End-user training programs planning model based on Information Technology and Information Systems (IT/IS) impact on individual work

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***Abstract*- Increasing number of service and manufacturing sectors are investigating the impact of information technology (IT) and information system (IS) on organizations. Also, IT training programs and their role in IS environment are being investigated. Previous studies suggested IT impact measurement for planning and assigning IT end-user training programs. This article develops and implements an integrated model to plan IT end-user training programs based on past IT end-user training programs success results specially IT impacts on individual works. Data Envelopment Analysis (DEA) and integer programming techniques are used to achieve the objective of this study. Previous studies either utilize qualitative measurements or DEA, whereas this study utilizes an integrated qualitative-DEA-integer programming model for planning and optimizing end-user training programs in context of IT/IS. The integrated DEA-integer programming model of this study ensures budget allocation for IT/IS resources achieve the goals and profits of organizations and their sub-organizations. The integrated model is applied to a large gas refinery composed of six major departments and 450 personnel. The result of implementing the proposed model shows its superiority and applicability.**

I. INTRODUCTION

As the resource commitments to information systems (IS) continue to escalate, the following types of questions are being asked more frequently than ever before: Is that investment in IS or information technology (IT) really worthwhile? Is that IT application we implemented a success? [1-4]. Both academics and practitioners recognize that the success of IT can potentially be measured through its impact on work at the level of the individual end-user [5]. To evaluate IS success, MIS researchers have measured a variety of constructs such as system and information quality [6], organizational benefits of IS projects [7], end-user computing satisfaction [8], IS success [9, 10] and IT impact on work [5, 11].

In today's end-user computing environment, the natural concern over how well designed IS must be augmented with an equally ardent concern about how effectively they are used or what impact they have on work [5]. Recognizing that the success of IT can be measured through its impact on the individual end-user, Torkzadeh and Doll [5] developed a 12-item instrument to measure the impact of information technology on work.

On the other hand, DeLone and McLean's [12] model considered the most comprehensive information system assessment model available in the IS literature [13]. DeLone and McLean's [12] conceptual model of IS success has been cited in over 300 refereed journal articles since its inception [14, 15]. Based on reviewing one hundred IS success articles published in the 1980s, DeLone and McLean proposed six dimensions representing the three levels of IS success: system quality, information quality, use, user satisfaction, individual impact, and organizational impact [15]. In their recent paper, they discuss many of the important IS success research contributions of the last decade, focusing especially on research efforts that apply, validate, challenge, and propose enhancements to the original model and propose an updated DeLone and McLean IS Success Model [14 p.9]. Their updated model has six dimensions: service quality, system quality, information quality, use, user satisfaction, net benefits. Those models, strength idea of using IT impact on work as IS success measure or clearly as a measure for net benefits aspect in Delone and McLean IS success model.

Torkzadeh et al [11]'s suggestion for using IT/IS impact on work instrument by IS managers to budget their end-user training programs is considered in this study. Furthermore, we introduce a model which allows organizations to budget and assign their end-user training programs based on the effectiveness of IT/IS applications and their impact on organization's personnel work. The proposed model has two major steps:

1. Firstly, sub-organizations based on past end-user training budgets and times and their current impact of their IT/IS application are ranked by Data Envelopment Analysis(DEA);
2. In the second step, based on the sub-organizations rank and the overall limited budget, an integer programming is formulated and solved to assign the appropriate training course to the sub-organizations.

The remaining part of the article is as follow. First literature review of the IT/IS impact on work is reviewed, then IT/IS success, and end-user training related factors and evaluation are discussed, and finally DEA technique is presented. In section 3 the proposed model and its steps are demonstrated.

Section 4 presents the results of applying model in a private organization. In section 5 conclusions and suggestion for future research are provided.

II. Literature Review

A. IT/IS Impact on Work

Based on an exploratory study, Torkzadeh and Doll [5] recommend a 12-item instrument for measuring the impact of IT on work. Relying on a review of the literature in MIS, social and economic impact of IT, and white collar productivity, they defined the following impact dimensions:

- Task productivity: the extent that an application improves the user's output per unit of time;
- Task innovation: the extent that an application helps users create and try out new ideas in their work;
- Customer satisfaction: the extent that an application helps the user create value for their internal or external customers;
- Management control: the extent that the application helps to regulate work process and performance.

The original exploratory study suggests high reliability and validity for this 12-item instrument. Reliabilities were measured using Cronbach's alpha. The reported reliability for task productivity, task innovation, customer satisfaction, and management control was 0.93, 0.95, 0.96 and 0.93, respectively. The 12-item instrument had a reliability of 0.92. Torkzadeh and Doll [5] also reported significant correlations between the impact measures and other theoretically related constructs such as user involvement, user satisfaction, and system usage [11]. These measures of IT impact on work are presented in Appendix A. Torkzadeh et al [11] by stating that acceptance of the Torkzadeh and Doll [5]'s instrument as a standardized instrument required further model validation through confirmatory techniques and factorial invariance tests, used confirmatory factor analysis to examine the fit of the proposed measurement model and to assess uni-dimensionality, validity, and reliability before testing the model for factorial invariance. They performed the factorial invariance tests across respondents from the USA and Mexico, and across two managerial levels. Then, they suggested to make comparisons between users of the same software package (e.g., to identify differences between individuals and assess training needs) and also may be used in information systems research on learning processes or continuous improvement behaviors. Specifically, they stated that "Information system managers may use these measures to more carefully budget their end-user training programs" [11, p.116].

B. End-User Training Related Factors and Evaluation

The critical role of end-user training is regularly noted by corporate managers, as evidenced by the fact that U.S. companies planned to spend approximately $57 billion on employee training in 2001 and that more than one-third (37%) of such programs were targeted at improving the computer skills of employees [18]. In 1959, in a classic analysis, Donald Kirkpatrick, a pioneer training and education researcher, proposed that training programs be evaluated at four levels: reaction; learning; behavior; and result [18, 19]. Radhakanta and Vincent [18] proposed a framework for evaluating end-user training programs which has two dimensions:

- The evaluation dimension, which suggests what to evaluate, and has five levels: (1) technology; (2) reaction; (3) skill acquisition; (4) skill transfer; and (5) organizational effect.
- The evaluator dimension, which identifies the person or group responsible for doing the evaluation and has three major constituencies: (1) training providers, (2) trainees, and (3) business managers

They stated that when implementing the framework several factors need to be evaluated [19] as shown in Table I.

TABLE I
FACTORS TO EVALUATE END-USER TRAINING PROGRAMS [18]

Evaluation level	Evaluator	Factors to evaluate
Technology	Training Provider	• Effectiveness of IT in supporting training-related tasks • Ease of use and usefulness of IT-based tools used by training providers
	Trainee	• Delivery and presentation of training materials • Ease of use and usefulness of communication tools
Reaction	Trainee	• Relevance of the course to the trainee's job • Satisfaction with course content and presentation • Quality of instruction • Effectiveness of instructor • Overall satisfaction with the training experience
Skill Acquisition	Trainee	• Knowledge and skill learned
Skill Transfer	Trainee	• Ability to apply the skill learned at work
	Manager	• Effect of the training on the trainee's performance
Organizational Effect	Manager	• Effect of the training on organizational goal achievement

Evaluation of the knowledge and skills acquired by the trainee must be made by training managers in light of the program's learning goals. Skills transfer can be evaluated by surveying trainees about how they are able to use the software and how often they seek help when using it. The evaluation plan and instruments to be used for data collection must be investigated and implemented as a part of the process for designing a training program and allocating resources (such as budget). Sang et al [20] developed an extended end-user training model and a detailed end-user training causal model and empirically studied the factors that are essential for successful end-user training. They found:

- The higher end-user abilities, the higher end-user IS acceptance

- The higher end-user abilities, the higher system utilization

Surprisingly, few consistent findings have resulted from empirical studies that have sought to find a direct effect between user training and acceptance or actual use of IT. Several studies showed that user training *does* influence users' skills and their acceptance of IT [22, 23]. Harrison and Rainer [24] found that user training had an effect on IT usage, but users' prior computer experience and age were more important determinants of IT acceptance and use. Michael et al [21] developed a research model that combines aspects of conventional training models with work group members' social influence, which according to our literature review, may be more important in shaping an employee's IT usage. In their model, amount of user training, perceived quality of user training, computer self-efficacy, coworkers' perceived training quality, coworkers' IT Usage, coworkers' IT perceived usefulness relationships with amount of IT Usage have been examined. The results showed that perceived quality of user training, coworkers' perceived training quality, coworkers' IT usage have positive relationships with amount of IT usage [22].

C. Data Envelopment Analysis (DEA)

DEA is a non-parametric method that uses linear programming to calculate the efficiency in a given set of decision-making units (DMUs). In this section we only describe the DEA model used in our model. The original DEA model (e.g. BCC) is not capable of ranking efficient units. CCR model assumes constant returns to scale (CRS). However, variable returns to scale (VRS) can be incorporated in it by appending the constraint ($el = \sum_{j=1}^{n} lj = 1$) and the resulting model is called BCC model. However, BCC model does not allow for ranking of efficient units as it assigns a common index of one to all the efficient DMUs. Therefore, this model is modified by Andersen and Petersen [25] for DEA based ranking purposes. In this study there are r outputs (Yrj) and m inputs (Xij) to be utilized by DEA for j = 1,…,n units or DMUs. Therefore, our original DEA model is as (1) to (5). This model is an output-oriented super-efficiency model that assumes variable returns to scale and gives a full ranking of DMUs which are sub organizations in our case, here. A full description of the procedure of determining the critical input and output indicators can be found in [26].

$$\text{Max } q \qquad (1)$$

s.t.

$$x_{io} - \sum_{\substack{j=1 \\ j\neq 0}}^{n} l_j x_{ij} \geq 0 \qquad i = 1,2,...m \qquad (2)$$

$$\sum_{\substack{j=1 \\ j\neq 0}}^{n} l_j y_{rj} \geq q y_{r0} \qquad r = 1,2,...s \qquad (3)$$

$$\sum_{\substack{j=1 \\ j\neq 0}}^{n} l_j = 1 \qquad (4)$$

$$l_j \geq 0 \text{ , } j \neq 0 \qquad (5)$$

III. THE PROPOSED MODEL

Empirical studies show that end-user training influences user acceptance of IT and IT usage [20-24]. On the other hand, IS success models imply that system use influence or impacts individuals and organizations and vice versa [12, 14]. Therefore, end-user training influences IT/IS impacts on individuals and on organization. On the other hand, as end-user training evaluation literature suggests [18], designing training programs and allocating resources to them must be done based upon the plan which considers past programs evaluation data. This idea is enforced by Torkzadeh et al [11] suggestion about using IT impact measure by managers to assign resources to different users training programs. Therefore, there is need to develop a model for using IT/IS success measures such as IT impact on work for planning and allocating end-user training programs. The proposed integrated model shown in Fig .1 has the following three steps:

1. First, organization planners and managers must choose the level of the organization which can monitor and collect the needed information (e.g. conducted end-user training programs, assigned resources to them, etc). In most organizations, this level will be the first or second level of organizational structure.
2. In second step, the DEA output-oriented variable returns to scale must be formulated and solved to determine the sub-organizations ranks with respect to IT/IS success. Indicators such as sum of the spent time and budget for user training in the sub-organizations may be used as input indicators. IT impact on individual works instruments such as the one which was proposed and validated by Torkzadeh and Doll [5, 11] can be used as measure of IT/IS success as output indicators. But those measures are in format of questionnaire (qualitative), and thus must be converted to quantitative values. For this purpose, Likert-scale shown in Table II can be used.

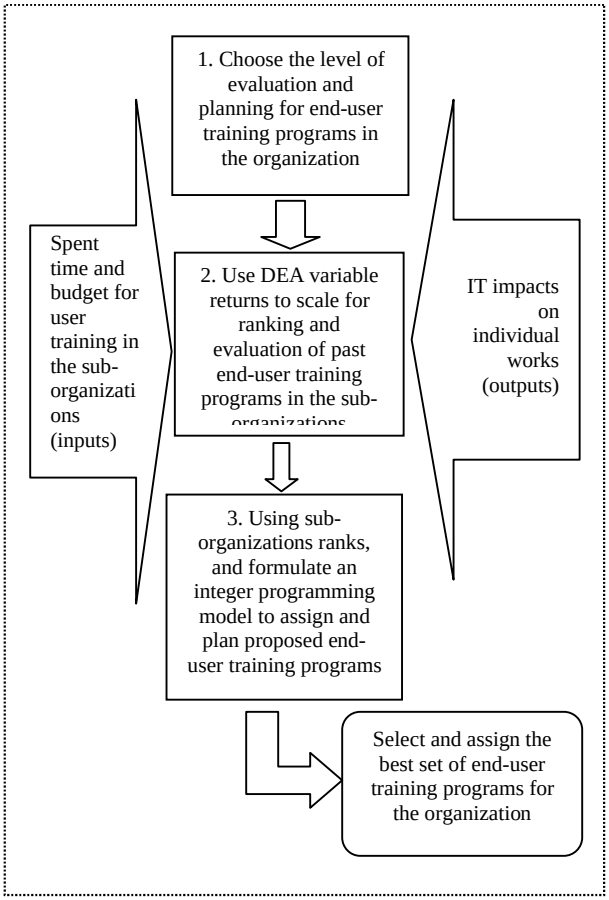

Fig. 1. The proposed integrated model for planning and optimizing end-user training programs in organizations

TABLE II

FIVE POINT LIKERT-SCALE

Question's possible replies in questionnaire	Related number
Without impact	1
Small impact	2
Moderate impact	3
High impact	4
Very high impact	5

The 12 item questions of IT impact on work must be distributed and collected among the sub-organizations users and according to the Likert-scale. To illustrate our point the responses are converted, summed and averaged for a hypothetical organization composed of three sub-organizations shown in Table III.

In evaluating efficiency of the spent resources on end-user training programs in sub-organizations and their impact on individual's work, due to this fact that increase in inputs (in this case which are spent time and budget on end-user training programs) will results in variable increase in outputs (IT/IS impact on individual works) for different quantity of inputs, we selected the DEA variable returns to scale for modelling and assessment purpose. End-user training needs is not continues and by achieving to the some level, after that IT impacts on work will not increase as past. For example, consider that a sub-organization spent 50 hours and 3000$ on its end-user training program, and their users scored different aspects of IT impact on their work as 40, 30, 60, 20 in a 100 scale. If we increase the mentioned sub-organization end-user training inputs to 100 hours and $6000, then their users scored different aspects of IT impact on their work as 60, 70, 65, and 50 in a scale of 100. Increasing to 150 hours and 9000$, their users scored different aspects of IT impact on their work as 65, 75, 70, 60 in a 100 scale. Reason for using the output-oriented model is that we are seeking to determine the spent input and resources efficiency in creating IT/IS success in individual level.

3. Finally, by using sub-organizations ranks which is determined in step 2, and considering other factors in selecting and assigning end-user training programs, an integer programming model is formulated and solved to assign and plan proposed end-user training programs. In organizations, stakeholders may assign the criteria to some sub-organizations due to their role or position in organization value chain (e.g. Production department, etc). Those criteria and other constraints such as budget can be applied in the following integer programming model:

$$\text{Max } Z = \sum_{i=1}^{nc}\sum_{j=1}^{np}(wr_i + wp_i)x_{ij} \qquad (6)$$

$$s.t.$$

$$\sum_{i=1}^{nc} b_i x_{ij} \le B \qquad (7)$$

$$\sum_{i=1}^{nc} x_{ij} \ge lb_j \qquad \forall j,\ j = 1,2,\ldots np \qquad (8)$$

$$x_{ij} = (0,1) \qquad (9)$$

In which

$$x_{ij} = \begin{cases} 1 & \text{If the proposed end-user training program i for sub-organization j is selected;} \\ 0 & \text{Otherwise} \end{cases}$$

Where *np* is the number of proposed end-user training programs, *nc* is the number of departments or DMUs; b_i is the required budget for each proposed end-user program. Also wr_i is the respected weight for the proposed end-user training program i from ranking sub-organizations (resulted from the DEA model discussed in the last section) and wp_i is respected weight for the proposed end-user training program i

from other criteria defined by stakeholders and lb_j is lower bound for number of courses which must be assigned to the sub-organizations j and B is the limited budget for overall IT training programs in the organization. For clarifying the proposed model, we applied model in a gas refinery discussed in the next section.

IV. The Case Study

A gas refinery with 450 personnel and six major departments was used as the case study. In each department different packages and special software's are used. Managers are faced with 12 proposed end-user training programs for their departments. There was $ 2300 annual IT budget for organizational end-users training budget in 2004. We firstly distributed and collected 60 questionnaires on IT impact of work (developed by Torkzadeh and Doll [5]). To verify the collected questionnaire, 8 questions were randomly selected and structural interview were performed to validate the results and consequently one of the questionnaire was deleted from further considerations. Then, responses with Likert-scale were converted and averaged for each department. The IT training budget and courses data for years 2002 and 2003 were available and collected (see Table III).

TABLE III

Gas refinery data used for ranking in the DEA model

Department No.	Inputs				Outputs			
	IT training programs spent times (hours)		IT training budget ($)		IT impact on work (average response in the 5 point Likert-scale)			
	2002	2003	2002	2003	Task productivity	Task innovation	Customer satisfaction	Management control
1	50	70	270	320	3.3	2.1	1.1	2.1
2	80	100	310	370	4.3	2.4	3.1	2.5
3	140	100	470	390	2.1	2.5	2.9	2.6
4	20	50	180	240	3.2	2.7	4.2	3.7
5	70	90	270	310	1.1	2.1	2.7	1.9
6	40	50	250	290	4.1	2.7	3.5	4.2

The DEA model was developed and solved for ranking and evaluation of past end-user training programs in the sub-organizations (6 departments) of the gas refinery (Table IV). In this study there are 4 outputs (y_{rj}) classified as task productivity, task innovation, customer satisfaction and management control and 2 inputs (x_{ij}) which are IT training programs spent times and budget to be utilized by DEA for j = 1,…,6 departments or DMUs. The reader should note that the averages of 2002 and 2003 are used for the above input indicators. Therefore, our practical DEA model for the gas refinery in context of IT/IS is as follows:

$$\text{Max } q \qquad (10)$$

$$s.t.$$

$$x_{io} - \sum_{\substack{j=1 \\ j\neq 0}}^{6} l_j x_{ij} \geq 0 \qquad i = 1,2 \qquad (11)$$

$$\sum_{\substack{j=1 \\ j\neq 0}}^{6} l_j y_{rj} \geq q y_{r0} \qquad r = 1,2,3,4 \qquad (12)$$

$$\sum_{\substack{j=1 \\ j\neq 0}}^{6} l_j = 1 \qquad (13)$$

$$l_j \geq 0 \text{ , } j \neq 0 \qquad (14)$$

TABLE IV

DEA Results for the 6 departments of the gas refinery

Department No.	DEA results	
	Efficiency	Ranking
1	0.890698	5
2	1.046512	3
3	0.925926	4
4	1.166667	1
5	0.813953	6
6	1.166667	2

There are 12 proposed end-user training programs. Therefore, according to the proposed integrated model an integer programming model is developed and solved to assign and plan the 12 proposed end-user training programs. Tables VI and VII show the required data used to develop the integer programming model.

TABLE V

The departmental data for the integer programming model

Department number (nc)	Lower bound for number of end-user training programs (lb_j)
1	0
2	0
3	1
4	1
5	2
6	0

Also wr_i is the respected weight for course i from ranking sub-organizations and wp_i is respected weight for course i from other criteria defined by stakeholders and lb_j is lower bound for number of courses which must be assigned to the sub-organizations j and $B=2,300$ is the limited budget for overall IT training programs in the organization. The integer programming model solutions with respect to the 12 proposed end-user training programs are presented in Table VI ("selected or not" column).

TABLE VI

The end-user training data for the integer programming model and proposed end-user training programs resulted from the integer programming model

The proposed end-user training program number (*itp*)	Required budget ($) (*b*)	Selected or not (x_{ij} = 0 or 1)	Target department number (*nc*)	Stakeholder weight (*wp*) from the DEA model	Weight for the proposed end-user training program i from ranking sub-organizations (from the DEA (*wr*)
1	200	1	1	2	5
2	450	0	2	5	3
3	190	1	4	6	1
4	100	1	1	2	5
5	300	1	3	7	4
6	310	1	2	5	3
7	290	1	6	3	2
8	375	0	4	6	1
9	500	1	5	8	6
10	90	1	6	3	2
11	220	1	2	5	3
12	450	0	1	2	5

$$\text{Max } Z = \sum_{i=1}^{6}\sum_{j=1}^{12}(wr_i + wp_i)x_{ij} \qquad (15)$$

s.t.

$$\sum_{i=1}^{6} b_i x_{ij} \le 2300 \qquad (16)$$

$$\sum_{i=1}^{6} x_{ij} \ge lb_j \qquad \forall j,\ j = 1,2,...,12 \qquad (17)$$

$$x_{ij} = (0,1) \qquad (18)$$

V. Conclusion and Results

An integrated model for planning and assigning IT end-user training programs in organizations based on IT impacts and productivity in sub-organizations was presented. The model is easy to implement and also is compatible the latest research in the area of end-user training program planning and evaluation base on IT/IS success and impact. Also, the model is easy to understand, learn and adopt in organizations. This model provides an ideal tool for planning end-user training programs in organizations and it can be integrated with other sections of IT budget assignment such as maintenance projects, new systems developments, updating systems.

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