Journal of ORGANIZATIONAL and END USER COMPUTING

Formerly Journal of End User Computing

Vol. 16, No. 1 Jan-Mar 2004

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The Effect of End User Development on End User Success

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ABSTRACT

End user development of applications forms a significant part of organizational systems development. This study investigates the role that developing an application plays in the eventual success of the application for the user developer. The results of this study suggest that the process of developing an application not only predisposes an end user developer to be more satisfied with the application than they would be if it were developed by another end user, but also leads them to perform better with it. Thus, the results of the study highlight the contribution of the process of application development to user developed application success.

Keywords: user satisfaction; measuring IS success; user development; end user computing; end users

INTRODUCTION

An end user developer is someone who develops applications systems to support his or her work and possibly the work of other end users. The applications developed are known as user developed applications (UDAs). So, while the technical abilities of user developers may vary considerably, they are basically required to analyze, design and implement applications. End user development of applications forms a significant part of organizational systems development, with the ability to develop small applications forming part of the job requirements for many positions (Jawahar & Elango, 2001). In a survey to determine the types of applications developed by end users, Rittenberg and Senn (1990) identified over 130 different types of applications. Over half of these were accounting related, but marketing, operations and human resources applications were also heavily represented. The range of tasks for which users develop applications has expanded as the sophistication of both soft-

ware development tools and user developers has increased, and this has led to a degree of convergence with corporate computing, so that the tasks for which UDAs are developed are less distinguishable from tasks for corporate computing applications (McLean, Kappelman, & Thompson, 1993). In addition to the traditional tasks that UDAs have been developed to support, Web applications are becoming increasingly common (Nelson & Todd, 1999; Ouellette, 1999).

Much has been written in the end user computing literature about the potential benefits and risks of end user development. It has been suggested that end user development offers organizations better and more timely access to information, improved quality of information, improved decision making, reduced application development backlogs and improved information systems department/user relationships (Brancheau & Brown, 1993; Shayo, Guthrie, & Igbaria, 1999). In the early UDA literature, the proposed benefits of UDA were seen to flow mainly from a belief that the user has a superior understanding of the problem to be solved by the application (Amoroso, 1988). This superior understanding should then enable end users to identify information requirements more easily and to thus create applications that provide information of better quality. This in turn should lead to better decision making. Other proposed benefits should also flow from this: user development of applications should allow the information systems staff to focus more on the remaining, presumably larger, requests and hence to reduce the application development backlog. This, in turn, should improve relationships between information systems staff and end users.

Despite the potential benefits to an organization of user development of applications, there are many risks associated with it that may lead to potentially dysfunctional consequences for the organization's activities. These risks result from a potential decrease in application quality and control as individuals with little information systems training take responsibility for developing and implementing systems of their own making (Cale, 1994), and include ineffective use of monetary resources, threats to data security and integrity, solving the wrong problem (Alavi & Weiss, 1985-1986), unreliable systems, incompatible systems, and use of private systems when organizational systems would be more appropriate (Brancheau & Brown, 1993).

As end user development forms a large proportion of organizational systems development, its success is of great importance to organizations. The decisions made by end users using UDAs influence organizational performance every day. Organizations carry out very little formal assessment of fitness for use of UDAs (Panko & Halverson, 1996); they therefore have to rely very heavily on the judgment of end users, both those who develop the applications and others that may use them, as end user developers are not the only users of UDAs. Bergeron and Berube (1988) found that 44% of the end user developers in their study had developed applications that were used by more than two people, and Hall (1996) found that only 17% of the spreadsheets contributed by participants in her study were solely for the developer's own use. Therefore, it is essential that more is known about UDA success, including whether end users are disadvantaged when they use applications developed by other end users. This paper explores the contribution of the development process to UDA success, and hence highlights differences between the success of UDAs when used by the developer and when used by other end users.

The literature on user participation and involvement proposes benefits that are thought to accrue from greater inclusion of users in the system development process. The benefits that have been proposed include higher levels of information system usage, greater user acceptance of systems and increased user satisfaction (Lin & Shao, 2000). The end user's superior knowledge of the problem to be solved is certainly one factor influencing these benefits, but the process of participating per se is also thought to have benefits. Those who have participated in systems development have a greater understanding of the functionality of the resulting application (Lin & Shao, 2000) and a greater sense of involvement with it (Barki & Hartwick, 1994), and hence a greater commitment to making it successful. User development of applications has been described as the ultimate user involvement (Cheney, Mann, & Amoroso, 1986). It could thus be expected to lead to systems that gain the benefit of a better understanding of the problem, and to end users with a better understanding of the application and greater commitment to making it work.

This study was designed to isolate the effect of actually developing a UDA on the application's eventual success for the user developer, and to measure that success in terms of a range of possible success measures. There has been little empirical research on user development of applications (Shayo et al., 1999), and most of what has been undertaken has used user satisfaction as the measure of success because of the lack of direct measures available (Etezadi-Amoli & Farhoomand, 1996). User satisfaction refers to the attitude or response of an end user towards an information system. While user satisfaction has been the most widely reported measure of success (Gelderman, 1998), there have been concerns about its use as the major measure of information systems success (e.g., Etezadi-Amoli & Farhoomand, 1996; Galletta & Lederer, 1989; Melone, 1990; Thong & Chee-Sing, 1996).

The appropriateness of user satisfaction as a measure of system effectiveness may be even more questionable in the UDA domain. Users who assess their own computer applications may be less able to be objective than users who assess applications developed by others (McGill, Hobbs, Chan, & Khoo, 1998). The actual development of an application, which may involve a significant investment of time and creative energy, may be satisfying other needs beyond the immediate task. User satisfaction with a UDA could therefore reflect satisfaction with the (highly personal) development process as much as with the application itself.

Other proposed measures of information systems success that might be appropriate for UDAs include: system quality, information quality, involvement, use, individual impact, and organizational impact (DeLone & McLean, 1992; Seddon, 1997). System quality refers to the quality of an information system (as opposed to the quality of the information it produces). It is concerned with issues such as reliability, maintainability, ease of use, etc. As this study relates to the success of a UDA for the eventual user, the user's perception of system quality is considered important. Information quality relates to the characteristics of the information that an information system produces. It includes issues such as timeliness, accuracy, relevance and format. As discussed above, improved information quality has been proposed as one of the major benefits of user development of applications.

Involvement is defined as "a subjective psychological state, reflecting the im-

portance and personal relevance of a system to the user" (Barki & Hartwick, 1989, p.53). Seddon and colleagues (Seddon, 1997; Seddon & Kiew, 1996) included involvement in their extensions to DeLone and McLean's (1992) model of information systems success. Use refers to how much an information system is used. It has been widely used as a measure of organizational information systems success (e.g., Gelderman, 1998; Kim, Suh, & Lee, 1998), but is only considered appropriate if use of a system is not mandatory (DeLone & McLean, 1992).

Individual impact refers to the effect of an information system on the behavior or performance of the user. DeLone and McLean (1992) claimed that individual impact is the most difficult information systems success category to define in unambiguous terms. For example, the individual impact of a UDA could be related to a number of measures such as impact on performance, understanding, decision making or motivation. Organizational impact refers to the effect of an information system on organizational performance. According to DeLone and McLean's model, the impact of an information system on individual performance should have some eventual organizational impact. However, the relationship between individual impact and organizational impact is acknowledged to be complex. Organizational impact is a broad concept, and there has been a lack of consensus about what organizational effectiveness is and how it should be measured (Thong & Chee-Sing, 1996). DeLone and McLean (1992, p. 74) recognized that difficulties are involved in "isolating the effect of the I/S effort from the other effects which influence organizational performance.". Again, this issue is likely to be magnified in the UDA domain, where system use may be very local in scope.

The fact that vital organizational decision making relies on the individual end user's perception of fitness for use suggests that more insight is needed into the role of application development in the success of applications, and that as well as user satisfaction, additional measures of success should be considered. This paper reports on a study designed to address this need by considering a range of both perceptual and direct measures of UDA success in the same study, and isolating the role that actually developing an application plays in the eventual success of the application.

RESEARCH QUESTIONS

The primary research question investigated in this study was:

> *Does the process of developing an application enhance the success of that application for the user developer?*

In order to isolate the effect of actually developing an application on its success for the user, this study compares end user developers using applications they have developed themselves, with end users using applications developed by another end user, on a number of key variables that have been considered in the information systems success literature. Spreadsheets are the most commonly used tool for end user development of applications (Taylor, Moynihan & Wood-Harper, 1998). Therefore, in this study a decision was made to focus on end users who develop and use spreadsheet applications.

In a study that investigated the ability of end users to assess the quality of applications they develop, McGill (2002) found significant differences between the system

quality assessments of end user developers and independent expert assessors. In particular, the results suggested that end users with little experience might erroneously consider the applications they develop to be of high quality. If this is the case, then end user developers may also consider their applications to be of higher quality than do other users. It was therefore hypothesized that:

H1: End user developers will perceive applications they have developed themselves to be of higher system quality than applications developed by another end user with a similar level of spreadsheet knowledge.

Doll and Torkzadeh (1989) found that end user developers had much higher levels of involvement with applications than did users who were involved in the development process, but where the application was primarily developed by a systems analyst or by another end user. It was therefore hypothesized that:

H2: End user developers will have higher levels of involvement with applications they have developed themselves than with applications developed by another end user with a similar level of spreadsheet knowledge.

End user developers have been found to be more satisfied with applications they have developed themselves than with applications developed by another end user (McGill et al., 1998), or with applications developed by a systems analyst (despite involvement in the systems development process) (Doll & Torkzadeh, 1989). It was therefore hypothesized that:

H3: End user developers will have higher levels of user satisfaction when using applications they have developed themselves than when using applications developed by another end user with a similar level of spreadsheet knowledge.

Increased user satisfaction has been shown to be associated with increased individual impact (Etezadi-Amoli & Farhoomand, 1996; Gatian, 1994; Gelderman, 1998; Igbaria & Tan, 1997). As end user developers are believed to be more satisfied with applications they have developed than are other users of these applications, it is to be expected that they will also perceive that these applications have a greater impact on their work. Therefore it was hypothesized that:

H4: End user developers will have higher levels of perceived individual impact when using applications they have developed themselves than when using applications developed by another end user with a similar level of spreadsheet knowledge.

As previously discussed, the end user computing literature has claimed that end user development leads to more timely access to information, improved quality of information and improved decision making (Brancheau & Brown, 1993; Shayo et al., 1999). While this may be partially due to end users having a better understanding of the problems to be solved by information systems (Amoroso, 1988), the actual process of developing an application may also lead to benefits resulting from a superior knowledge of the application. It was hence hypothesized that:

H5: End user developers will make more accurate decisions when using appli-

cations they have developed themselves, than when using applications developed by another end user with a similar level of spreadsheet knowledge.

H6: End user developers will make faster decisions when using applications they have developed themselves than when using applications developed by another end user with a similar level of spreadsheet knowledge.

METHOD

Participants

The target population for this study was end users who develop their own applications using spreadsheets. In order to obtain a sample of end user developers with a wide range of backgrounds, participants were recruited for the study in a variety of ways. It was recognized that the time required for participation (see below) would make recruitment difficult, so participants were offered a one-hour training course entitled "Developing Spreadsheet Applications" as an incentive. This session focused on spreadsheet planning, design and testing. They were also given $20 to compensate them for parking costs, petrol and inconvenience. Recruitment occurred firstly through a number of advertisements that were placed in local newspapers calling for volunteers, these were-followed by e-mails to three large organizations that had expressed interest in the study and finally word of mouth brought forth some additional participants. The criteria for inclusion in the study was previous experience using Microsoft Excel. While being essentially a convenience sample, the participants covered a broad spectrum of ages, spreadsheet experience and training.

Procedure

Fourteen separate experimental sessions of approximately four hours were held over a period of five months. Each session involved between seven and 17 participants (depending on availability) and a total of 159 end users participated overall. Each experimental session consisted of four parts (see Table 1). The study used a within-subjects research design as this has been shown to provide superior control for individual subject differences (Maxwell & Delaney, 1990).

In Part 1 participants were asked to complete a questionnaire to provide demographic information about themselves and information about their background with computers and spreadsheets. The questionnaire also tested their knowledge of spreadsheets. They were not told the objective of the study.

In Part 2 the participants were given a problem statement and asked to develop a spreadsheet to solve it using Microsoft Excel. The problem related to making

Table 1: Experimental session outline

Part	Activities	Approx. Duration
1	Collect background information and assess spreadsheet knowledge	30 minutes
2	Develop spreadsheets (see Appendix 1 for the problem statement)	1.5 hours
3	Use spreadsheets to answer decision questions and complete perceived system quality, involvement, user satisfaction and perceived individual impact questions (see Appendix 2 for the questionnaire items)	1 hour
4	Training session	1 hour

choices between car rental companies (see Appendix 1 for the problem statement). Participants were provided with blank paper to use for planning if they wished, but otherwise were left to develop the application as they wished. They were encouraged to treat the development exercise as they would a task at work, rather than as a test. Participants could use on-line help or ask for technical help from the two researchers present in the laboratory during each session.

Once all participants in the session had completed their spreadsheet, they undertook Part 3 of the session. Each participant was given a floppy disk containing both the spreadsheet they had developed and a spreadsheet from another participant in the session. Matching of participants was done on the basis of the spreadsheet knowledge scores from Part 1, in the expectation that participants with a similar level of spreadsheet knowledge would develop spreadsheets of similar sophistication.

To control for presentation order effects, each participant was randomly assigned to use either their own or the other spreadsheet first. They then used the spreadsheet to answer 10 questions relating to making choices about car rental hire. The time taken to answer these questions was recorded. They then completed a questionnaire containing items to measure: perceived system quality, involvement, user satisfaction and perceived individual impact. Once the questionnaire and their answers to the car rental decision questions were collected, each participant then repeated the process with the other spreadsheet on their floppy disk. A different but equivalent set of car rental decision questions was used. Eighty of the participants ended up using the application they had developed first, and 79 participants used the other application first.

Instruments

The development of the research instruments for this study involved a review of many existing survey instruments. To ensure the reliability and validity of the measures used, previously validated measurement scales were adopted wherever possible. Factor analysis of the items used to measure the constructs that were not directly measured was undertaken to examine discriminant validity of the constructs. Discriminant validity appeared to be satisfactory for all operationalizations except for user satisfaction and perceived individual impact, which were highly correlated ($r = 0.95$, $p < 0.000$). However, as these instruments were used in a closely related study on end user success (McGill, Hobbs, & Klobas, 2003) and discriminant validity demonstrated for that study, a decision was made to accept these operationalizations.

Spreadsheet Application Development Knowledge

Spreadsheet application development knowledge relates to the knowledge that end user developers make use of when developing UDAs. The instrument used to measure spreadsheet development knowledge was based upon an instrument used by McGill and Dixon (2001). That instrument was developed using material from several sources including: Kreie's (1998) instrument to measure spreadsheet features knowledge; spreadsheet development methodologies from Ronen, Palley and Lucas (1989) and Salchenberger (1993); and Rivard et al.'s (1997) instrument to measure the quality of UDAs. The final instrument contained 25 items. Each item was presented as a multiple choice question with five options. In each case the fifth option was 'I don't know' or 'I am not fa-

miliar with this feature'. Nine of the items related to knowledge about the features and functionality of spreadsheet packages, eight items related to development process and eight items related to spreadsheet quality assurance. The instrument was shown to be reliable with a Cronbach's alpha of 0.78 (Nunnally, 1978).

Involvement

The involvement construct was operationalized using Barki and Hartwick's (1991) instrument. They developed the scale for information systems based on the general involvement scale proposed by Zaichkowsky (1985). The resulting scale is a seven point bi-polar semantic differential scale with 11 items. See Appendix 2 for a list of the questionnaire items used to measure involvement.

The instrument, as used in this study, was shown to be reliable with a Cronbach's alpha of 0.95 and involvement was created as a composite variable using the factor weights obtained from measurement model development using AMOS 3.6.

Perceived System Quality

The items used to measure perceived system quality were obtained from the instrument developed by Rivard et al (1997) to assess the quality of UDAs. Rivard et al.'s instrument was designed to be suitable for end user developers to complete, yet to be sufficiently deep to capture their perceptions of components of quality. For this study, items that were not appropriate for the applications under consideration (e.g. specific to database applications) were excluded. Minor adaptations to wording were also made to reflect the environment in which application development and use occurred. The resulting perceived system quality scale consisted of 20 items, each scored on a Likert scale of 1 to 7 where (1) was labeled 'strongly agree' and (7) was labeled 'strongly disagree'. See Appendix 2 for a list of the questionnaire items used to measure perceived system quality.

The instrument was shown to be reliable with a Cronbach's alpha of 0.94 and perceived system quality was created as a composite variable using the factor weights obtained from measurement model development using AMOS 3.6.

User Satisfaction

Given the confounding of user satisfaction with information quality and system quality in some previous studies (Seddon & Kiew, 1996), items measuring only user satisfaction were sought. Seddon and Yip's (1992) four-item seven-point semantic differential scale that attempts to measure user satisfaction directly was used in this study. A typical item on this scale is 'How effective is the system?', measured from (1) 'effective' to (7) 'ineffective'. See Appendix 2 for a list of the questionnaire items used to measure user satisfaction.

The instrument was shown to be reliable with a Cronbach's alpha of 0.96 and user satisfaction was created as a composite variable using the factor weights obtained from a one factor congeneric measurement model developed using AMOS 3.6.

Individual Impact

In this study, it was explicitly recognized that an individual's perception of the impact of an information system on their performance might not be consistent with other direct measures of individual impact, and hence three measures of individual impact were included in the study. These were individual impact as perceived by the end user, accuracy of decision making, and time taken to answer a set of questions.

Perceived individual impact was mea-

sured using items derived from Goodhue and Thompson (1995) in their study on user evaluations of systems as surrogates for objective performance. The instrument was shown to be reliable with a Cronbach's alpha of 0.96. See Appendix 2 for a list of the questionnaire items used to measure perceived individual impact.

In addition to the end user's perception of individual impact, two direct, easily quantifiable, aspects of individual impact were also measured. These were decision accuracy and time taken to answer a set of questions, and were also used by Goodhue, Klein and March (2000) in their study on user evaluations of systems.

Two sets of 10 different but equivalent questions involving the comparison of costs of car rental companies under a variety of scenarios were created. The questions ranged from comparison of the three firms when no excess kilometer charges are imposed through to questions where excesses are applied and basic parameters are assumed to have changed from those given in the original problem description. A typical question is "Which rental company is the cheapest if you wish to hire a car for 6 days and drive approximately 1,500 kilometers with it?" Participants were asked to provide both the name of the cheapest firm and its cost. The questions were piloted by four end users and slight changes made to clarify them. The equivalence of the two sets of questions in terms of difficulty and time to complete was also confirmed by measuring the time taken to answer each set using the four applications created during piloting of the task.

RESULTS

Of the 159 participants, 32.7% were male and 67.3% were female (52 males, 107 females). Their ages ranged from 14 to 77 with an average age of 42.7. Participants reported an average of 4.5 years experience using spreadsheets (with a range from 0 to 21 years). One hundred and twelve (70.4%) reported using spreadsheets at work and 92 (57.9%) reported using spreadsheets for personal use.

Table 2 provides descriptive information about each of the variables of interest. Data analysis was undertaken using MANOVA. Pillai's Trace ($F = 5.45$; $df = 6, 306$; $p < 0.000$) indicated that there was a significant multivariate effect for being the developer. Each of the hypotheses was then addressed using univariate F-tests (see Table 2). As a number of comparisons were being made, the level of significance

Table 2: End user developer perceptions and performance when using their own or another application

	Developer + User			User Only			Comparison	
	Mean	Std. dev	N	Mean	Std. dev	N	% incr.	Sign.
Perceived system quality	4.64	1.27	157	3.98	1.48	156	16.6	<0.001
Involvement	9.36	2.73	157	8.17	3.20	156	14.6	<0.001
User satisfaction	4.44	1.86	157	3.63	2.07	156	22.3	<0.001
Perceived individual impact	9.38	3.94	157	7.26	4.30	156	29.2	<0.001
Number of decisions correct (/10)	4.43	3.33	157	3.47	3.22	156	27.7	0.010
Time to make decisions (minutes)	17.75	10.00	157	15.31	7.22	156	15.9	0.014

was conservatively set at 0.01.

End users perceived applications they had developed themselves to be of higher quality than applications developed by other end users. On average, there was a 16.6% difference in perceived quality when the developer was assessing his/her own application. This increase was significant ($F = 17.96$; $df = 1, 311$; $p < 0.001$). End user developers were also significantly more involved with their own applications ($F = 12.42$; $df = 1, 311$; $p < 0.001$) and significantly more satisfied with them ($F = 13.22$; $df = 1, 311$; $p < 0.001$). The average difference in involvement if the user was also the developer was 14.6% and the average difference in user satisfaction was 22.3%. Thus, Hypotheses 1 to 3 were supported.

End users perceived applications they had developed themselves as having a significantly greater impact on their decision performance ($F = 20.65$; $df = 1, 311$; $p < 0.001$), and this was confirmed as they made a significantly larger number of correct decisions ($F = 6.70$; $df = 1, 311$; $p = 0.010$). The average difference in perceived individual impact of the application was 29.2% and the average difference in the number of decisions correct was 27.7%. Thus, Hypotheses 4 and 5 were supported. It was also hypothesized that end user developers would make faster decisions when using the application they had developed themselves. However, this hypothesis was not supported. End users took longer on average to answer the questions using their application ($F = 6.10$; $df = 1, 311$; $p = 0.014$). On average, the difference in decision time was 15.8%.

DISCUSSION

The results of this study suggest that the process of developing an application not only predisposes an end user developer to be more satisfied with the application than they would be if it were developed by another end user, but also leads them to perform better with the application than they would if it were developed by another end user. While previous research has established the positive impact of the process of end user development on subjective measures such as involvement (Doll & Torkzadeh, 1989) and user satisfaction (Doll & Torkzadeh, 1989; McGill et al., 1998), its impact on directly measured performance has not previously been established. The results of this study highlight the contribution of the process of application development to application success. This contribution appears to be beyond the advantages achieved by an increased knowledge of the problem situation, as in this study the effects of domain knowledge were controlled for by the within-subjects design. Thus, end user developers benefit not only from better understanding of the problem to be solved (Amoroso, 1988), but also from the process of application development.

The end user developers in this study had significantly higher levels of involvement, user satisfaction and perceived individual impact when using applications they had developed themselves than they did when using applications developed by another end user with approximately the same levels of spreadsheet development knowledge. They also perceived their applications to be of higher system quality. These results are consistent with the results in the literature on user involvement in the development of organizational systems. For example, Doll and Torkzadeh (1988) found user participation in design to be positively correlated with end user computing satisfaction, and Lawrence and Low (1993) found that the more a user felt involved with the development process, the more satisfied they were with the system. The

results are also consistent with McGill et al.'s (1998) study in the end user developer domain, where end user developers were found to be more satisfied with their own applications.

The results also strongly support Cheney, Mann and Amoroso's (1986) claim that end user development can be considered as the ultimate user involvement. The higher levels of perceived system quality for end users' own applications highlight the subjectivity of system quality for end users. This issue has been raised by Huitfeldt and Middleton (2001), who argued that the standard system quality criteria are oriented towards information technology maintenance staff rather than towards end users and that "it is still difficult for an end user, or software development client, to evaluate the quality of the delivered product" (p. 3). Although the instrument used to measure perceived system quality in this study was designed specifically for end users (Rivard et al., 1997), informal feedback from participants suggests they found quality assessment a difficult task. In contrast to 'software engineering' definitions of system quality (e.g., Boehm et al., 1978; Cavano & McCall, 1978), Amoroso and Cheney (1992) implicitly acknowledge this difficulty by defining UDA quality as a combination of end user information satisfaction and application utilization. This, however, ignores the underlying necessity for the more technical dimensions of system quality to be taken account of in order to have reliable and maintainable applications.

End user developers made significantly more correct decisions when using their own applications than when using an application developed by another end user. In this study, all participants had been provided with the same problem statement and all had spent time considering the problem in order to develop an application. All participants had also used both the application they had developed and another application, so domain knowledge was not a factor. The improved performance could be due to a greater familiarity with the application itself, achieved through the development process. Successful use of user developed spreadsheet applications appears to require substantial end user knowledge because of the lack of separation of data and processing that is commonly found (Hall, 1996; Ronen et al., 1989). Users of UDAs do not usually receive formal training in the particular application; yet training is associated with successful use (Nelson, 1991). Developing an application allows the user to develop a robust understanding of it that makes it easier to use and makes it possible for them to successfully adjust aspects of it when necessary. The development process can be seen as a form of training for future use of the application, and it can circumvent problems that might otherwise occur because of lack of training and/or documentation.

The improved performance could also be due to a greater determination to achieve the correct answers, because of the higher levels of involvement. This explanation receives support from the additional time user developers spent making the decisions. On average, the user developers spent an extra two-and-a-half minutes trying to answer the 10 questions. This was unexpected, as it would be logical to expect end users to spend less time using the applications they understand best, but may be due to the end user developers' greater commitment to succeeding with their own applications. Comments from participants during the sessions support this possible explanation. In addition, many participants continued working on their applications once the formal part of the experiments was completed; some even continued to adapt their appli-

cations over a number of days.

McGill et al. (1998) questioned the usefulness of user satisfaction as a measure of UDA success after finding that developers of UDAs were significantly more satisfied with applications they had developed than other end users were with the same applications. They speculated that increased satisfaction might be a reflection of the role of attitude in maintaining self esteem, and expressed concerns that this increased satisfaction might blind end user developers to problems that exist in the applications they have developed. However, no measures of performance were included in that study. This study suggests that the raised levels of user satisfaction and other perceptual variables were appropriate, as they were consistent with better levels of performance.

Both subjective and direct measures of UDA success have an important role to play in research on user development of applications. Shayo et al. (1999) noted that subjective measures are less threatening and easier to obtain, thus making end user computing research easier to conduct. Subjective measures can also reflect a wider range of success factors than can be captured using direct measures such as decision accuracy. However, exclusive use of subjective measures can be problematic because users are asked to place a value on something about which they may not be objective. By including both types of measures, this study has demonstrated a range of benefits attributable to end user development and has provided a measure of confidence that increases in subjective measures are also associated with increases in some direct measures.

The results of this comparison between end user developers using their own applications and end users using applications developed by other end users has implications for staff movement in organizations. If an end user develops an application for his or her own use, and its use has a positive impact on performance, this does not guarantee that the same will be true if another end user starts to use it. Organizations should recognize that the use of UDAs by end users other than the developer may carry with it greater risks. If an end user developer has developed an application for his or her own use and then leaves the position or organization, it can not be assumed that another end user will necessarily be able to use it successfully. In addition, if users are developing applications for others to use, particular attention must be paid to ensure that these applications are of sufficient quality for successful use not to rely on additional insight gained during the development process. As previously discussed, the development process provides a form of preparation for future use of an application and may reduce dependence on training and documentation. However, users of a UDA who were not involved in its development still rely heavily on documentation and training, and the importance of them must be emphasized.

Several limitations of the research are apparent and should be considered in future investigations of end user development success. First, the only application development tool considered was spreadsheets. While spreadsheets have been the most commonly used end user application development tool (Taylor et al., 1998), the generalizability of the results to users of other development tools, such as database management systems and Web development tools, needs to be investigated in future research. A second limitation of the research was the constraints resulting from the use of a laboratory experiment research approach. The spreadsheets that participants developed were probably smaller

than the majority of spreadsheets developed by users in support of organizational decision making (Hall, 1996). In addition, because of the finite nature of the experiment, end users did not have the same incentive to succeed as would be expected in a work situation. The artificial nature of the environment and task may have influenced the results. While the research situation chosen provided the benefit of control of external variability and hence internal validity, it was not ideal in terms of providing external validity. It would be valuable to undertake a field study in a range of organizations to extend the external validity of the research.

CONCLUSION

In conclusion, this study suggests that the process of developing an application leads to significant advantages for the end user developer. In the past, the proposed benefits of user development of applications have been mainly attributed to a belief that the user has a superior understanding of the problem to be solved by the application system (Amoroso, 1988). In this study, all end users should have had equal knowledge and understanding of the problem when using both the application they had developed and the other application so any differences in domain knowledge were not a factor.

The relative success of the end user developers when using their own applications in this study may flow from their superior knowledge of their own applications, thus confirming one of the proposed advantages of user involvement in organizational information systems development. The advantage of superior knowledge of the application is likely to be particularly important with spreadsheet applications where data and processing are usually integrated (Hall, 1996; Ronen et al., 1989). Future research should investigate whether these findings also hold when other application development tools are used and with other groups of end user developers.

There have been concerns expressed in the literature about user development of applications as an inefficient use of personnel time, distracting end users from what they are supposed to be doing (Alavi & Weiss, 1985-1986; Davis & Srinivasan, 1988; O'Donnell & March, 1987). However, this study suggests that the potential risk of inefficient use of personnel time may be compensated for by superior decision making later, based upon insights gained from system development. While development of applications by more experienced user developers or by information systems professionals may ensure a more reliable and maintainable application (Edberg & Bowman, 1996), end user development is currently a pervasive form of organizational system development and it is encouraging to identify this benefit of it. However, the findings relating to differences in end user success between those who have developed the application they are using and those who haven't emphasize that organizations should recognize that the use of UDAs by end users other than the developer may carry with it greater risks, and that these must be addressed by particular attention to documentation of applications and training for other users. It is not appropriate that successful use relies on insight gained during the development process. UDAs must be sufficiently robust and reliable to be used by a wide range of users.

APPENDIX 1

The problem statement given to participants in Part 2 of the experimental session

CAR RENTAL PROBLEM

Deciding which car rental company to choose when planning a holiday can be quite difficult. A local consumer group has asked you to set up a spreadsheet to help people make decisions about car rental options. The spreadsheet will enable users to determine which company provides the cheapest option for them, given how long they need to hire a car and how much driving they intend to do.

After investigating the charges of the major companies, you have the following information about the options for hiring a compact size car in Australia.

- Advantage Car Rentals charges $35 per day for up to 100 kilometers per day. Extra driving beyond 100 kilometers per day is charged a $0.25/km excess.
- OnRoad Rentals charges $41 per day. This rate includes 200 free kilometers per day. Extra kilometers beyond that are charged at the rate of $0.30/km.
- Prestige Rent-A-Car charges $64 per day for unlimited kilometers.

Your task is to create a spreadsheet that will allow you or someone else using it to type in the number of days they will need the car and the number of kilometers they expect to drive over the time of the rental. The spreadsheet should then display the rental cost for each of the above three companies.

APPENDIX 2

Items included in questionnaire to measure end user perceptions

Perceived system quality	**strongly disagree**				**strongly agree**		
Using the spreadsheet would be easy, even after a long period of not using it	1	2	3	4	5	6	7
Errors in the spreadsheet are easy to identify	1	2	3	4	5	6	7
The spreadsheet increased my data processing capacity	1	2	3	4	5	6	7
The spreadsheet is easy to learn by new users	1	2	3	4	5	6	7
Should an error occur, the spreadsheet makes it straightforward to perform some checking in order to locate the source of error	1	2	3	4	5	6	7
The data entry sections provide the capability to easily make corrections to data	1	2	3	4	5	6	7
The same terminology is used throughout the spreadsheet	1	2	3	4	5	6	7
This spreadsheet does not contain any errors	1	2	3	4	5	6	7
The terms used in the spreadsheet are familiar to users	1	2	3	4	5	6	7
Data entry sections of the spreadsheet are organized so that the different bits of data are grouped together in a logical way	1	2	3	4	5	6	7
The data entry areas clearly show the spaces reserved to record the data	1	2	3	4	5	6	7

The format of a given piece of information is always the same, whereever it is used in the spreadsheet	1	2	3	4	5	6	7
Data is labeled so that it can be easily matched with other parts of the spreadsheet	1	2	3	4	5	6	7
The spreadsheet is broken up into separate and independent sections	1	2	3	4	5	6	7
Use of this spreadsheet would reduce the number of errors you make when choosing a rental car	1	2	3	4	5	6	7
Each section has a unique function or purpose	1	2	3	4	5	6	7
Each section includes enough information to help you understand what it is doing	1	2	3	4	5	6	7
Queries are easy to make	1	2	3	4	5	6	7
The spreadsheet provides all the information required to use the spreadsheet (this is called documentation)	1	2	3	4	5	6	7
Corrections to errors in the spreadsheet are easy to make	1	2	3	4	5	6	7

Involvement

This car rental spreadsheet is:

unimportant	1	2	3	4	5	6	7	important
not needed	1	2	3	4	5	6	7	needed
nonessential	1	2	3	4	5	6	7	essential
trivial	1	2	3	4	5	6	7	fundamental
insignificant	1	2	3	4	5	6	7	significant
means nothing to me	1	2	3	4	5	6	7	means a lot to me
unexciting	1	2	3	4	5	6	7	exciting
of no concern to me	1	2	3	4	5	6	7	of concern to me
not of interest to me	1	2	3	4	5	6	7	of interest to me
irrelevant to me	1	2	3	4	5	6	7	relevant to me
doesn't matter to me	1	2	3	4	5	6	7	matters to me

User satisfaction

How adequately do you feel the spreadsheet meets your information processing needs when answering car rental queries?	inadequately 1	2	3	4	5	6	adequately 7
How efficient is the spreadsheet?	inefficient 1	2	3	4	5	6	efficient 7
How effective is the spreadsheet?	ineffective 1	2	3	4	5	6	effective 7
Overall, are you satisfied with the spreadsheet?	dissatisfied 1	2	3	4	5	6	satisfied 7

Perceived individual impact

The spreadsheet has a large, positive impact on my effectiveness and productivity in answering car rental queries	disagree 1	2	3	4	5	6	agree 7
The spreadsheet is an important and valuable aid to me in answering car rental queries	disagree 1	2	3	4	5	6	agree 7

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