INCLUDING EXPLICITLY THE QUESTION OF 'WHICH' IN EVALUATION STUDIES

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Abstract: Existing studies of user acceptance factors try to provide answers to the questions of 'why', 'what', 'who', 'when' and 'how'. In this paper, we propose to include the explicit question of 'which' into future evaluation studies. Two distinct approaches are discussed to address the question of 'which'. The aim is not to show which is the best, but rather to demonstrate the potential of some alternative approaches to addressing 'which'.

1 INTRODUCTION

Effective evaluation of health care information systems is necessary to ensure systems adequately meet the requirements and information processing needs of health care organizations. The issue of user acceptance of healthcare technology is often the main focus of research in evaluation studies (Yi et al., 2006; Martens et al., 2008). Evaluation outcomes may allow decision makers to take appropriate courses of action. However, to be able to take appropriate action, decision makers need to know not only factors that contribute towards acceptance but also which among these factors are the most crucial in influencing user acceptance. Knowing the level of importance of each of the factors would help decision makers handle the factors appropriately, rather than focusing effort equally on all. Although there are studies that discuss the critical success factors (Jen and Chao, 2008; Wu et al., 2007), a formal methodology to answer the question of 'which' should be explicitly introduced as a vital aspect of user acceptance studies. In this paper, we propose several approaches that could help to answer explicitly the question of 'which', that is *which* is the most influential factor in user acceptance.

2 BACKGROUND

According to (Friedman and Wyatt, 1997), evaluation is carried out to find answers to the following:

- The question of 'Why': This question tries to answer the purpose of evaluation. There are studies for example concerned with user adaptation to the new technology which examine specific attributes such as user satisfaction (Schaper and Pervan, 2007; Yi et al., 2006).
- The question of 'What' and 'Who': There are mainly four main major stakeholders interested in the results of evaluation work. These are the organization, the user of the system, the developer, and of course the patients.
- The question of 'When': Evaluation can be carried out during any or all three phases within the system development life cycle, which are pre-implementation (development), during implementation, and post-implementation (Yusof and Papazafeiropoulou, 2008).
- The question of 'How': There are two distinct approaches for evaluation which are the objectivist approach and the subjectivist approach.

In our previous publications, we have proposed a novel evaluation model of user acceptance of technology factors (K.S-Mohamadali and Garibaldi, 2009; K.S-Mohamadali and Garibaldi, 2010). In this paper, we access the proposed factors using methods discussed below to show how these method could help to answer an explicit question of 'which'.

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3 METHODS

3.1 Multi-criteria Decision Analysis (MCDA) Techniques

MCDA is a discipline which aims to support decision makers when they are faced with various conflicting evaluation items. Various MCDA methods are available, such as the Analytic Hierarchy Process (AHP), Goal Programming (GP), Fuzzy AHP, Data Envelopment Analysis (DEA), Multi-attribute utility theory, Scoring methods, Electra, and many more. An on-line questionnaire was distributed to the medical schools of various universities in the UK from January 2011 until March 2011. 38 users responded to the questionnaire. Respondents were asked to indicate the extent to which they felt the influence of various factors towards their acceptance of medically related software through pairwise comparison methods using linguistic variables (ranging from 1 = equally important to 9 = Absolutely More Important).

3.1.1 Classical AHP Approach

The basic steps involved in this methodology are as follows (Zahedi, 1986):

- Step 1: Set up the hierarchy structure by breaking down the decision problem.
- Step 2: Collect the input data by pairwise comparisons of the decision elements according to a given ratio scale.
- Step 3: Use the 'eigenvalue' method to estimate the relative weights of the decision elements.
- Step 4: Aggregate the relative weights of decision elements to arrive at a set of ratings for the decision alternative. Synthesize them for the final measurement of given decision alternatives.

3.1.2 Fuzzy AHP: Chang's Method

The weights of the factors and sub-factors were recalculated according to the Fuzzy AHP methodology using the same data set. Fuzzy AHP incorporate fuzzy values into the AHP method. There are several variations of fuzzy AHP. One approach is known as Chang's extent analysis on fuzzy AHP (Chang, 1996). The steps of Chang's extent analysis can be given as in the following:

Step 1: The value of fuzzy synthetic extent with respect to the ith object is first defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \tag{1}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^{j}$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed such as

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{2}$$

and to obtain $\left[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1}$, the fuzzy addition operation of $M_{g_i}^{j} (j = 1, 2, ...m)$ is performed such as

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{3}$$

then the inverse of the vector above is computed, such as

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{n=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_j} \right) \tag{4}$$

Step 2: The degree of possibility of $M_2 = (a_2, b_2, c_2) \geq M_1 = (a_1, b_1, c_1)$ is defined as

$$V(M_2 \geq M_1) = sup_{y \geq x} [min(\mu_{M_1}(x)), \mu_{M_2}(y))] \tag{5}$$

and can be expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) \tag{6}$$

$$= \begin{cases} 1 & \text{if } M_2 \geq M_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases} \tag{7}$$

To compare M_1 and M_2 we need both the value of $V(M_1 \geq M_2)$.

Step 3: The degree of possibility for a convex fuzzy number to be greater than the convex fuzzy number $M_i (i = 1, 2, ..., k)$ can be defined by $V(M \geq M_1, M_2, ..., M_k) = V(M \geq M_1)$ and $(M \geq M_2$ ... and $(M \geq M_k) = \min V(M \geq M_i)$,

$$i = 1, 2, 3, ...k. \tag{8}$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k) \tag{9}$$

For $k = 1, 2, ..., n; k \neq i$. The weight vector is given by

$$W' = (d'(A_1), d'(A_2), ..., d'(A_i))^T \tag{10}$$

where $A_i (i = 1, 2, ..., n)$ are n elements.

Step 4: Via normalization, the normalized weight vectors

$$W = (d(A - i), d(A_2), ...d(A_n))^T \tag{11}$$

where W is a non-fuzzy number.

3.2 Structural Equation Modeling (SEM Technique)

Structural equation modeling (SEM) is a statistical technique which can be used to test and estimate causal relations using a combination of statistical data and qualitative causal assumptions (Hair et al., 2010). SEM techniques allow for both confirmatory and exploratory modeling which means it can be used for both theory testing and theory development. An online questionnaire was published from December 2010 until April 2011 for a period of four months. In total we obtained 113 respondents. We used WarpPLS version 2.0 software to analyze the data with the application of a jack-knifing technique to determine the significance levels for loadings, weights and path coefficients (Kock, 2011). Partial Least Square (PLS) path modeling is one of the statistical methods for SEM which can be used to model the complex relationship of multiple endogenous (independent) and exogenous (dependent) variables.

4 RESULTS AND DISCUSSION

4.1 Classical AHP

By applying steps 3 and 4, we computed the normalized value followed by local weights for each of the factors and sub-factors. Once we obtained local weights for each of the factors and sub-factors, we then computed the global weights for each of the individual sub-factors by multiplying the importance of each factor with those of the sub factors. The results are shown in Table 1. As can be seen, AHP suggests Information Quality (IQ), = 0.203, as the most influential factor of user acceptance.

4.2 Fuzzy AHP

By using formula (1) above, the resultant weight vector is $W' = (0.826, 1.000, 0.534)^{\mathrm{T}}$. After normalization, the normalized weight vector of each objective with respect to the individual, technology and organization factors is obtained as $W_{\text{goal}} = (0.350, 0.424, 0.226)$. Using the same steps discussed in above section, we calculated the weight of each of the factors within these three broad categories. The resulted weights are shown in table 1. Fuzzy AHP also suggests that Information Quality (IQ), = 0.207, as the most influential factor.

Table 1: The Global Weight of the Factors.

Factor	AHP	Fuzzy AHP
PE	0.108	0.140
EE	0.055	0.052
SI	0.021	0.000
ISE	0.152	0.159
SWQ	0.153	0.195
SERQ	0.065	0.022
IQ	0.203	0.207
FC	0.171	0.200
MS	0.075	0.026

4.3 Structural Equation Modeling Technique

Based on the two-step approach recommended by (Anderson and Gerbing, 1988), we have analyzed the measurement model to test the reliability and validity of the instrument and also analyzed the structural model to test the proposed relationships. Our model confirmed both reliability and validity properties. The structural model indicated the casual relationships among constructs which include the estimates of the path coefficient and R-squared value. Figure 1 exhibits the structural model and the analytical results. As can be seen, the SEM method assigns Software Quality(SWQ), with an R-squared value=0.26, as the most important weight which suggest this is the most influential factor.

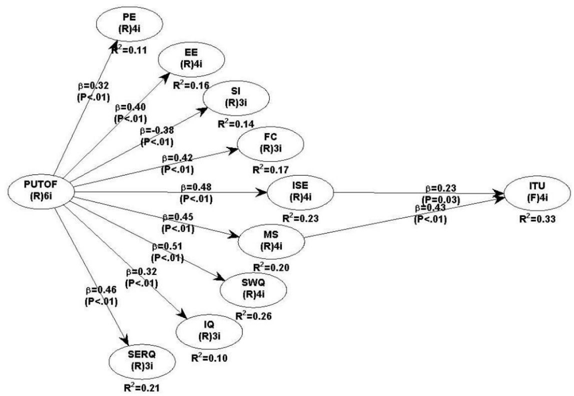

Figure 1: Loading of the factors using SEM.

5 ENHANCING THE EVALUATION QUESTIONS IN EVALUATION STUDIES

In this paper, we have demonstrated two methods (MCDA and the SEM technique) which can help to answer the explicit question of ‘which’. This question of ‘which’ is explicitly added into existing evaluation questions as shown in Figure 2. The dotted lines show the original evaluation questions. The solid line is the proposed ‘which’ question, which we believe, should be addressed in *every* evaluation study.

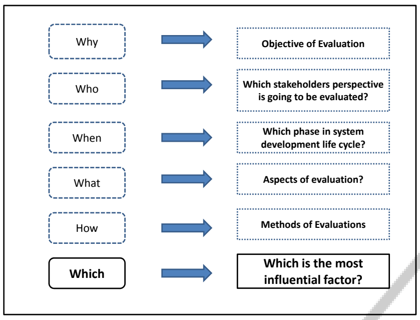

Figure 2: An Enhanced Evaluation Question of ‘Which’.

6 CONCLUSIONS

Evaluation of the factors that influence user acceptance of the software technology is a crucial and important effort. Originally, evaluation is carried out to find the answer to five main questions which are ‘why’, ‘what’, ‘who’, ‘when’ and ‘how’. We believe the question of ‘which’ also needs to be explicitly addressed and specifically recognised in all evaluation studies. Two distinct approaches are discussed in this study to determine the weighting between factors. The approaches presented in this study are not intended to show which is the best to be used to evaluate users’ acceptance factors, but rather to illustrate some of the various options which are available to be used to derive weights among evaluation factors and, hence, to explicitly answer the question of ‘which’. Future evaluation studies should explicitly incorporate the ‘which’ question in order to realize the maximum benefit for the various stakeholders.

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