A study to validate an end user computing model – towards predictive quality

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Abstract

End user computing (EUC) is an activity that provides a significant proportion of the computerised information systems now developed for business. We refer to published work which supports the concept of EUC, expresses concern about the quality of EUC outcomes, and addresses the measurement of the success of EUC. We describe a research model which is designed to enable the measurement/prediction of the impact that changes to selected contributing factors (i.e. IT skills, IS/business knowledge, tool support characteristics, and role/authority) make on the quality of EUC outcomes. We discuss how we have piloted the validation of the model using a questionnaire technique. We conclude that the instrument and model show signs of being valid, and describe how end users can be categorised by their levels of IT/business/IS knowledge and expertise. Finally, we discuss how we plan to continue with our research, and in particular our aim to prototype the design of advanced EUC tool support.
1. Introduction

End user computing (EUC) has been defined as being the reliance of a user on IT to personally develop software (Amoroso & Cheney [4]). An alternative definition is that EUC is the direct use of computing resources by business personnel (Bergeron et al. [6]). Our studies distinguish between these types of activity, and conclusions on findings are made in that context. It is claimed that EUC has the following important advantages over the more traditional approach to systems development (Alavi & Weiss [3], Amoroso & Cheney [4], Van Heusden & Wijnen [12]):

* eliminating the problems associated with ineffective communications between analysts and end users.
* ownership transfer to end users
* enhanced productivity and effectiveness
* improved user-friendliness in systems

In contrast, some warn that EUC is prone to suffer from having poor design, documentation, and integration and that guidance and control is needed to effectively address these problems (Alavi & Weiss [3], Salchenberger [26], Cale [9]). EUC researchers are not alone in their consideration of how improvements in the quality of developed systems might be achieved - currently there is a trend for the wider systems development community to find ways of lowering software costs and improve quality (Khoshgoftaar & Allen [18]). Alavi [2] makes the following recommendations aimed at improving the quality of end user developed applications:

i) Documented quality policies which are actively implemented and also supported by all levels of management.
ii) Quality assurance reviews should be made of EUC products, especially where systems are multi-user and/or business critical systems. A quality assurance group (perhaps comprising members of an EUC support unit) could provide a service to the end users.
iii) End users could prototype the design of a required system, which could then be 'refined' and fully implemented by an end-user support group.
iv) High quality re-usable software modules should be made available to end user developers.
v) End users should receive training in areas such as systems development techniques, use of IT tools, and general problem solving.
We feel that these recommendations have deserved a much greater prominence in recent reviews of past research in this area (and indeed a greater degree of use as a basis for subsequent research). We support the spirit of these recommendations, but would like to add the recommendation that business users should be provided with more usable and powerful EUC tools; and so obviating the need for users to gain excessive degrees of IT specialist expertise.

Doll & Torkzadeh [11], Igbaria & Nachman [15], and Amoroso & Cheney [4] consider the measurement of the quality (in terms of user satisfaction) of end user developed applications. This work utilises questionnaire techniques to gather data, and Amoroso & Cheney [4] is largely based on methods developed by Ives et al. [16], Bailey & Pearson [5], and Bostrom [7].

There have been many attempts to model and measure the criteria for success of EUC (eg. Cheney et al. [10], Rivard & Huff [24], Doll & Torkzadeh [11]), and it has been shown (Bergeron et al. [6]) that the identified criteria, in order of importance fall into the following categories:-

1. Organisational Effectiveness
2. User Appreciation
3. Quality of Applications
4. Efficiency of Applications
5. Adequacy of Applications (in terms of user autonomy)

Rivard et al. [25] have developed and tested a construct to measure the quality of user-developed applications. The dimensions used are: reliability, effectiveness, portability, economy, user-friendliness, understandability, verifiability, and maintainability. In turn, each quality dimension is composed of a set of criteria which are addressed by survey questions.

Much of published work on EUC does not focus on the characteristics of EUC tools. However, some interesting work in this area (Agusa [1], Hirakawa & Ichikawa [13] and Kanda et al. [17]) is aimed at using 'visual' (eg. using icons) and easy to understand approaches to help business users build systems.

Our research addresses the issue of further empowering the business end user by providing tool support which bridges the gap between the user and the skills needed to personally design and produce computerised information systems. The work introduces the concept of 'CAUSE' (Computer Aided User System Evolution) tool support to business users. Elsewhere, we relate previous research into the automation of the analyst role to EUC (Lawrence & Shah [19]), introduce our EUC research direction (Lawrence & Shah [20]),
and describe our approach to modelling the EUC environment (Lawrence & Shah [21]). We suggest that it is important that, in addition to assessing the performance of EUC, that we gain sufficient awareness of the various factors which affect EUC outcomes. This might allow a greater degree of planning in terms of managing and controlling outcome quality. We now briefly describe a research model which represents how EUC contributing factors interact to produce EUC outcomes.

2. Research model

We have developed an EUC research model (Lawrence & Shah [21]) which illustrates our view that the following factors contribute to EUC effectiveness:

* User IT Sophistication
* Business/IS knowledge
* Role/Authority
* EUC tool characteristics

Fig. 1 shows the elements involved in the 'End User Domain' of the model (the EES model - EUC Effectiveness and Scope) - those factors which apply at the 'individual' level. We recognise that, at the corporate level (within the 'Organisational Domain'), there are factors such as IT specialist support, IT Specialist development capabilities, EUC supporting infrastructure, and the nature of business/IS requirements, which help determine the scope and effectiveness of EUC in corporate terms.

Business and Information Systems Knowledge + Role/Authority

= Business Precision

User IT Sophistication + Business Precision + Tool Support

= EUC Effectiveness and Scope

Fig. 1: The 'EES' Model (End User Domain elements)
To begin to fully understand the mechanics of how EUC can be managed to bring optimum corporate benefits, requires the eventual additional consideration of the factors in the Organisational Domain. This must be covered by a subsequent stage of research due to the immensity of the issues involved and the demands of industry based studies.

The User IT Sophistication (UIS), see fig. 1, is a measure of the IT skills and experience possessed by the end user. Business Precision (BP) represents the extent to which the user understands the complexities and business issues involved in an IS, and whether the user has the power and the freedom to get involved with EUC with a sufficient degree of time and effort commitment. The EUC 'tool characteristics' factor addresses the issue of the extent to which the EUC tools available meet the needs of the user. The effectiveness of the EUC outcomes is viewed as the culmination of the three aforementioned factors. In a sense this is 'potential' effectiveness, as 'Organisational Domain' factors will play an important part in determining the extent to which EUC activities have a favourable impact in corporate terms.

In the pilot study, we have viewed the EUC effectiveness in terms of the type and volume of implementations, and the perceived success of those implementations (eg. maintenance requirements, business benefit, etc). We regard the primary importance of the EES model as being a vehicle to enable the effects of changes to one or more contributing factors to be predicted. To facilitate this predictive feature we have developed a means of measuring the various aspects and investigating links between contributors and outcomes. The model is likely to be useful in cost/benefit analysis exercises and hence assist businesses in the task of forming effective strategies relating to EUC resourcing, training and tool/infrastructure support provision. We use a questionnaire survey to gain measures of the various factors for particular individuals, which incorporates the concept of measuring the breadth, depth, and finesse of the areas addressed by the questionnaire (after Huff et al. [14]).

3. Scope of pilot survey

The purpose of the pilot study was to test question-wording and suitability, to test the analysis techniques, and to provide some initial validation of the EES model. There had already been much time spent reviewing the questionnaire design, examining its validity (Moser & Kalton [23]), and developing the data analysis approach. The pilot study was the opportunity to complete a field trial.
4. Results and conclusions of Pilot Survey

The detailed analysis of the results (based on 15 responses from 70 questionnaires sent out) involved establishing if there is any evidence to validate the survey instrument, and also involved studying the findings in terms of validating the EES model and considering other EUC issues.

4.1 Validity of survey instrument The ordinal and free text responses for each individual participant have been closely studied to check for consistency. It has been found that (with only one exception) the profiles of IT experience, business/IS knowledge, role/authority, tools characteristics, and implementation effectiveness (each addressed in different sections of the questionnaire) match very well with the profiles provided via the free text information. In the exception case there was not any free text information to utilise for checking purposes. The details, of course, cannot be published here due to the need to maintain confidentiality. Statistical analysis (Spearman) has been used to examine correlations between all the questions on the questionnaire, and a summary is presented in Table 1. The purpose is to check if the various sections address separate issues, and if questions within particular sections address related issues.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>D</th>
<th>E</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9/91</td>
<td>5/126</td>
<td>2/42</td>
<td>10/126</td>
<td>14/140</td>
</tr>
<tr>
<td>B</td>
<td>********</td>
<td>33/36</td>
<td>10/29</td>
<td>3/81</td>
<td>8/90</td>
</tr>
<tr>
<td>D</td>
<td>********</td>
<td>********</td>
<td>1/3</td>
<td>1/27</td>
<td>3/30</td>
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<tr>
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<tr>
<td>C</td>
<td>********</td>
<td>********</td>
<td>********</td>
<td>********</td>
<td>44/45</td>
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</table>

The matrix shows the ratio of the number of significant correlations against the total number of correlations measured for the matrix cell. Each cell represents a specific set of correlations between questions from two distinct sections, or between questions within the same section. The significance 'threshold' is taken from standard tables which take the sample size into account.

Firstly, we looked at the correlations between questions within particular sections to see if they tended to be higher than those between questions in different sections (the idea being that the former should be much more closely
correlated to indicate that the questions are targeting the same aspects). The results show that correlations between responses for questions within each of sections B, C, and E tend to be high (B = Business/IS knowledge, C = Implementation effectiveness, E = tools characteristics). There is some indication of correlations for questions within section D, but little indication for those within section A (A = IT experience, D = role/authority). The low frequency of significant correlations within section A could be attributed to the fact that some of the questions in the section used terms (eg. 'package' and 'tool') unclear to several respondents - this may have caused some confusion.

In general there is a lower degree of correlation between questions from separate sections, except for a few of fairly strong correlations between section A and section E questions, and section B and section D questions. In the former case, the section A questions concerned ask about experience with tools, and so it is expected that these responses will correlate with section E, which itself deals with the availability of tools and their characteristics. In the latter case, many of the questions show good correlations - this suggests that the authority and freedom to express IT ideas increases as the awareness and knowledge of the business area, and the related information systems, increases (as one might expect). Standard deviations were determined for the responses to particular questions and the findings suggest that the questions differentiated between the various participants.

We can conclude that these findings, collectively, suggest that there is reasonable evidence for the survey instrument being valid.

4.2 Validation of EES model and consideration of other EUC issues

4.2.1 Statistical validation of EES model Statistical analysis (Spearman) of the ordinal responses shows that there are reasonably clear correlations between the totals for Section B and D, for Sections B and C, and for Sections E and C (B = Business/IS knowledge, D = Role/authority, E = Tool characteristics, C = measured EUC effectiveness). Moderate correlations apply between the totals for sections A and C (A = IT Experience). These findings, even with a small sample, show that the identified contributing factors seem to significantly affect the effectiveness of the EUC outcome - and hence indicates model validity. The correlation between totals for sections B and D confirm a relationship discussed earlier. The statistical findings are supported by the fact that a 'non-statistical' analysis of the ordinal and free text responses shows that the measured effectiveness for a participant tends to be broadly in line with what would be expected.
4.2.2. **Business user categorisation** We can use the findings to place the participants into categories of varying business/IS/IT 'expertise'. The categories are in order of increasing potential for high EUC effectiveness. In our view, the higher the level of business/IS experience, the higher the potential, and within any level of this experience (i.e. naive, fair, and expert) the potential is increased with increasing IT experience. Table 2 shows that the participants in the pilot survey have levels of IT experience of either 'fair' or 'expert' - which is to be expected as computerisation is no longer a new phenomenon in business. The majority of the pilot survey participants (11 out of 15) are placed in the top two categories - showing relatively high levels of both business/IS and IT expertise.

Table 2: Business User Categorisation Results

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Naive</th>
<th>Total Fair</th>
<th>Total Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business+IS/IT Naive</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus+IS naive/IT fair</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus+IS naive/IT expert</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus+IS fair/IT naive</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus+IS fair/IT fair</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus+IS fair/IT expert</td>
<td>8</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Business+IS/IT expert</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Four (out of 15) of the participants are categorised as being 'business/IS naive. This factor could be one in which organisations need to focus in order to significantly raise the potential of particular business users.

Table 3 shows a summary of the ratings of scores for role/authority and tools. It shows that many users have EUC tools which have limited scope and power, and indicates that a significant proportion of users might be constrained in EUC activities by the nature of their role/authority, and of the EUC tools. This is supported by some of the free text responses received.

Table 3: Role/Authority and Tools Ratings (pilot study)

<table>
<thead>
<tr>
<th>Role/IT Tools</th>
<th>No. High scores</th>
<th>No. Medium scores</th>
<th>No. Low scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>
4.2.3. Potential for advanced EUC tool prototyping  We can use the results to identify participants who might have characteristics and experience suitable for taking part in the prototyping of advanced EUC tools. We are able to identify that 3 out of the 15 participants (in the pilot study) are likely to be good candidates for EUC tool prototypers. All three participants demonstrate high levels of IT experience and skills, and of knowledge in at least one business/IS area, together with a clear interest in using tools to advance their EUC activities.

4.2.4. Improvements to Questionnaire (after Pilot Study) Minor changes have been made to Section A and B (mainly comprising the provision of definitions for sensitive terms used in questions), but the main amendments have been to Section C and E. As a reaction to further background reading (in particular Bergeron et al. [6]; Branchseau & Brown [8]), Section C now also addresses levels of 'user access to information', 'actual use', and 'user satisfaction', in addition to the other aspects (eg. business benefit, implementation frequency etc). It is expected that these changes will significantly improve the accuracy of future conclusions drawn from scores totalled for Section C - which is a key section as it provides the 'measured' level of EUC effectiveness. The structure of Section E has been slightly altered so that there is less 'bias' towards users who utilise tools which are capable of producing 'complex' applications. Our observation of Rivard et al. [25], which describes a potentially useful measurement construct, was too late to be taken into account in the enhancement of section C for use in the current full survey.

A new section has been included in the questionnaire, to enable a thorough and expansive analysis of the types of EUC activities, the degree of assistance that other end users, and IT specialists, give with the various activities, together with an indication of the satisfaction that the user has with the outcomes and the tools utilised. We use a list of tasks which is an extended/amended version of that used by Mclean & Kappelman [22] in their survey of end users.

5. Further research

At present a full survey of business users in a wide range of organisations is underway - using the improved version of the questionnaire. Responses are now only beginning to be received (we eventually expect in excess of 100 returns), but already there are signs that the validity of the model is likely to be confirmed. We intend, with the larger sample, to derive a 'regression equation'
which can be used to calculate effectiveness based on given contributory factor values. Depending on the statistical significance of the equation, we intend to use the equation for predictive purposes. We also plan to use a non-statistical analysis of the responses to move towards predicting EUC quality.

Currently we are developing a short version of the questionnaire. The motivation behind this is to increase access to the questionnaire, and hence form a wider profile of EUC participants/activities. Organisations are reluctant to include large numbers of their business users in the survey, as the questionnaire is quite demanding and takes between 15 and 35 minutes to complete. We are keen to overcome this reluctance, as we are very interested in gaining EUC profiles of groups of business users within particular companies. In the future, we plan to invite appropriate survey participants, to assist us with the task of prototyping the design of advanced EUC tools. We also intend to test the ability of the EES model to provide predictions of the impact of changes to EUC contributing factors.

6. Conclusions

1. A reasonable amount of validatory evidence relating to the survey instrument has been obtained. Several improvements to the questionnaire have been triggered, with the aim of making it easier to understand, and to improve the scope and targeting of issues addressed.
2. The statistical and non-statistical analysis suggests that even with the small sample size, there are fairly clear links between 'business/IS knowledge' and 'tool characteristics' factors and EUC effectiveness. Links are also indicated between the 'IT experience' and 'role/authority' factors and EUC effectiveness. This analysis gives initial evidence of the validity of the EES model. We expect to be able to use the model to predict the impact on the quality of EUC outcomes as a result of making planned changes to the contributing factors.
3. Even the small number of responses showed that most of those surveyed seem to have a reasonably high degree of IT skills, and business/IS knowledge. It has been demonstrated that the survey results can be used to categorise the participants into one of nine levels of IT and business/IS expertise.
4. This study leads to further research which includes the further validation of the model, testing of the prediction capabilities of the model, and the prototyping of advanced EUC tool design.

Acknowledgements - thanks are expressed to David Goda for his assistance with the task of statistical analysis of survey data.
7. References


