

Using End User Characteristics to Facilitate Effective Management of End User Computing

DONALD L. AMOROSO

University of Colorado, Colorado Springs

The End-User Characteristics Matrix, a mapping of user characteristics onto four end-user taxonomies, provides a more detailed perspective on the end user as developer/operator of computer-based information systems. Understanding individual end users is probably the most critical element to effectively managing end-user computing in organizations. Yet many managers do not really understand the end user they are attempting to manage. The purpose of this paper is to develop a framework which will allow the manager of end users to identify and describe user characteristics which differentiate, define, and help us better understand the end user. Previous literature on end users is discussed where four end-user taxonomies were presented, categorizing end users according to one or more characteristics, along with empirical research which utilized those taxonomies. The Rockart and Flannery end-user taxonomy has been the most widely used framework since 1983. The most comprehensive taxonomy, Cotterman and Kumar's User Cube, was used as the basis for definitions in this research. The end user located in the developer/operator plane, identified as the fastest growing category of end users, was investigated in depth. Empirical research in end-user computing was examined to identify the set of user characteristics. Researchers studying end-user computing can use the matrix as a starting point to visualize how past research taxonomies and empirical studies are interrelated. Practitioners, anxious to develop policies to manage EUC, can concentrate their efforts on certain user characteristics they observe to be problematic.

After a decade of wild and rampant growth in end-user computing (EUC), we are still searching for a set of principles which will allow us to more effectively manage it. A significant phenomenon of the 1980's, EUC continues to be an important issue for managers of tomorrow's organization. The increase in EUC literature provides evidence of this trend. Basically, managing end-user computing can only be more effective when we learn how to manage individual end users. We will only be able to take great leaps ahead when we have a better understanding of the end users we are managing.

Despite the growth of EUC, practitioners, academics, and vendors have different understandings of the

term "end-user computing". This term is often substituted for "user" or the person that "uses" the reports generated by a computer. In addition to different definitions and assumptions, there is a variety of end-user classification schemes from which to organize research designs. A research base which does not share common definitions from which to investigate end-user computing creates a number of difficulties. First, the results are not comparable because the same language is not spoken. We simply do not understand the end users we are studying. Second, some study findings, using different definitions, are contradictory and inconclusive. Surely we do not want to recommend to managers that

they establish corporate policies from inconclusive research results? Third, some researchers fail to utilize existing theoretical definitions in their variable operationalizations. As each of the frameworks offer differing perspectives on the end user, researchers in the end-user computing area have either been forced to choose one framework or create a new one in which to work.

Rockart and Flannery, early investigators of end-user computing, felt that top managers must understand their end users before they can even start to develop a strategy for effectively managing their EUC environment (Rockart and Flannery, 1983). Since 1982, several researchers have attempted to develop a categorization of end users in order to investigate a firm's EUC environment (Davis, 1985; Lefovitz, 1979; Martin, 1985; McLean, 1979; Rivard and Huff, 1985; Rockart and Flannery, 1983). A framework is necessary to provide researchers and practicing managers with a common way of comparing the results of investigative research. Further, it creates a relevant context for readers of the research to evaluate and interpret the results. Finally, a framework promotes commonly used definitions. Unfortunately, the characteristics classifying end users vary significantly in the literature. Frankly, another new typology is not needed; rather we simply need a better understanding of the end user using existing ones. In this research then, we will use the Cotterman and Kumar three-dimensional taxonomy of end users as a vehicle for our discussion in order to provide consistency of terminology (Cotterman and Kumar, 1989).

The purpose of this paper is to identify and describe user characteristics which differentiate, define, and help us better understand the end user. We will review the relevant literature on end-user computing in order to lay the groundwork for discussing those characteristics. Derived from the literature, four end-user taxonomies and ten user characteristics will be used to develop an End-User Characteristics Matrix. The diversity of the end-user community lends even more evidence for differentiated training, support, and software tools.

Review of the Literature

The MIS literature has portrayed the user in many different ways. Churchman and Schainblatt (1965) were the first to present a user/manager and analyst dichotomy (Churchman and Schainblatt, 1965). This dichotomy prompted the recommendation of the concept of "mutual understanding" between the user and the analyst. Users were categorized early in the MIS literature by the

way they interacted with the computer in order to obtain outputs. In this section, several end user taxonomies are presented along with empirical studies which utilized those taxonomies.

The CODASYL End-User Taxonomy

In 1979, the CODASYL End-User Facilities Committee, commissioned the study of the explosive growth in end-user computing, initially classifying users as direct or indirect, and later adding the category of the intermediary user (Lefkovitz, 1979). A *direct user* is one who interacts with a computer-based information system (IS) in either the batch or interactive mode to receive periodic computer reports. In contrast, an *indirect user* does not interface directly with the computer, but rather uses the outputs from the system to make decisions or perform tasks. An *intermediary user* interacts directly with the computer but does not utilize the output. Later, Joseph Davis (1985) developed a taxonomy of general MIS users from previous studies. He identified potential differences among the three CODASYL end-user categories which include direct, indirect, and autonomous users. An *autonomous user* is one who acts on his/her own behalf to interact with the computer. It was found that most end users categorized in previous studies fall into Davis' autonomous users category.

Three early attempts to classify end users illustrates the interest among IS practitioners and academicians alike in deriving a working definition of the MIS user. The CODASYL report was the first effort to classify the growing subset of end users. From that report, McLean (1979) and Martin (1982) developed basic classification schemes which included level of training, type of application, and level of technical understanding (Martin, 1985; McLean, 1979). Hackathorn and Keen (1981) describe an end user as computer users who have exercise direct, personal control over all aspects of information technology including equipment selection, software selection, software development, customization of applications, and data management. Hackathorn and Keen state, "...emphasis is on the end user of the technology, acting as programmer, analyst, etc. - without role differentiation". The emphasis of this research was on identifying user characteristics which focused on the relationship between the user and the technology. Differences were observed to occur both in the system usage and in the system development process.

The Rockart & Flannery End-User Taxonomy

Rockart and Flannery (1983) took a broader view of end-user computing than previous research studies when

they introduced six distinct classes of end users who differed significantly from each other in terms of computer skills, method of computer use, application focus, and the amount of support needed and obtained. *Nonprogramming end users* access computerized data through a limited, menu-driven application program usually provided by others. *Command-level end users* are able to specify, access, and manipulate data in order to generate unique reports. *End-user programmers* utilize both command and procedural languages directly for their own personal information needs. *Functional support personnel* support other end users and themselves in the development of applications. *End-user computing support personnel* and *DP programmers*, fluent in end-user languages, aid other end users in the development process.

Four studies utilized the Rockart and Flannery taxonomy as a means of classifying their respondents. In a study related to Rockart and Flannery, Quillard, et al. (1983) used the characteristics from the Rockart and Flannery study adding level of programming and level of technical understanding to their list. They derived a working definition of the end user as a person who develops an application primarily for his or her own use utilizing end-user software tools. Brancheau, et al. (1985) conducted a field study to obtain the end user's viewpoint regarding the information center. End users were self-classified based upon user descriptions provided by Rockart and Flannery. Experience was regarded as an important user characteristic. Sumner and Klepper (1987) investigated user applications with developing end users falling in Rockart and Flannery's *command level*, *end-user programmer*, and *functional support* categories (Sumner, 1985). The primary user characteristics they examined included the degree of user involvement in application development, training and development of end users, and the nature of applications developed. Amoroso and Cheney (1987) investigated the end-user computing environment in 18 large North American insurance firms. The majority of end users (75%) fell into the command-level end user and end-user programmer categories.

The Rivard & Huff End-User Taxonomy

Rivard and Huff (1985) delineated three end-user types based on distinct patterns concerning the reasons why users developed applications and for whom they were developed. Their study classified end users by functional area, type of application, and experience with end-user computing. Rivard and Huff examined only end users who developed their own applications. Their

first end-user category *micro DP department users* includes users who respond to programming requests from other users in their departments. The second group are *staff analysts* who develop applications that they themselves use to solve problems or provide information to others. The third group *opportunity seekers* includes users who have extensive expertise in their own functional area and some computer expertise. They typically develop decision support applications for their own use. In a follow-up article from the same research effort, Rivard and Huff (1988) reported the importance of the quality of data processing (DP) support for end-user developed applications, user satisfaction with independence from DP, and the computer background of end users. The Rivard end-user taxonomy was not utilized by other researchers to date.

Other Studies

Davis and Olson (1985) reported four additional interrelated end-user characteristics. The first characteristic is the degree of software manipulation versus development. The second characteristic is level of technical understanding which involves two distinct concepts: 1) the general level of computer knowledge and 2) the knowledge gained from using a specific system. The authors reported that *novices and experts* interact with a system in different ways. The third characteristic deals with the degree of frequency using and/or developing applications. Rockart and Flannery (1983) defined a frequent user as one who utilizes the computer to perform tasks or solve problems in a reasonable time frame. Quillard, et al., (1983) answering Rockart and Flannery's need for a "reasonable time frame", suggested that a frequent user is one who utilizes a specific application more than three hours weekly. The fourth characteristic distinguishes *primary users* from *secondary users*. This dimension is similar to the earlier CODASYL (Lefkowitz, 1979) classification of direct versus intermediary users. Davis and Olson define a primary user as one who benefits from the system's output. Secondary users are responsible for the input to the system, as are intermediary users, but they do not use the output to perform their jobs.

Recently, three studies were conducted which investigated end-user usage patterns. Lee (1986) studied usage patterns and sources of assistance for personal computer users. He found that the extent of PC usage was correlated with prior knowledge of EUC tools. Support, specifically development assistance, was found to be critical, supplied by colleagues rather than traditional training methods. Application type was

found to be a significant user characteristic, carried throughout Lee's study. The level of technical understanding was investigated with each end user. In a study investigating the management of personal computer use, Pyburn (1986) interviewed end users with at least one year of experience. Bergeron and Berube (1988), reported the results of a study which examined user support structures, characterized end users by experience, type of application, degree of programming required, knowledge of microcomputer tools, and training acquired. None of these studies utilized a taxonomy or framework for categorizing end users.

The User Cube Taxonomy

Perhaps the taxonomies which were described above are too simplistic. In 1989, Cotterman and Kumar found, "the lack of a clear-cut and commonly accepted definition and classification scheme for end users..." The argument for a comprehensive end-user classification scheme was made earlier. They offer the following definitions:

End user - any organizational unit or person who has an interaction with the computer-based information system as a consumer or producer/consumer of information.

End-user computing - the producer activities of the end users relative to the organization's computer-based information system.

By definition, the data processing department, sole producers of information are excluded from their definition of the end user. Activities of producer/consumers of information in the EUC environment are summarized by operation, development, and control. *Operation* is the initiation and termination of system operation, monitoring, or operation of hardware/software, and necessary manual tasks. *Development* is the performance of any or all tasks of the system development process, whether traditional systems development life cycle or prototyping. *Control* is the decision-making authority to acquire, deploy, and use the resources needed to develop and operate the computer-based information system. Cotterman and Kumar state that, "Operation, development, and control are three key dimensions that allow us to distinguish between various types of end users. Figure 1 illustrates the User Cube as presented by Cotterman and Kumar. The letters on the cube represent the plane on which the user resides. The larger letters indicate a plane on the front, top, or right side of the cube. Corner

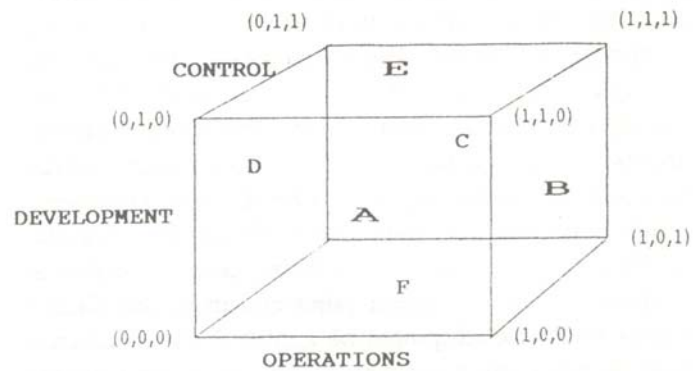


Figure 1. The User Cube (Cotterman & Kumar)

points are labeled with zeros and ones and represent 8 types of end users. For example, an end user who has direct access over computer operations while also developing the application would reside at point (1,1,0).

Following its presentation, the authors mapped existing definitions and classifications to the cube, face validating its comprehensiveness. To review their taxonomy, let us review each of the earlier taxonomies below. The CODASYL categorization of *intermediary user*, specifying requirements for reports, would lie on the development line from points (0,0,0) to (0,1,0). *Direct end users* who operate computer equipment exist on the operations line from (0,0,0) to (1,0,0). The user described in the CODASYL taxonomy then maps to plane A on the front face of the Cube in Figure 1. The users differentiated in the Rockart and Flannery taxonomy fall into the operator and/or developer dimensions, i.e., plane A in Figure 1. Control does not seem to enter into this taxonomy. The Rivard and Huff taxonomy dealing primarily with development would be described along the operations line, specifically around point (1,1,0).

Building the End-User Characteristics Matrix

In the remainder of the paper, we will focus our discussion of user characteristics in the direction which will yield the largest impact on the end-user population. We will use the User Cube as the basis for definitions, but we want to primarily investigate plane A as the majority of users in previous studies fall into this space. Cotterman and Kumar did not identify where the bulk of end users presently lie on their User Cube nor where the growth in end-user computing will take place. Three

Type of End User	(1983) Rockart & Flannery	(1983) Quillard et al.	(1985) Brancheau et al.	(1987) Sumner & Klepper	(1987) Amoroso & Cheney
Nonprogramming end user	9%	1%	4%	0%	3%
Command-level end user	22%	35%	26%	26%	41%
End-user programmers	30%	36%	41%	13%	36%
Functional support	53%	20%	29%	61%	16%
EUC support	7%	8%	0%	0%	4%
DP programmers	15%	0%	0%	0%	0%
Reported Sample Size	140	83	53	31	260

Table 1. Composite of End Users Studied Using the Rockart & Flannery Taxonomy

steps are taken in the development of the End-User Characteristics Matrix. First, a composite is developed of the end users that were investigated in previous studies. Second, a summarization and categorization of user characteristics is presented. Finally, the EU Characteristics Matrix is developed by mapping the user characteristics described in previous studies to the taxonomies in plane A.

Step 1: Composite of End Users Studied

Articles were examined to identify those studies which explicitly identified one of the previously identified taxonomies from which end users studied were categorized. Only five published studies reported using the Rockart and Flannery taxonomy, including, of course, the Rockart and Flannery study. Table 1 summarizes the user categorization in each of the five studies. All of the studies examined end-user computing in both microcomputing and mainframe environments.

The Rockart & Flannery and Sumner & Klepper studies indicated a large group of end users found in the *functional support* group. In a separate study, Quillard, et al. reported only 20% in the *functional support* group, while 71% in the *command-level end user* and *end-user programmer* categories. Brancheau, et al. and Amoroso & Cheney also found an extremely high concentration of end users in these two categories, 67% and 77% respectively. It appears from the five studies that the *nonprogramming end user*, which is defined along the operations line from points (0,0,0) to (1,0,0), on the User Cube, does not reflect a high-growth category of end users. End-user categories apparently strongly reflect the development dimension. One might argue that the five studies represented in Table 1 were biased toward developing end users. However, the Brancheau, et al. (1985) study investigated the information center and the

participants self classified themselves. Self classification, in this study corroborated by IC managers in 75% of the cases, appears to yield a more unbiased categorization.

Both the Quillard, et al. and Amoroso and Cheney research suggest that the growth in EUC would come from the command-level end user and end-user programmer categories (Amoroso and Cheney, 1987; Quillard, et al., 1983). They found 71% of the end users randomly surveyed fell into these two categories. Davis (1985) identified the autonomous users as the fastest growing group of end users in the 1990's. We find, by reading Davis' description of autonomous users, that the autonomous user maps to Rockart and Flannery's command-level end user and end-user programmer categories. Perhaps the Sumner and Klepper data was skewed toward the functional support group as they were investigating information systems strategy in their research (Sumner, 1985). One cannot, however, deny the growth that will take place in the functional support group over the next decade. Other studies were not included in this analysis because they had not explicitly referenced a specific end-user taxonomy.

Step 2: Summary of User Characteristics

After summarizing previous literature and categorizing the variety of user characteristics presented in those studies, ten characteristics emerged. Table 2 presents this summary information. Again, we are looking for explicit findings in the studies investigated indicating importance of a particular user characteristic. Descriptions of each of the user characteristics can be derived from the continuum measures. The continuum measures were taken from valid research instruments. Likert scales were used in the majority of studies investigated.

User Characteristic	Continuum Measure	Research Where Derived
Computing skills	Low vs. high	Amoroso and Cheney, 1987; Hackathorn and Keen, 1981; Lee, 1986; Quillard, et al., 1983; Rockart and Flannery, 1983
Programming required	Yourself vs. others	Amoroso and Cheney, 1987; Bergeron and Berube, 1988; Davis, 1985; Hackathorn and Keen, 1981; Quillard, et al., 1983
Level of EUC support	Required by vs. provided to	Amoroso and Cheney, 1987; Lee, 1986; Quillard et al., 1983; Rivard and Huff, 1988; Rockart and Flannery, 1983
Training/education	Few vs. multiple tools	Amoroso and Cheney, 1987; Bergeron and Berube, 1988; Hackathorn and Keen, 1981; Martin, 1985; McLean, 1979; Sumner, 1985
Knowledge of EUC tools	Manipulation vs. development	Benson, 1983; Davis and Olson, 1985; Hackathorn and Keen, 1981; Lee, 1986
Location of end users	Function vs. IS group	All of the studies
Nature of applications	Small/simple vs. large/complex	Amoroso and Cheney, 1987; Bergeron and Berube, 1988; Davis, 1985; Kasper and Cerveny, 1985; Lee, 1986; Quillard, et al., 1983; Rockart and Flannery, 1983; Sumner, 1985
Technical understanding	Novice vs. expert	Amoroso and Cheney, 1987; Churchman and Schainblatt, 1965; Hackathorn and Keen, 1981; Kasper and Cerveny, 1985; Lee, 1986; Quillard, et al., 1983
End-user attitudes	Positive vs. negative	Amoroso and Cheney, 1987; Rivard and Huff, 1988; Sumner, 1985
End-user experience	Low vs. high	Amoroso and Cheney, 1987; Bergeron and Berube, 1988; Brancheau, et al., 1985; Pyburn, 1986/87; Rivard and Huff, 1984; Rivard and Huff, 1988.

Table 2. Summary of User Characteristics

Step 3: Mapping User Characteristics Onto End-User Taxonomies

The final step in the development of the EU Characteristics Matrix involves mapping the user characteristics in Table 2 onto the end-user taxonomies presented earlier. The data collected in the Amoroso and Cheney study was the primary source of information for the matrix [3]. Additionally, empirical studies were used to provide face validity for the matrix. The End-User Characteristics Matrix is presented in Figure 2. A taxonomy from McLean and Martin, derived from the CODASYL report, was separated out of the CODASYL classification as differences in user characteristics were noted.

End-user roles will continue to evolve as information technology advances, despite researchers' attempts to classify them. For example, the greater the advances in producing user-friendly software products, the greater the changes in user characteristics. These changes, in turn, will produce a shift in the characteristics over user types. We can certainly see that with respect to the level of programming required, knowledge of EUC tools, and the nature of applications being developed. Applications






that are more complex will be developed by end users who have little or no experience.

Discussion

We now will discuss each of the user characteristics in the context of Cotterman and Kumar's User Cube. Although the Cube takes important steps toward providing a comprehensive taxonomy for future research and management, the characteristics which define and represent each user type largely remain uninvestigated. The End-User Characteristics Matrix, consisting of ten user characteristics mapped onto four end-user taxonomies, was primarily derived from previous research and a field study of 260 end users. The matrix is important because it provides a framework for understanding the end user.

To discuss the convergence of the end-user characteristics with the User Cube, the three dimensions of the Cube are utilized: 1) operations, 2) development, and 3) control. Each of these dimensions was defined earlier (see the section titled, "The User Cube Taxonomy"). At this point, it seems prudent to break out the definition of control as suggested by Cheney, Mann, and Amoroso

End-User Categories	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Rockart & Flannery (1983)	Non-programming End Users	Command level Users	End-User Programmers	Functional Support	End-User Computing Support	Programming Support
McLean (1979); Martin (1982)	Non-DP Trained Users	DP Amateurs		1	DP Professionals	
CODASYL (1979)	Direct Users	Autonomous Users		2		
Rivard (1982)	3	Staff Analyst			Micro DP Department	
			Opportunity Seeker			

User Characteristics						
Computing Skills	Little	Low				High
Programming Required	None	For Yourself		For Others		
Level of EUC Support	Required by Users			Provided to Users		
Training/Education	Few Software Packages					Multiple Software Packages
Knowledge of EUC Tools	Manipulation	Manipulation/Development		Development		
Location of End Users	Functional Area				Info Center	IS Group
Nature of Applications	Small/Simple					Large/Complex
Technical Understanding	Novice					Expert
End User Attitudes	"Let Others Do It"		"I'll Do It Myself"		"Let Me Help You"	
End User Experience	Little	Low				High

¹ Both DP Amateur and DP Professional type end users are pushing into the Type 4 user group.

² CODASYL has not classified end users into these types.

³ Rivard did not classify end users into this type.

DESCRIPTION OF END-USER CATEGORIES:

Rockart and Flannery (1983)

- Nonprogramming end users: who have access to computer-stored data through software provided by others.
- Command level users: who perform simple inquiries and generate unique reports for their own purposes.
- End-user programmers: who utilize both command and procedural languages directly for their own information needs.
- Functional support: who are sophisticated programmers supporting other end users within their own functional area.
- Information center support: who are located in a centralized location providing a variety of services to end users.
- Programming support: who develop end-user application projects on a "contract" basis within the corporation.

McLean (1979) and Martin (1982)

- Non-IS trained users: who use code written by others in the course of their work, but do not program applications.
- IS amateurs: who are non-IS personnel who write code for their own use and others on an occasional basis.
- IS professionals who write code for others; they do not use the application system.

CODASYL (1979) and Davis (1985)

- Direct users: who interact directly with information systems or receive periodic reports; who use one or more systems designed, developed, and implemented by systems analysts.
- Autonomous users: who develop, design, implement and use application programs to support personal or a group's information needs.
- Indirect users: who do not directly interface with computers but rather utilize intermediaries (not presented in the following end-user framework).

Rivard and Huff (1985)

- Staff analysts: who develop applications they themselves use to solve problems or to provide information to others.
- Opportunity seekers: who actively identify problems which could be solved or analyzed using a computer.
- Micro DP department users: respond to requests from other users in their department and often other departments.

Figure 2. End-User Characteristics Matrix

(1986) into “controllable” and “partially controllable.” *Controllable* indicates the ability of managers and/or end users to directly and totally change his or her environment. We will expand the term “control”, as defined earlier, to include the concepts of self-control over application development, as well as management of scarce resources.

Computing Skills

Operations. End users recognize that insufficient computing skills represent a major disadvantage in user developed applications and that it takes them longer to arrive at a workable solution than the IS group (Rivard and Huff, 1985). End users who reported limited computing skills (Non-Programming and Command-Level End Users) care about computing only to the extent that it helps them get their own work done (McLean, 1979). Kasper and Cerveny concluded that the quantity of computing skills has a direct effect on end users’ willingness to use and develop end-user applications. Heterogeneous computer backgrounds explain why some end users discern a given tool as easy to use, while others perceive the same tool and difficult to use (Rivard and Huff, 1985).

Development. Users that develop applications need to learn basic computer concepts and techniques in order to be effective with hardware, software, and application development. Rivard and Huff (1988) found that end users with better computing skills backgrounds will have more positive attitudes toward end-user development.

Control. Along with building computer skills related to good development practice, also considered important are the control issues associated with the operations and development environment. For example, proper backup procedures and file management skills represent critical computer skills on the operations side. Likewise, computer skills relative to understanding how to technically use the computer and related equipment to accomplish the desired applications is an important element of control.

Knowledge of EUC Tools

Operations. Awareness of user characteristics can help the end user determine criteria and analyze alternatives for tool selection. Depending upon the intended use of a tool for manipulation or development, end users and/or managers can investigate the importance of flexibility, ease of use, and power of the software and hardware.

Development. Lack of proper knowledge with respect to a tool and its capabilities can result in using the

wrong tool to solve a problem (Alavi and Weiss, 1986). Also, end users may be solving the wrong problem or not creating an effective solution with a selected tool. Therefore, end users must be sure there is a conceptual match between the tool and the application.

Control. Inadequate training, resulting in inadequate knowledge of EUC tools, in the use of high-level languages and other key EUC tools can be expected to lead to poor quality applications and insufficient use of computing resources. End users classified at the lower end of the scale (Type 1 or 2) gain no significant control of their environment through the use of EUC tools for manipulation only. Development dimensions might offer opportunities to interject needed control elements into an environment where there are many risks.

Technical Understanding

Operations. In 1983, Rockart and Flannery reported that most (60%) end users were utilizing the computer primarily as a tool to solve a problem or perform a required function. As an end user gains understanding with a certain technology, the introduction of yet newer technologies leaves many end users without a complete understanding of the hardware and software they are using to accomplish a task. New capabilities are often not utilized.

Development. The fact that users with better computer background have a more positive attitude toward user developed applications suggests that attempts should be made to improve general computer literacy of users prior to their being taught how to use a given tool and prior to their undertaking development activities. Users are likely to be more confident in their ability to develop applications and more satisfied with the experience (Rivard and Huff, 1988).

Control. Operation and development risks result, at least partially, from a lack of technical understanding. Testing to alleviate certain risks associated with development, tends to come from a platform of solid understanding of good development practice.

End-User Experience

Operations. There are long learning periods and considerable practice required for end users to become proficient with software tools. Skills are required in a number of different areas including hardware, software, data, and telecommunications. A failure to gain experience or proficiency in one of these important computing areas often results in a lowering of personal productivity.

Development. Experience on the development side differs from operations in that development methodolo-

gies and techniques must be practiced before proficiency will result. Lack of development experience will result in specialization within an organization. End users will seek out those individuals who have the specialized set of skills needed to contribute to the development of an application.

Control. End-user experience is a valuable asset when acquiring computer technologies. It aids in determining how information technology might benefit the firm and in preparing appropriate justification for acquiring additional resources and ensuring that a lack of integration does not result.

End-User Attitudes

Operations. Good experiences generate favorable attitudes and encourage continued utilization of computer technologies (Amoroso, 1988; Cheney, et al., 1986). Psychological climate is affected by and in turn impacts the success of EUC. Unrealistic expectations (low or high) have been found to inhibit success of the EUC facility. EUC success and the psychological climate are mutually dependent (Cheney, et al., 1986).

Development. Users with more training and experience tend to form expectations about an application which are closer in line with those of the information systems group. Three research studies concluded that the more positive a user's attitudes toward the development of end-user applications, the higher the degree of overall user satisfaction (Amoroso, 1988; Cheney, et al., 1986; Rivard and Huff, 1988.).

Control. Management has some influence over end-user attitudes. End users do not prefer to give up all control over hardware, software, data, and development. The perceptions of an end user's individual abilities to develop applications and their self-sufficiency in doing so are critical dimensions of user attitudes. Many end users, developing applications, tend to give the IS group much of the blame when things fail, but little credit when they succeed. (This is human nature, of course.) Perhaps individuals tend to rate lower their satisfaction with aspects controlled by outsiders while rating higher their satisfaction with aspects that they control (Rivard and Huff, 1988).

Location of End Users

Operations. When technical knowledge is scarce, end users will seek out organizational consultants to solve problems. These tend to be the Type 4 end users. Information centers tend to provide end users with a centralized location for hardware and software questions and concerns.

Development. Type 5 and 6 end users provide development support for the other end-user types. They tend to be located in and report to the IS group, which is often centralized.

Control. The degree of control relative to the IS department, might be a function of the prominence or influence of a given functional area or department.

Programming Required

Operations. Much of the emphasis of this characteristic lies in the discovery of which direction the programming effort is headed. Type 1 end users tend to do little or no development, concentrating on operations, and therefore require programming and modification from other knowledgeable end users or IS staff. Programming for the operations of mainframe and other centralized computing resources is still left to central IS groups.

Development. While Type 2 and 3 end users are applications developers, they tend to seek programming assistance to a greater extent than their Type 4 through 6 counterparts. Since they are located in the functional areas, their needs for applications are often critical and the time frame is often short.

Control. Programming is more of an advanced computing skill and requires extensive training, usually on a variety of software packages and languages. The results, consequently, provide higher levels of self-control in the development of applications. End users have taken control over much of the programming functions, using Functional Support End Users to a greater degree,

Nature of Applications

Operations. The degree of user sophistication may directly rely upon the size and complexity of the application. Large, powerful applications may pose a problem to novice end users, in that they are ill-equipped to deal with operations problems that may result. Applications which are organizational in scope, rather than personal, also creates situations where end users must build a substantial degree of expertise to master certain capabilities.

Development. When building models, end-user developers must evaluate the environment in which the model will be used. Several factors which can increase the complexity of the application under development include: (1) dynamic versus static, (2) probabilistic versus deterministic, (3) optimizing versus satisficing. Developers should also consider as to the type of users who will utilize the application. Complexity will in-

crease when the number of users increases or there is a higher frequency of use. The sophistication of the end-user operator can also increase the level of application complexity. Type 1 and Type 2 developers may consider all of this complexity too difficult to deal with and consequently build smaller and less sophisticated applications.

Control. End-user developers who are faced with a large degree of complexity and who do not realize it may attempt to place applications into operation which have serious control risks. For example, unsophisticated developers may use the wrong tool to solve a common problem, primarily due to their familiarity with it rather than its usefulness to the problem. Also, unsophisticated end-user developers may inadvertently introduce errors into an application creating downstream audit and control problems. Decision makers then may be in the position of making bad decisions with faulty data. Also, organizational applications create substantially more control issues than do personal applications, such as data integrity, security, and access.

Level of EUC Support

Operations. One of the major questions addressed by corporate executives is, "how much support is needed and to whom should it be given." Research has shown that unsophisticated end users will require substantially more support than adept end users. Each emerging technology has a new learning curve associated with it and end users will gain expertise after they have surpassed several learning hurdles. Rivard and Huff (1988) concluded that the greater the user satisfaction with organizational support, the greater the user satisfaction with end-user computing.

Development. Functional support personnel are often needed by unsophisticated end users who are developing applications or more sophisticated end users who are creating complex models. Some of the functions carried out by functional support personnel include: 1) providing technical expertise, systems development, software tools, and troubleshooting a host of other technical problems associated with the development of applications. In contrast, the IS group tends to focus on corporate-wide applications, mainframe operations, telecommunications and interfacing, and large application maintenance. Other concerns include security, documentation, and backup.

Control. The management of data resource underlies the effectiveness of end-user developed applications. Data, considered a corporate resource, is crucial to the development and utilization of end-user applications

and must therefore be managed in order to ensure integrity, accuracy, and reliability. Data management issues must be incorporated into the computing strategy of a firm. Policies have to be established and promulgated to provide guidelines for end-user computing which address data management and other critical issues.

Training/Education

Operations. To be self-sufficient, end users of all types need to acquire tools, skills, and understanding. Training and educational programs provide the necessary basis for the end-user facility, and therefore the end user, to be successful (Amoroso and Cheney, 1987; Cheney, et al., 1986). When surveyed, end users cited the need for improved and varied training opportunities above all other corporate sponsored programs (Nelson and Cheney, 1987).

Development. Training will reduce the development time necessary to design and build applications. Further, development risks can be reduced by training that emphasizes good development practice in the corporation. End users in the lower end-user types seek training in the general introduction of computers, analysis and design of computer applications, organization and definition of problems, data retrieval, and the completion of requirements. End users in the upper end of the spectrum require training in the expanded use of specific software packages, fourth-generation languages, and data integration.

Control. As end users become better trained and educated, they will be better able to effectively glean the advantages of EUC development. Training and education has been positively linked to higher quality software development (Amoroso, 1988; Rivard and Huff, 1985).

Conclusions

A working definition of the end user is crucial when attempting to understand the end-user computing phenomenon which is now occurring in most organizations. The End-User Characteristics Matrix provides an integration of user characteristics that when mapped to the developer/operator/control dimensions of the cube yields insight into the continuous variables shown by the Cube. Such an integrated taxonomical description of end users is useful to both researchers and practitioners. It can assist researchers in framing research and identifying areas of particular interest. It provides a structure in which different research approaches can be compared and the results of such studies used to increase understanding about the end user.

Use by practitioners will lead to increased understanding of the highly diverse end-user computing and aid in end-user management. The basis for achieving the benefits of end-user computing can be accomplished despite conflicting corporate and IS goals when end users are better understood. The characteristics of the EU Characteristics Matrix combined with users' location on the Cube can be the basis of determining the profile of the end users. Practitioners, anxious to develop policies to manage EUC, can concentrate their efforts on certain user characteristics they observe to be problematic while clarifying how the IS department can best serve these users and meet organizational goals.

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Donald L. Amoroso is Assistant Professor of Information Systems at University of Colorado, Colorado Springs. He has authored a book entitled, Managing Microcomputer Technology as an Organizational Resource and is presently working on a second book called, Decision Making Using Lotus 1-2-3. Dr. Amoroso has published 15 articles in leading information systems journals including Journal of Management Information Systems, Information and Management, Data Base, Information Resources Management Journal, Information Strategy: The Executive's Journal, Information Management, and Journal of Microcomputer Management and has also published in 24 conference proceedings. Presently he is studying creativity in systems development.

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