/tool fit impacts relationship between utilization and productivity. |
| Alavi et al. (1990) | Behavior-based controls increase application hygiene. Outcome-based controls lead to more satisfaction with development process but more stress for end users |
| Igbaria & Nachman (1990) | Various individual-level variables and IS leadership style correlated with user satisfaction |
| Klepper & Sumner (1990) | Most user-developed applications required only evolutionary changes over 18 months with user turnover the greatest threat to stability |

**Figure 10.** Findings for context and outcome components.

account for context differences in industry and firm size between the two national samples.

Six of the seven outcome studies identified in Figure 10b are field studies, and five of these address the individual level of analysis. Each of the three studies testing a relationship with an end-user satisfaction measure utilize different surrogate measures for the dependent variable. This makes it difficult to draw conclusions. There is, however, growing evidence that the individual-level impacts of end-user computing depend on the appropriate fit between end user, task, and tool. There is also some initial evidence that user-developed applications may not be as unstable as previously thought.

Unfortunately, the literature in Figure 10 shows very little progress (from a positivist perspective) toward accumulating findings for either the context or outcome components. It is somewhat surprising that we do not know more about what differences in context are important for the management of EUC and what combinations of organization and individual factors result in effective EUC outcomes. Unlike the research for the EUC management components, little prior research exists to base recommendations on.

We need more research specifically directed at relationships between EUC management factors and external context variables such as industry structure, technology availability, and language. Now that papers on EUC management outside of North America are beginning to appear at U.S. conferences, opportunities for pursuing cross-cultural studies are more numerous.[5] A reported time lag in levels of EUC diffusion between the United States and nations in Asia and Central Europe also provides opportunities for exploiting our knowledge of EUC management in North America.

Many research opportunities also exist for examining for the internal context factors. Researchers can now investigate the way EUC management has unfolded within different types and sizes of firms. Cultural and structural influences may prove to be important. The workgroup influences on EUC management factors, including informal help networks, are particularly important and deserve more research. The technology investment factor should receive more attention as organizations evolve toward client/server platforms in the 1990s. In time, it will be difficult to distinguish a firm's overall IT investment from its investment in EUC technology (see Section 7.2).

Similarly, more research is needed on variables in the outcome component—after all, this is ultimately what EUC is all about. At the individual level, additional studies are needed to understand end-user computing satisfaction. Studies utilizing standardized instruments will help facilitate accumulation of knowledge. At least one major long-term study of desktop computing examining quality of worklife is in progress [Kling et al. 1990]; more are needed. With managers increasingly being called on to justify current and planned investments in EUC technology, research on end-user productivity is of major practitioner interest. Recent studies which provide convincing evidence of EUC outcomes can serve as exemplars for further research (for example, Pentland [1989], and Carlsson [1990]). Such studies can help determine the impact of long-term learning about EUC well beyond the first-order impacts of end-user software training. Group productivity and group effectiveness will also become more important in the future with the expected growth in local-area networks and with the increasing availability of tools designed to support collaborative work.

As for the effectiveness and quality of user-developed applications, the small amount of empirical evidence in the literature does not support the dire predictions of some early researchers. Researchers and managers might be advised to look at end-user-developed applications, not with an eye toward controling their development, but with an eye toward better educating and supporting their end-user developers to ensure application effectiveness beyond the short term.

Because of the difficulty of establishing cause-and-effect relationships, some might argue that research on the study of organization-level effectiveness may be counterproductive. Certainly such research is difficult to conduct. We argue that it is important to examine both real and perceived outcomes of end-user computing at the organization level. Harris and Katz's [1991] study on the relationship between IT investment and organizational performance may serve as an exemplar for this area of research.

## 7. FUTURE DIRECTIONS

Although more than 90 articles on EUC management have been published from 1983 to 1990, our analysis suggests that the field has generated only a small amount of empirically based knowledge about (1) the contingent relationships among EUC factors in the organization component, (2) the contingent relationships among the individual factors of end user, task, and tool and how they relate to end-user actions, (3) the reciprocal relationships between the organization EUC management factors and the individual factors, (4) the impacts of context

[5] For example, the Special Interest Group on Computer Personnel Research (SIGCPR) conference held in Cincinnati, Ohio (April 1992) included several papers reporting on EUC management practices outside the United States Similar papers are beginning to appear at the International Conference on Information Systems (ICIS) and the Hawaii International Conference on System Sciences (HICSS).

variables on EUC management factors, and (5) the outcomes of widespread end-user computing within organizations. Of growing concern to the practitioner, there is little empirical evidence to link organization and individual EUC management factors to organization-level outcome variables.

There are several reasons for this situation. First, there has been no overall framework to provide the "big picture" for researchers in this area. Second, the EUC phenomenon has a relatively short history, and many researchers have been involved in concurrent investigations. Third, it is possible that researchers have been reluctant to undertake validation studies of some previously published conceptual models out of a concern that the models were conceived at an earlier point within the dynamically changing EUC phenomenon. This concern is but one of several conceptual and methodological problems identified with empirical studies which attempted to validate the Gibson and Nolan stage model (for example, Benbasat et al. [1984]). Unfortunately, the result is that EUC management stage models which have received only partial or no empirical support are now being transmitted to tomorrow's managers via textbooks—a situation perhaps analogous to the transmission of the unvalidated Nolan stage model one decade earlier.

Our overall conclusion from the analyses in Sections 3–6 is that only modest progress has been made toward accumulating a body of knowledge for any of the research streams on EUC management. Too few studies build on prior literature, and even fewer studies utilize theory from reference disciplines to help build a cumulative research stream. The research model presented in Figure 1 can be utilized to help "make sense" of the prior literature and to help identify where a new study "fits in." An emphasis should be placed on studies which move a research stream from an exploratory to a confirmatory phase [Straub 1989] by improving the existing conceptual models and deriving propositions from them and by providing empirical data which have been collected and analyzed for the purposes of hypothesis testing (see Figures 4, 6, and 7). These types of inquiries maximize the field's opportunity for accumulating knowledge. On the other hand, we also will continue to need exploratory studies for investigating variables as yet unresearched, as well as for describing new characteristics that emerge over time.

The bidirectional relationships among EUC management factors depicted by double-headed arrows in the EUC management research model are not well researched. These arrows suggest the need for "fit" among factors within a component, as well as among components. Looking at the organization component, for example, an appropriate fit among strategy, technology, and management action variables at a specific point in time is implied. Similarly, within the individual component, an appropriate fit among end user, tool, task, and end-user action at a specific point in time is implied. A fit between the organization and individual components is also implied. Indeed, understanding how variables from these two components are related is the key to effective EUC management.

Although the evidence is not conclusive, the literature discussed in Sections 3–6 support our view that the coalignment of a large number of interacting variables is instrumental for producing positive outcomes for EUC. Additionally, we find that literature in the reference disciplines supports this conceptualization of fit and refers to it as "covariation." Future EUC researchers are referred to studies in the organization theory and strategic management literatures such as those by Drazin and Van de Ven [1985] and Venkatraman [1989] which provide guidelines for operationalizing and analyzing this and other conceptualizations of fit.

### 7.1 Methodological Issues

As discussed in Sections 3–6, many of the early EUC studies are concerned with "what it is" rather than "how it should be managed." Now that EUC research has matured, the field needs to establish shared meanings through well-developed definitions, clear statements of research scope, and tightly designed research. This section provides additional guidelines (and examplars) for the methodological issues that need to be addressed by EUC researchers.

### Grounding the Inquiry in Theory

Among the four dozen conceptual and empirical studies summarized in Figures 4, 6, 7, and 10 only nine studies are theory based. While this is considerably greater than the two percent found in the IS literature from 1968 to 1988 [Alavi et al. 1989], it is still somewhat disappointing given the recency of the EUC literature. For those who employ the scientific approach, a good theory not only provides testable propositions, but also guidance for selecting independent, intervening, and dependent variables, as well as for operationalizing and measuring those variables.

While the successful application of theory is dependent on the researcher's "ability to see the parallels between theoretical constructs and real problems" [Robey and Zmud 1990, p. 33], it can be argued that the EUC literature provides a wealth of descriptive data for helping to draw these parallels. Only a small number of theoretical frameworks are referenced in the literature. Depending on the EUC factors of interest, many additional theories can be applied. Robey and Zmud derive 16 propositions on the "rise and demise of information centers" by applying eight different theoretical perspectives from the organizational sciences. They demonstrate that this discipline is a rich source of theoretical models.

### Designing the Research Approach

A review of Figure 2 shows that researchers have relied almost totally on field study strategies with data collection by interview and questionnaire. This situation is not surprising given the existence of multiple stakeholder groups important for understanding EUC management. Field interviews allow for semi-structured approaches, and the personal contact helps to increase the commitment of research participants. But other research approaches must be considered.

Case studies can yield important insights. They are uniquely suited to open-ended, detailed investigation of EUC phenomena. Case studies are also well suited to investigating models with hundreds of variables and collecting data for network analyses. They can be employed to collect data over time and may be an inexpensive way to accumulate longitudinal data (for example, Carlsson [1990]).

Experimental designs can also yield important insights. Here judicious use of controls narrows the research to manageable number of variables. Laboratory experiments have recently yielded insights on end-user training [Bostrom et al. 1990; Sein and Bostrom 1990; Davis and Davis 1990]. This strategy appears to be a good choice for studying relationships between organization and individual factors if experiments can be designed to approximate a workgroup environment. No field experiments were located in our survey. These too can yield important knowledge. For some EUC inquiries, the risks inherent in this approach can be reduced by focusing on workgroup and individual issues.

Several evolutionary models await testing with longitudinal data. True longitudinal research is difficult to design and implement and is not always feasible. When retrospective data collection is employed, the use of focus groups is recommended. This approach is useful for achieving consensus on the events of interest (for example, Brancheau and Wetherbe [1990]). Cross-sectional field studies can also be enriched with follow-up data collection. This is a relatively inexpensive way to approximate a longitudinal design (for example, Klepper and Sumner [1990]).

### Sampling Populations

The characteristics of populations sampled and the appropriateness of a sample for a given inquiry have not always been addressed by EUC researchers. For example, none of the studies at the individual level make a rigorous attempt to survey a *representative* sample of an *overall* organizational population. The data reported are biased toward heavy users, interesting applications, and the IS department's perspective. Typical respondents in EUC management research include IS managers, IC managers, and end users. User department managers and executives are rarely represented.

When a sample contains different types of stakeholders, responses are often pooled without considering the effects on analysis. This problem might be attributable to slow progress in EUC role classifications. Today, however, enough conceptual progress has been made to expect researchers to be sensitive to the pitfalls of pooling responses from potentially different types of respondents. Recommended procedures for handling this problem include narrowing the sample to a specific class of respondents (for example, Sumner and Klepper [1987a]) or testing for significant differences between classes of respondents before pooling responses (for example, Cotterman and Kuman [1989]).

### Selecting Variables

The chronological listing of literature in Figure 2, the literature analysis presented in Sections 3–6, and the accompanying lists of research variables should reduce the need for independent scanning and synthesizing efforts by future EUC researchers. Some variables listed in Figures 3, 5, 8, and 9 have received less attention than others. Our discussion in Section 6, for example, makes numerous suggestions for selecting variables to study the context and outcome components. While research in the organization sciences can provide guidance here, the IS literature should also be consulted. There are also several examples of empirical studies which attempt to validate prior models or portions of models (see Figures 4, 6, and 7), as well as studies which rely on prior EUC research for selecting the variables of interest (for example, Saaksjarvi et al. [1978], Lind et al. [1989], Brancheau and Amoroso [1990], and Brown and Wynne [1990]). Examples also exist of research designs which control a number of context variables by either sample design (for example, Pentland [1989]) or statistical analysis (for example, Brancheau and Wetherbe [1990]).

### Measuring Variables

EUC researchers are strongly encouraged to borrow and refine measurement scales from relevant prior studies. The dual goals of consistent measurement and accumulated knowledge are more attainable, and time spent on rigorous scale development can be reduced. Studies measuring satisfaction at the individual level, for example, have utilized prior user information satisfaction and job satisfaction instruments (for example, Bergeron and Berube [1988], Ghani and Al-Meer [1989], and Igbaria and Nachman [1990]).

On the other hand, the relevance of instruments developed outside the EUC environment needs to be carefully considered. Doll and Torkzadeh [1988] and Torkzadeh and Doll [1991], for example, offer an instrument to measure EUC satisfaction based on the user information satisfaction instrument [Ives et al. 1983]. For this instrument they exclude items designed for the more "traditional DP environment" (EDP staff/services, user knowledge/involvement) and add items that measure ease of use and product information. This EUC satisfaction instrument is intended for direct users of any application, whether developed by an

IS professional or an end user, and should prove useful in future research where it can be tested and refined.

### 7.2 New Directions

We envision two themes to be important for EUC management research in the 1990s. The first theme relates to the recognition that in many organizations EUC has become an extension of organizational computing. Some authors have termed this the "convergence of organizational and end-user computing" [McLean and Kappelman 1992].[6] The second theme relates to EUC as a social-learning phenomenon. This theme relates to expanding our view of EUC to encompass the dual concepts of individual and organizational learning.

#### EUC as an Extension of Organizational Computing

Organizational computing has traditionally dealt with enterprise-wide applications based on mainframe computers. In contrast, end-user computing has traditionally dealt with individual and departmental applications based on personal computers. To date, the research on managing these activities remains disjoint. But two recent studies find that EUC is no longer clearly separable from organizational computing. McLean and Kappelman [1992] propose that EUC has become indistinguishable from corporate computing "by the type of application or by the size or type of hardware." They suggest that EUC be distinguished instead by the reporting relationship—i.e., computing which does not report directly to an IS department. Clark [1992] reports that some IS executives define EUC as standalone microcomputing, while others define it as synonymous with decentralized (or dispersed) systems development activities. We agree with these reports of "convergence" in terms of both technology and locus of responsibility.

The trend toward a convergence of information technologies has been widely forecast and is well recognized. We are rapidly moving toward a world of "information at your fingertips"[7] with user interfaces that are increasingly easy for people to use and software applications that are increasingly easy to generate. Within this environment, equipment architectures, operating systems, and network links are transparent to end users and accessible through uniform interfaces. The source of a particular data element of interest and the identity of the developer of a particular software application are camouflaged. Further research in computer science will be essential for providing the technologies and tools to make such an environment possible (see Hartmanis and Lin [1992]).

The trend toward convergence in terms of locus of responsibility for EUC and organizational computing may be less well understood. During the 1980s traditional IS tasks have been increasingly decentralized. Systems planning, development, and maintenance responsibilities are increasingly being assigned to multiple IS units (instead of a single central unit) in large U.S. organizations [Brown and Magill 1992]. Similarly, end-user support groups which combine IS and non-IS personnel have become commonplace. During the 1990s, the computer operations function is expected to become more decentralized due to increased downsizing options. Traditional distinctions between IS and end users will become more blurred as the dispersion of IS tasks and the hiring of employees with EUC skills accelerates in the future.

What does this trend mean for EUC management research of the 1990s? Information systems and computer science researchers are used to dealing with top-

[6] We find it "fitting" that a reconceptualization coauthored by McLean is leading us into the 1990s, just as a decade earlier he anticipated the user application development phenomenon of the 1980s [McLean 1979]

[7] The title of Microsoft CEO Bill Gates' keynote address for COMDEX Fall 1990

ics which are "moving targets." However, we propose that this trend has major consequences for EUC research. In studies which focus on the individual component, future research designs will need to account for the multiple relationships in our model. Increasingly robust designs will become a prerequisite for accumulating findings as tool characteristics evolve, end-user characteristics change, and the adoption and use of EUC tools becomes a position requirement instead of an individual option. Similarly, research which focuses on the organization component will need to account for major changes in EUC strategy and tactics. For example, EUC strategies may be a part of overall IS strategies, no longer aimed at tool diffusion per se but at diffusion of the "know-how" required to make the best use of these tools. End-user technology investments may be increasingly driven by departmental (or workgroup) computing instead of "personal" computing concerns. Specific support services or control policies/procedures may be embedded in the user interface rather than embodied in a centralized information center or local support group.

Conceptualizing EUC as an extension of organizational computing also signals the need for increasing attention to relationship among the components in our model. As discussed in Section 3, much of the literature on the organizational component has addressed EUC management actions only from the perspective of the IS organization, and many of these studies have focused only on organizations that have implemented a separate integrating unit, such as an information center. Investigations of EUC management actions need to be expanded to include potential relationships with traditional systems development activities, as well as activities outside the purview of a central IS department. Investigations of key factors in the context component also become important for accumulating knowledge. For example, we need to understand which EUC management differences are due to different organization designs for systems development and which are due to different industry characteristics. When attempting to apply "what we know" from North American EUC research to other nations, we will need to know which socio-cultural differences are important. As for relationships with the outcome component, if a primary attraction of EUC for end users is "more control over the form of computerization in their work" [Dunlop and Kling 1991, p. 195], then technology environments which affect perceived control need to be examined in future research on computer-human interaction.

Although the trend toward convergence will have major consequences for EUC management research in the 1990s, the research of the prior decade cannot be ignored. On the contrary, just as the exploratory field descriptions and conceptual work published in the mid-1980s were relied on by later EUC researchers to ground their work in theory, recent studies offer opportunities to move the field toward more confirmatory research.

### EUC as a Social-Learning Phenomenon

There is little doubt that innovations in end-user technology will continue to become available to users in the future. Pen-based computers, multimedia workstations, and personal-communication networks are either commercially available or just on the horizon. These and related IT innovations will enable further increases in the penetration and scope of end-user computing activities within organizations. Even as leading-edge companies determine effective ways to manage their existing technology investments, new technology applications will require additional investments and further adaptation and change. Given the general support we find for contingency models based on the level of EUC technology maturity, we believe the field needs to look more closely at the individual and organization learning which underlies the maturation process.

Innovation diffusion theory has already proved useful for understanding some aspects of EUC. Unfortunately, this theory fails to provide a complete explanation of the underlying processes involved in tool adoption and use. Some of the assumptions underlying the theory are not fully met in the end-user computing environment. Here again, our advice is not to ignore the theory, but to use it as an organizing framework for furthering understanding of EUC. EUC researchers have already incorporated the theory of reasoned action into the innovation diffusion framework to gain a clearer understanding of tool adoption and use by individual users [Moore and Benbasat 1992]. This theory helps explain individual behavior by examining behavioral intentions, attitudes, and subjective norms [Ajzen and Fishbein 1980]. Valid and reliable instruments now exist within the EUC context for supporting further empirical research. But other perspectives should also prove useful for augmenting the innovation diffusion framework. The knowledge barrier approach to innovation diffusion, for example, recognizes the critical role of learning in the adoption and diffusion of complex technologies [Attewell 1992]. In this view, the technical know-how and application knowledge required for effective IT use are important barriers to diffusion. A key for management becomes facilitating the reduction of such barriers and supporting individuals' efforts to overcome them. Social cognitive (learning) theory should prove useful for understanding how individuals overcome knowledge barriers [Bandura 1986; Wood and Bandura 1989; Compeau and Higgins 1991]. This theory explains psychosocial functioning (end-user action) in terms of bidirectional causation among personal factors, environmental events, and past behavior. The theory is broad in scope and rich in detail. It may prove more difficult to test than more simplistic learning theories, but our analysis and others' (for example, Klepper and Ryan [1992]) suggests that more refined learning models are required to improve understanding of EUC.

Moving beyond the individual component, decisions by end users to adopt and use EUC tools are not made in a vacuum. The organizational management of EUC both enables and constrains individual action and learning [Eveland and Tornatzky 1990]. Thus, factors such as management action, the boundaries between managers and end users, and the characteristics of the communication channels and linking mechanisms employed help shape individual tool adoption and use. Even though individual learning provides the foundation for organizational learning, the two processes are distinct. Organizational learning involves knowledge acquisition, storage, distribution, and interpretation which increases an organization's range of potential "behaviors" [Huber 1991]. Of the major processes involved, organizational memory appears the most critical (and least understood) for facilitating learning [Walsh and Ungson 1991]. Organizations often do not know what they know, and thus fail to apply lessons learned in the past (as when IS personnel and end users, or even pockets of end users, are isolated from one another). It seems possible that EUC management could play an important role in facilitating the maintenance of organizational memory and improving the distribution of knowledge about EUC within an organization. Further research aimed at the interaction between individual and organizational learning takes on theoretical importance for researchers and practical importance for managers. Other perspectives on EUC management are possible, but given the prevalence of change in the EUC environment, the learning paradigm should prove quite fruitful.

## 8. LIMITATIONS AND CONCLUSIONS

Despite its attempt to be comprehensive, this study has a number of limitations. First, our literature analysis is limited by its bibliographic scope. Given the selection of specific journals and North American conferences, the research on EUC management being conducted in Europe and Asia is not well represented. Relevant studies published by researchers in reference disciplines also may not be well represented. Second, due to the nature of the publication outlets examined, the survey has a bias toward positivism. Our assumption is that the positivistic approach is useful for understanding EUC management. Other approaches based on the interpretive perspective should also prove useful in the future, but they are not yet well represented in the literature [Orlikowski and Baroudi 1991].

Failure to build on prior EUC research and failure to rely on theoretical knowledge accumulated in key reference disciplines have been major obstacles to furthering our understanding of EUC management. To meaningfully contribute to the further development of EUC management research, future researchers need to build on prior research not only in the conceptual design of the study but also its execution. In addition to joining prior calls for theoretically grounded and longitudinal research, we recommend that future EUC research questions be better defined and narrower in scope, and that empirical investigations be more tightly controled. We argue for studies with stronger internal validity and suggest that the accumulation of these studies will move the field toward greater external validity. These efforts must be complemented with exploratory research aimed at describing new EUC management environments and investigating as yet unexamined variables and relationships.

Given the current pace of technological and organizational change, accumulating knowledge about EUC management is important. While EUC management research may lag too far behind the EUC phenomenon to provide meaningful guidelines for large companies with effective EUC management practices, much can be learned from their experiences that could be useful for companies not at the leading edge of the EUC phenomenon, as well as for individuals (professionals and students) who will be involved in EUC in the future. The EUC phenomenon is so prevalent today that any North American field researcher should be able to tap adequate-sized research samples with a range of EUC history and factor characteristics. The opportunity to apply findings to firms in nations which lag behind the U.S. and Canada in terms of EUC diffusion should not be overlooked. As this analysis suggests, a great deal of knowledge is still waiting to be discovered. Over the long term, the findings from EUC management research will increase our knowledge about managing organizational computing and improve our understanding of the interplay between the organizational and individual learning processes. For many organizations, these may be the keys to survival in the next century.

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