Constructing a Multi-criteria Framework for Evaluating Asynchronous E-learning System: a User Satisfaction Perspective

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Abstract: - The asynchronous e-learning system (AELS) has been prevalent in both academia and industry. However, conventional evaluation of the AELS has leaned heavily towards the technical aspects of information systems. Since user satisfaction has been extensively proved and recognized as being a critical factor in influencing the success of information systems, this study deals with AELS evaluation from the perspective of user satisfaction. A survey of college students was carried out to collect data, which was then analyzed by analytic hierarchy process. The results show that the most important dimension of decision criteria was the learner interface. Operational stability, ease of accessing shared data, useful content, and capability of controlling learning progress top each dimension, respectively.

Key-Words: - Asynchronous e-learning system; analytic hierarchy process; multi-criteria decision making

1 Introduction
Over the past few decades, asynchronous e-learning system (AELS) has emerged as one of the most important information technology (IT) applications. Its great potential for disseminating knowledge regardless of the time and location, contrary to traditional restricted learning environments, has attracted stakeholders in the fields of both IT and education. The wide proliferation of AELS applications in both academia and industry demonstrates this trend, resulting in the need to examine their effectiveness.

Since users are key stakeholders in any information system (IS) or IS service, the construct of user satisfaction has often been used as a surrogate for the effectiveness or success of such systems or services [19]. The level of one user’s perceived satisfaction with a particular system can significantly influence the degree of his reliance on that system, as well as future decision about whether he will reuse it. This study, therefore, has adopted the user satisfaction perspective as the basis for evaluating AELS. In the past, user information satisfaction (UIS) [11] and end-user computing satisfaction (EUCS) [7] were two major well-developed and validated constructs, representing the concept of user satisfaction with regard to IS or IS service. However, the inherent properties of an AELS allow a special group of users, the learners, to have a greater ability to demonstrate their unique points of view regarding user satisfaction, as compared to conventional users of other computer-based IS [23]. Because of this, a new approach for evaluating AELS should be specifically customized towards not only user satisfaction, but also towards learner satisfaction.

The purpose of this study is to construct a multi-criteria decision-making (MCDM) framework from a user (learner) satisfaction perspective for AELS evaluation and selection. By disclosing multiple aspects of the construct of user satisfaction, this framework will be comprised of the following components designed to resolve different portions of the aforementioned problem organizations may encounter in their practices:

1. A hierarchy structure, identifying what criteria can be applied to this context, how these criteria can be classified into dimensions, and how these criteria and dimensions can be arranged as a hierarchy.
2. A preference structure, exploring learners’ perception towards the relative importance of the criteria, and the dimensions of these criteria. This may help answer what it is that learners regard highly in terms of user satisfaction in an AELS environment.

This paper is organized as follows: Section 2 describes the concept of user satisfaction and the development of user-satisfaction scales. Research
methodology, including the establishment of a hierarchy structure for evaluating AELS and a brief introduction to the AHP used in this study, is presented in Section 3. Based on the results of AHP, Section 4 presents a preference structure which constitutes the framework. Finally, we draw conclusions in Section 5.

2 User Satisfaction
Satisfaction is the aggregate of a person’s feelings or attitudes towards the many factors that affect a certain situation [1]. In the field of IS, many believe that the concept of user satisfaction was originally proposed by Cyert and March [4]. They argued that if a formal IS can successfully satisfy a user’s requirements, then his sense of satisfaction will be reinforced, and this IS will continue to be used. If the opposite is true, the user’s sense of frustration will lead him to abandon this IS and seek an alternative. Such a concept was later developed to represent the degree to which users believed the IS they were using conformed to their requirements, which directly affected whether they liked using the system [2,7,11]. Thus, in many studies, user satisfaction has become a surrogate for assessing the effectiveness or success of IS [6,9,18,19].

In the past, many scholars have attempted to measure user satisfaction. Prior to the 1980s, many studies pointed to “flexibility” or “easy to change and adapt” as the more important factors [16,17]. After the 1980s, many scholars began to conduct systematic studies to develop a comprehensive and reasonable set of factors. For example, Bailey and Pearson [1] adopted a semantic differential technique and employed 32 managers serving as subjects from eight organizations to develop a questionnaire with 39 items in order to measure the level of perceived user satisfaction with IS. Ives et al. [11] suggested that user information satisfaction (UIS) was the subjective or perceptual measure for judging whether a system is successful, and that it could be used for assessing how users regard the IS services they consume. By replicating Bailey and Pearson’s findings, they employed 800 production managers in U.S. manufacturing organizations as subjects. The results showed that UIS was best discussed by dividing it into three parts: electronic data processing (EDP) staff and services, information product, and knowledge or involvement.

The scales devised in the studies of Bailey and Pearson and Ives et al. primarily focused on the indirect or intermediate users in a traditional EDP environment. Doll and Torkzadeh [7] considered these scales inappropriate to the environment of end-user computing (EUC) and were of the opinion that, in contrast to a traditional EDP environment, the measurement of user satisfaction in an EUC environment should be carried out with respect to specific applications. Additionally, they also contended that EDP-based user satisfaction scales ignored the concept of ease of use in the field of human-machine interface. Thus, they focused on this issue and developed an instrument with 18 items, which could be classified into the following five dimensions: system content, system accuracy, report format, ease of use, and system timeliness, to measure end-user computing satisfaction (EUCS). Subsequent studies confirmed that the EUCS scale had a high level of both reliability and validity, even in a cross-cultural setting [15].

In addition to UIS and EUCS, Palvia [18] conducted research focusing on the satisfaction of small business users with information technology (SBUSIT) and concluded that the existing satisfaction scales were all directed at EDP and EUC environments, and that they were unsuitable for small enterprises. The results of Palvia’s study determined that the SBUSIT included the following dimensions: software adequacy, software maintenance, information content, information accuracy, information format, ease of use, timeliness, security and integrity, productivity, documentation, vendor support, and training and education. In addition, Wang [23], by consulting UIS and EUCS, conducted an exploratory study directed at e-learners in industries in Taiwan and used factor analysis to generate key dimensions for measuring learner’s satisfaction. The results revealed that a total of 17 items applicable in measuring satisfaction in an e-learning environment could be classified into the following dimensions: content, personalization, learning community and learner interface.

This study focuses on the learners of AELS, and what we refer to as user satisfaction is conceptually close to the definition of EUCS. The studies of McHaney et al. [15] and Wang [23], based on Doll and Torkzadeh’s EUCS [7], were empirically conducted in Taiwan, and moreover, an e-learning environment is the background of Wang’s study. Thus, our study uses his work as the primary theoretical basis, supplemented by the other studies mentioned above.

3 Methodology
In this section, the nature of MCDM and the AHP method are briefly reviewed and a hierarchy structure is proposed as the basis for constructing the MCDM framework. In addition, our data collection procedure is also explained.

3.1 Multi-Criteria Decision-Making and Analytic Hierarchy Process

Multi-criteria decision-making (MCDM), sometimes referred to as multi-criteria decision aid or multi-criteria decision analysis, is a rapidly developing area in operational research and management science; it has been widely used for resource allocation, energy planning, project management, and so on [12,22]. MCDM deals mainly with discovering the preference structure of a decision organization regarding multi-criteria problems and applying that structure to the evaluation of alternatives. Accordingly, the decision organization can then select the most feasible alternative to reach its goal. A complete MCDM cycle involves the following basic elements: criterion set, preferences structure, alternative set and performance values [24], which are used in two different phases of this cycle. The aim of the first two elements is to construct a framework for evaluation, while the last two deal with selection from the pool of alternatives based on their performance values.

As engaging in MCDM, in order to obtain an objective hierarchy structure to demonstrate the relationship between the goal and criteria, a hierarchical analysis must be carried out by incorporating literature review, systematic analysis, empirical investigation, brainstorming, or interpretive structural modeling [14]. The goal of the hierarchy may be “a perceived better direction of a decision organization” [22]. On the other hand, the criteria represent the “standards for judging” [10], which should be complete, operational, decomposable, non-redundant, and minimal in size [12,22]. It is of note that the resulting hierarchy structure is layer-based; a more complex problem may result in a structure with more layers.

The focus of the MCDM cycle is the weights of criteria, especially in the evaluation phase. Among several procedures that have been proposed, the AHP, developed by Saaty [20], is one of the most prevalent because of its superiority in judgment, consistency tests and measuring scales over others [8,13]. It supports the decomposition of a complicated problem into components, or the so-called criteria in this study, and then arranges them into a form of hierarchy. Through a series of pairwise comparisons between criteria, a pairwise comparison matrix can be obtained. Afterward, the principal eigenvector is calculated and normalized to derive the priority vector which provides a measure of the relative importance of criteria [5,21]. Finally, the consistency test of a decision maker’s input into a pairwise comparison matrix is necessary to examine the rationality of his judgment. Satty proposed a consistency ratio, defined by \( CR = \frac{CI}{RI} \), to measure the degree of consistency, where CI stands for the consistency index and is defined by \( CI = \left( \frac{\lambda_{\text{max}} - n}{n - 1} \right) \), \( \lambda_{\text{max}} \) is the largest eigenvalue of an \( n \times n \) pairwise comparison matrix, RI stands for a random index, which is a reciprocal matrix generated randomly. A value of CR less than 0.1 is deemed as sufficiently consistent.

3.2 The Hierarchy Structure

The hierarchy structure used in this study for evaluating AELS was adapted from Wang’s [23] work, where the user satisfaction scale for an e-learning environment was carefully examined in terms of reliability, content validity, criterion-related validity, convergent validity, discriminant validity and nomological validity, resulting in 4 dimensions comprising a total of 17 items. Although the original idea of AHP relies heavily on integrating experts’ opinions derived from a procedure such as brainstorming to complete the hierarchical analysis, the empirical investigation, as mentioned in the preceding subsection, is the recommended choice to produce a result comparable in quality [14], since a rigorous empirical validation, like Wang’s, promises a more reliable instrument.

We felt uncomfortable, however, with so many criteria which could complicate the MCDM process, as echoed by the principle of minimal size in the criterion set. In addition, the results of Wang’s work were based on a simple orthogonal factor solution where derived factors, with a high intra-factor consistency, were mathematically independent of one another. The highly inter-correlated criteria within a dimension, an outcome of high intra-factor consistency, may be conceptually or connotatively redundant, thus inspiring further examination. This validation was carried out through discussions with 3 professors of MIS and 5 experienced learners in order to rate the adequacy and relevance of the criterion items in terms of AELS evaluation. A total of 4 criteria were eliminated from the aforementioned validation, with the remainder being rhetorically refined. As a result, we ended up with 4
dimensions, comprising a total of 13 criterion items in the hierarchy structure, with the top of the hierarchy, namely the hierarchy’s goal, labeled as *The Evaluation of AELS*, shown in Fig.1.

![Diagram of hierarchy structure for evaluating AELS]

### 3.3 Data Collection

A survey was carried out to collect the data required for this study. The subjects were students enrolled in a data processing course, taught by an AELS at *National Chengchi University*. Three classes were selected, and the students were asked to fill out a paper-based AHP questionnaire at the end of an 18-week-long semester. As a result, a total of 145 valid samples were returned. Although the whole AHP process inherently emphasizes experts’ opinions, such a procedure for collecting data in this study was designed due to pairwise comparisons between criteria require subjects to have a considerable level of experience in using AELS. The experienced students are deemed as being more capable of comprehending the meaning of these criteria, thus increasing the credibility of the results. The demographic information of the subjects is summarized in Table 1.

<table>
<thead>
<tr>
<th>Profile of subjects</th>
<th>n</th>
<th>%</th>
<th>Profile of subjects</th>
<th>n</th>
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<tbody>
<tr>
<td><strong>Year</strong></td>
<td></td>
<td></td>
<td><strong>College</strong></td>
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<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>53</td>
<td>36.6</td>
<td>Science</td>
<td>9</td>
<td>6.2</td>
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<tr>
<td>Sophomore</td>
<td>32</td>
<td>22.1</td>
<td>Business</td>
<td>48</td>
<td>33.1</td>
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<tr>
<td>Junior</td>
<td>21</td>
<td>14.5</td>
<td>Law</td>
<td>4</td>
<td>2.8</td>
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<tr>
<td>Senior</td>
<td>37</td>
<td>25.5</td>
<td>Communication</td>
<td>12</td>
<td>8.3</td>
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<tr>
<td>Others</td>
<td>2</td>
<td>1.4</td>
<td>Liberal arts or foreign language</td>
<td>8</td>
<td>5.5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Social science</td>
<td>53</td>
<td>36.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Others</td>
<td>11</td>
<td>7.6</td>
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<td><strong>Experience in computer usage</strong></td>
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<td><strong>Past experience in AELS usage</strong></td>
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<td>Less than 1 year</td>
<td>2</td>
<td>1.4</td>
<td>Yes</td>
<td>83</td>
<td>57.2</td>
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<td>1 - 5 years</td>
<td>72</td>
<td>49.7</td>
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<tr>
<td>5 - 10 years</td>
<td>58</td>
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<tr>
<td>Over 10 years</td>
<td>13</td>
<td>9.0</td>
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</table>
4 MCDM Framework: The Preference Structure (Results of AHP)

In this study the integration of the preferences of the subjects will be carried out by the pool first and pool last methods [3]. The pool first method begins by calculating the geometric means of the marked responses in each question from each subject to create an integrated comparison matrix. This matrix is then processed to produce an integrated preference structure. On the other hand, the pool last method first produces a preference structure for each subject, and then integrates them by calculating the arithmetic means of the weights of each criterion and dimension from each subject. In addition, the pool last method provides the coefficient of variation (CV), defined by $CV=\frac{\text{standard deviation}}{\text{mean}}$, to represent the level of the variation in the subjects’ perceptions of the relative importance of criteria and dimensions since this method can produce the preference structures for individual respondents. In addition, not every set of responses with respect to dimensions or goal from each subject would pass the consistency test. Therefore, for both methods, we provide the results, as shown in Table 2, for the sample after removing those responses which did not pass the test.

It is found that the preference structures produced by the two methods are identical. The results indicate that the most important dimension with respect to AELS evaluation is learner interface, with system content and personalization ranked second and third, respectively; the learning community is judged by subjects as being less important. Moreover, operational stability, ease of accessing shared data, useful content, and capability of controlling learning progress are at the top of each dimension, respectively.

Table 2 Adjusted weights of dimensions and criteria

<table>
<thead>
<tr>
<th></th>
<th>Dimensions</th>
<th>Criteria</th>
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<td></td>
<td>D1 D2 D3 D4</td>
<td>D5 D6 D7 D8</td>
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<td>0.37 0.18 0.25 0.20</td>
<td>0.23 0.20 0.26 0.31</td>
</tr>
<tr>
<td>CR</td>
<td>0.000</td>
<td>0.001</td>
</tr>
</tbody>
</table>

5 Conclusions

The AHP results demonstrate that learners in an AELS environment regard the learner interface as being the most important dimension. This means that a user-friendly, well-designed and easy-to-use learner interface, therefore, becomes one of the critical factors in determining whether learners will enjoy using and will accept the AELS. Operational stability of the interface is also of great importance to the learners. Consequently, the design of an AELS learner interface with these above mentioned properties is essential. Those maintaining these systems should also pay attention to whether the present learner interface conforms to the learners’ requirements by responding to their ever-changing needs in a timely manner. Learners also place great value on the system content. This should remind AELS administrators to continuously include sufficient, up-to-date, and useful content, in addition to the latest technical aspects in design (e.g., learner interface design). In comparison with other application systems, the nature of the AELS emphasizes learning outcomes, implying learning effectiveness. As a result, characterizing more of the non-technical aspects of the system content is critical. This signifies that, in addition to technical engineers, a sound AELS needs a high level of participation from other non-technical experts, such as educators, teaching material editors and...
pedagogy professionals in its establishment stage and subsequent operation. This way, the quality of the system content and the level of learner understanding can be ensured.

This study has presented the concept of combining user satisfaction and MCDM to evaluate AELS. Previously, many user-satisfaction-related studies focused on developing scales with high reliability and validity to measure this construct, while most MCDM studies were based on expert opinions, which can cause problems with external validity or generalizability when dealing with user-orientated problems. This study applies user satisfaction scales which are extensively validated, transforms them into a hierarchy structure, and employs AELS learners as the objects of data collection in order to conduct the analysis for establishing an MCDM framework. As this is a single environment study, subsequent confirmatory studies are required to increase the generalizability of the results.

References: