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Critical Functionalities of a Successful e-Learning System – An Analysis from Instructors' Cognitive Structure toward System Usage

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Critical Functionalities of a Successful e-Learning System – An Analysis from Instructors' Cognitive Structure toward System Usage

Abstract

While an overwhelming majority of information systems research on e-learning has focused analyses mainly on the student level, this paper provides a fresh complimentary perspective from that of the instructors in understanding what critical functionalities of an e-learning system instructors will deem useful such that they will continue using the system. This research applies the means-end chain methodology to analyze the relation between instructors' personal values and the functionalities of the e-learning system. This research finds that the most critical functional requirements of the e-learning system for instructors can be categorized to two dimensions – instruction presentation and student learning management. The instruction presentation requirement includes e-syllabus and electronic whiteboard, while student learning management requirement are fulfilled by online forum, online roll call, threaded discussions, and assignment management. This research discovers that instructors develop sense of accomplishment, self-fulfillment, and fun and enjoyment of life through using the e-learning system with the aforementioned functionalities, which motivate them to continue using the system for instruction. Our research findings provide practical implications for the design and implementation of successful e-learning systems.

Keyword: e-learning system, means-end chain, critical functionalities, requirement analysis

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1. Introduction

The rapid development of Internet and information technologies has heralded new modes of instruction and learning with e-learning as the prime example, and generated new opportunities for the delivery of education in this information age. Earlier work in the e-learning area focused on presenting detailed descriptions of the architecture of the system per se. Siemer and Angelides [33] are among the first to propose a comprehensive method for the internal and external evaluation of an intelligent tutoring system to provide suggestions on the overall improvement of the architecture and behavior of the system. Xu and Wang [39] develop a personalization model for virtual learning environments and a prototype system to demonstrate the implementation of dynamic e-learning processes. They further conduct a field experiment to compare the performance of the virtual learning environment with personalization versus that of a non-personalized one. Developing and empirically testing an analytical framework grounded on economic theory, Ozdemir, Altinkemer, and Barron [26] identify the important institutional and student characteristics that affect the adoption of technology-mediated learning.

As e-learning systems become more readily available, many instructors started their trials of using e-learning system in their teaching. Their willingness to try the e-learning system, however, does not guarantee that they will continue to use the system. Prior studies show that information system users' continued usage of the system is determined by their perceived usefulness of the system. The studies in [5, 30] indicate that a major factor for the continued usage of the system is the perceived usefulness formed through the actual usage experience. Thus, the design of an information system should take into account those functionalities useful to its users. However, what functionalities of the system are useful to the users are not actualized until they actually use the system.

How to perform requirement analysis phase in the system development life cycle efficiently and effectively has been a long standing research issue in information systems research.[1] There are three main approaches described in prior literature to analyze the functional requirements of an information system in general and an e-learning system in particular. The first approach uses the traditional systems analysis and design methodology to identify instructors' requirements that will fulfill their instructional goals. For example, Govindasamy [10] favors this approach and believes that the instructor has five major requirements for an e-learning system including developing content, storing and managing content, packaging content, student support, and

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[1] For example, using "requirement analysis" as the exact phrase to search Google Scholar results in 12,300 research articles as of December 2008.

assessment. The second approach employs pedagogies as the basis of requirements to develop an e-learning environment suitable for instruction. For instance, Mishra [23] believes that constructivism is the most suitable theory for e-learning system design, and develops an integrated framework to transform learning theories to basic instructional approach and online approach. Further, Ainsworth and Fleming [1] analyze several different pedagogies and develop authoring tools that allow instructors to create learning environments by customizing imported computer-based training domain content according to their views of how materials should be delivered. The third approach applies problem-oriented approach to identify requirements. The first step in this approach is to list the problems that will be encountered in the teaching and learning process. Then, the system is designed according to the solutions to those problems identified [3, 9, 20, 25].

Since requirements analysis as an early phase of the systems development life cycle cannot account for users' usage experience ex ante, the e-learning system more often than not doesn't meet instructors' real needs for teaching, irrespective of which requirements analysis approach described above is adopted [21]. Absent real usage experience, Govindasamy [10] finds that the e-learning system with most functionalities will be selected for development although many of those functionalities or tools may not be used at all, resulting in a waste of development effort. A worse case ensues when some functionalities are not easy to use, creating instructional difficulty and increasing the cognitive burden of the instructors. These unexpected negative effects that are difficult to foresee during the design phase have significant impact on instructors' perceived value of the system and hamper their willingness to continue to use the e-learning system.

This research applies the means-end chain analysis method to examine instructors' cognitive structure toward e-learning system usage, and identifies critical requirements of successful e-learning systems by uncovering the relationship between the functionalities of an e-learning system and the instructors' perceived values derived from those functionalities. The means-end chain theory can show the relationship among the attributes of an object under consideration (namely, the functionalities of an e-learning system in this research), the consequences of using the object by an individual, and the personal values derived from these consequences. The means-end chain (MEC) method per se is a decision analysis methodology with wide range of applications in both decision analysis and decision support systems. For example, to investigate how marketing strategy decision-making evolves within a new environment of technological advances, global competition, and re-alignment of organizational processes, Jarratt and Fayed [15] apply the MEC technique to probe the respondent for their strategy development experience and how they incorporate organizational and market challenges in the strategy decision process. The MEC theory provides the theoretical underpinnings that accounts for the differences in consumers purchase decision making with and without DSS support and with and without the availability of physical products for inspection [28]. Montibeller, et al [24] propose a reasoning map tool for multi-criteria decision aid with an aim to provide an integrated approach to problem structuring and evaluation where the MEC captures a decision maker's reasoning in the problem structuring phase. Grenci [11] applies the MEC in the decision abstraction phase that transforms customer needs to product specification in an online customer decision support system that configures or defines complex and customizable products on an individual basis. Lin, et al. [19] adopt an expanded MEC theory to develop a logic deduction procedure for creating a more effective marketing decision support system.

The rest of this paper is structured as follows. Section 2 reviews the means-end chain theory used in this research to elicit the critical functionalities of a successful e-learning system for instructors. In Section 3, we describe the subjects participating in our study, the method of data collection, and the analysis methodology used to derive the hierarchical value map that depicts the relationship between the functionalities of an e-learning system and the instructors' perceived values derived from those functionalities. The main research findings and discussions drawn from the research results are presented in Section 4. Section 5 provides concluding remarks and practical implications of our research.

2. Means-end chain theory

The means-end chain model constructs a hierarchical value map (HVM) to systematically obtain information about individuals' perception of an object under consideration by analyzing the relation between the attributes of the object and consequences and values accrued to individuals [13, 16, 32]. An example of the HVM is shown in Figure 1. The means-end chain model categorizes the perception and requirements of individuals toward the object under consideration to provide a concrete basis for relevant decision making.

--- Insert Figure 1 About Here ---

The attributes of an object in Figure 1 refer to its physical observable characteristics as well as abstract feelings derived from the object. In the context of e-learning system, attributes are those functionalities provided by the system, e.g., discussion forum and electronic whiteboard. The consequences in Figure 1 are defined as any result accruing to the individuals after experiencing the object, including functional consequences and psychosocial consequences [13, 27]. Functional consequences are the benefits of experiencing the object. For instance, using multimedia instruction can attract students' attention and make the instruction process more efficient. Psychosocial consequences for individuals can be psychological or sociological in nature. For example, using suitable e-learning software can take care of the learners' individual differences, thereby ensuring the learning rights of learners. Values, including instrumental values and terminal values, refer to the psychological needs of individuals accomplishing important goals through the object [31]. The instrumental value reflects an external orientation relating to how we are perceived by others (e.g., “makes me feel more important” or “makes me feel accepted”), whereas the terminal value is concerned with the desirable end-states of existence (e.g., happiness, security, and accomplishment).

The analysis methodology of means-end chain model has been improved by many scholars after its inception. The laddering technique [28] is the most recent and frequently used analysis methodology to uncover the attributes-consequences-values hierarchy. Through in-depth one-on-one interviews, laddering technique develops meaningful “ladders”, i.e., associations between the attributes of an object with the values of the interviewee. The laddering technique applies a series of directed probes – questions such as “Why is that important to you?” – during the interview process with the specific goal to draw hierarchical value maps by establishing sets of linkages between key perceptual elements of attributes, consequences, and values. Laddering has been successfully applied in market segmentation, evaluation of a product or brand, and developing advertising strategy [14, 27, 34, 36, 37]. More recently, application of means-end chain model has been expanded to understand the requirements of web communities and consumers’ loyalty to online stores in the e-commerce setting [2, 17].

3. Research Methodology

3.1 Subjects and Procedure

The objective of this research is to identify critical functional requirements of a successful e-learning system by understanding the cognitive structure toward system usage of those instructors who have used such systems and their values derived from using these systems. The cognitive structure of the users of the e-learning system in our study is embodied by the ladders which portrays how instructors mentally link the system's intrinsic and/or extrinsic attributes (the functionalities) to personally relevant consequences and how the system facilities the achievement of desired end states (the values).

The subjects of our study are instructors of the K12 Digital School (http://ds.k12.edu.tw/) in Taiwan, who offer college level courses taken by K-12 teachers to fulfil their professional growth certification requirements. The K12 Digital School, sponsored by the Ministry of Education, is one of the largest and most successful e-learning organizations in Taiwan. The subjects of our study use the same e-learning system "Wisdom Master Pro", an e-learning system with SCORM 2004 and QTI certifications. The same features are available to the subjects of our study. Since the subjects need to have actual usage experience of the object under consideration in order for the means-end chain analysis to effectively elicit their perceptual orientations, the means-end chain analysis methodology is used to derive the instructors' cognitive structure *after* their usage of the e-learning system, not their a priori belief towards the system. While the socio-cultural background of the subjects may influence the subjects' perception of the e-learning system beforehand, such influence should be minimal on their ex post experience of the e-learning system.

We sent 356 e-mail invitations to the instructors of K12 Digital School to participate in our study. Among the 103 responses, 40 expressed interests and 31 of them completed our study.

Table 1 shows the background of the subjects of this study. The subjects have on average 9.4 years of teaching experience, implying that most of them are experienced instructors. About two thirds of the subjects are male, consistent with the gender profile of information system users. A majority of the subjects (84%) have offered online courses more than two times, with each course running three to four months. We found from the ladders derived from the interview process that most subjects quickly came up with the linkages with their personal values. This indicates that most subjects can clearly express their requirements of the system.

--- Insert Table 1 About Here ---

To make the interview process more efficient, we e-mailed the goals and outline of the interview to the subjects beforehand. We conducted face to face interview with 24 of the 31 subjects who agreed to participate in our study, while 6 of them interviewed with us via MSN or

Skype with web cam, and 1 through telephone interview. The preferred interview medium was chosen to ensure convenience and low pressure for the subjects.

3.2 Method of Data Collection

A ladder in laddering, a common analysis methodology of means-end chain to collect and analyze data, represents a linkage between the key perceptual elements across the range of attributes, consequences, and values of the subject. The subject may form no ladder or many ladders. Different subjects will have different perceptions of the same object, leading to different results. Laddering can be classified into soft laddering and hard laddering [14]. Using one-to-one in-depth interviews, soft laddering explores the hidden values of the subject in order to find the factors affecting those values. Hard laddering relies on large samples from questionnaires, and performs validity analysis using statistical methods. We used soft laddering to collect data since our goal is to gain in-depth understanding of the values and perceptions of instructors who have used various functionalities of e-learning systems.

To derive sufficient ladders, authors of this study who are versed in laddering technique collected data from interviewing thirty one instructors, more than the required twenty respondents reported in [29]. Each subject of our study generated on average five ladders. With three elements in each ladder, we have 465 data points, exceeding the required number of samples to generate useful linkages. Collecting useful data needed for this research requires skillful in-depth interview techniques to uncover the true perceptual orientation of the respondent, a somewhat time-consuming process. For this study, the interview time for each subject, excluding the preamble, ranges from forty to sixty minutes.

The first step in laddering is to ask the respondents to draw distinctions from products or services of same attributes and to describe reasons behind the distinctions by prompting the question “Why is it important?” repeatedly such that the respondents can recall their perceptual result of using the system to come up with the Attributes-Consequences-Values ladder. Figure 2 shows an example of the A-C-V ladder of the services of a convenience store. Therefore, the interview agenda of this study is as follows: (1) Ask the instructors to compare the traditional teaching environment with online learning environment, and describe which functionalities of the e-learning system are useful. (2) Ask the instructors why such functionalities are useful for instruction. (3) Ask the instructors to explain why such consequences are of value to them. Through this step-by-step interview, respondents could clearly articulate their views of using the e-learning system, enabling us to collect needed data for this research.

--- Insert Figure 2 About Here ---

When the instructors were unable to express their response clearly or strayed away from the interview topic, we used the six techniques suggested in [28] to guide the respondents' thoughts, which include, for instance, (1) "evoking the situational context" for the respondents to think of a realistic occasion in which they would use the e-learning system, (2) "postulating the absence of an object or a state of being" to help respondents verbalize meaningful associations by encouraging them to consider what it would be like to not have an e-learning system, (3) "negative laddering" to inquire why respondents did not do certain things when they couldn't articulate why they did the things they did, (4) "age regression contrast probe" to move respondents backward in time for them to verbalize their feelings and behavior, (5) "third-person probe" to elicit response from instructors when it was difficult for them to identify their own motives, (6) "redirecting techniques: silence/communication check" where silence on the part of the interviewer was used to give the respondents time to look for more appropriate answer, and communication check meant repeating the answer from respondents for clarification.

3.3 Content Analysis

The data collected from the interview were coded and categorized independently by six instructors, who have experience of using the e-learning systems, to produce the summary content code table of attributes, consequences, and values in Table 2. The coders were shielded from each other during the coding process. Disagreements on coding were resolved after consultation with area experts. The detailed coding results are shown in Appendix 1. The attributes in this study refer to functional elements of the e-learning system including the functionalities, tools, and user interfaces of the system. Consequences are the benefits for instructors' instruction and students' learning accrued from using the system. Finally, values are the personalized beliefs for instructors derived from consequences.

--- Insert Table 2 About Here ---

Fleiss Kappa's inter-coder reliability measure is used to verify the coding reliability [8]. The κ value computed from Appendix 1 is 0.714, implying that the coding of our study is within the range of trusted reliability.

3.4 Constructing summary implication matrix

In the second step of content analysis, we construct summary implication matrix that records the number of direct and indirect linkages between attributes and consequences, between consequences and consequences, between attributes and values, and between consequences and values. Take Figure 2 as an example, the linkage between ATM and convenience is a direct linkage, while there exists an indirect linkage between ATM and security. Tables 3 and 4 show the A-C and C-V implication matrix respectively where the number before the decimal point in each entry of the table represents the frequency of direct linkages and the number after the decimal point for frequency of indirect linkages. For complete summary linkage data, readers are referred to Appendix 2.

--- Insert Tables 3 and 4 About Here ---

3.5 Constructing hierarchical value map

In the third step of content analysis, we convert the summary implication matrices to hierarchical value map (HVM) with special attention paid to the five types of relations and cutoff levels described in [28]. Grunert, Beckmann and Sørensen [12] point out that the cutoff level should be at least three when the number of samples is between thirty and sixty. Thus, we adopt a cutoff of four relations to construct the HVM.

In constructing the HVM from summary implication matrices, we start from those relations in the A-C matrix that exceed the pre-determined cutoff level, then move to C-C matrix, and finally C-V matrix. For example, starting from A1 attribute in Appendix 2, the first entry meeting the cutoff level of 4 is (6.1) linking to C2, which leads us to examine the C2 row where the (5.1) entry links to C22, …, etc. Repeating these steps produces the HVM in Figure 3. As shown in Figure 3, we derive six critical functionalities of e-learning system (i.e., attributes), eleven consequences, and three values.

--- Insert Figure 3 About Here ---

4. Research Findings and Discussions

After analyzing the collected data, we derive fourteen attributes, twenty four consequences, and eight values. After transformations through summary implication matrices, the original data result in the hierarchical value map (HVM) of Figure 3 that contains six critical functionalities of the e-learning system, eleven consequences, and three values. We present the research findings in the following.

4.1 The Critical Functionalities

The six critical functionalities of the e-learning system shown in the HVM of Figure 3 are e-syllabus, electronic whiteboard, threaded discussions, assignment management, online forum, and online roll call. These six most critical functionalities are categorized into instructional presentation and student learning management according to the common perceptions of the respondents discovered from soft laddering. The respondents felt that the e-syllabus and electronic whiteboard functionalities are most helpful in presenting the instruction, while threaded discussions, assignment management, online forum, and online roll call functionalities were believed to be most useful in managing students' learning process.

4.1.1 Instructional Presentation

The electronic whiteboard functionality helps instructors articulate the content of their instruction. For instance, the electronic whiteboard can show the detailed process of solving a math problem and record the associated discussions more clearly and conveniently than the traditional instructional environment. This functionality helps both the instructors in teaching and students in reviewing the materials afterwards. In addition, instructors believe that the electronic whiteboard helps the interactions between the instructor and students since students are more willing to ask questions on the electronic whiteboard, and users who are slow typists find it a good communication medium. The interactions via electronic whiteboard make the teaching experience fun and interesting, hence providing the linkage with "the fun and enjoyment of life" value.

In an asynchronous learning environment, instructional materials such as text and multimedia video are posted on the web to interact with learners. Some functionalities of the system are designed to make navigating the materials more structured and efficient. For instance, the e-syllabus with hyperlink feature enables the learners to quickly locate the content they wish to explore. With the e-syllabus functionality of the e-learning system, instructors can organize and revise teaching materials promptly. The e-syllabus together with a teaching plan can make the teaching more organized. Moreover, other functionalities of the e-learning system such as threaded discussions and assignment management can be linked with the e-syllabus to make it more convenient for the instructors. From the students' perspective, the e-syllabus functionality allows the students to learn in their preferred way. Ultimately, the e-syllabus functionality results in the value of fulfillment for instructors.

4.1.2 Student Learning Management

The management of students' learning has two components – ensuring the students' concentration and participation during class, and keeping track of students' learning result. The online roll call and online forum functionalities can help instructors monitor students' concentration and participation in online courses. Whether students concentrate and participate during the course of e-learning has an effect on the quality of instruction, especially in an online environment with many uncertain factors. For example, students may browse other web sites and are distracted from learning during class, negatively impacting learning effect. To ensure that students are focused during class is thus an important part of conducting e-learning for instructors. Our research indicates that online roll call, having five direct linkages to keeping track of students' learning situation (C11), is a functionality needed by instructors to achieve a smooth e-learning by keeping track of students' attendance and reminding students to pay attention. Online roll call is hence a critical functionality for a successful e-learning system.

Many instructors in our research consistently report that the online forum functionality can bring about students' interests in discussion. Those students who initially are reluctant or unwilling to contribute become more involved and active, increasing their sense of participation in the e-learning. Although some respondents state that the depth of discussions is limited by the time constraint, online forum helps interactions among students and brings together the instructors and students, indirectly improving the management of students' learning.

Assignment management and threaded discussions are two functionalities for keeping track of students' learning result. Through the delivery of assignments and deadline management, the assignment management functionality makes students more focused and efficient in learning, and helps instructors in assessing students' learning and identifying struggling students for further assistance. Although the linkage between assignment management and students' learning is indirect as shown in Figure 3, instructors believe that assignment management helps students' learning through the delivery of assignments and discussions thereof. As instructors seem to believe that it is easier to find information from the Web to build knowledge in using the assignment management functionality of an e-learning system, instructors will open the privilege of browsing assignments to students if they believe the sharing of assignments will reduce the mistakes made in assignments. The assignment management functionality makes the distribution of knowledge far more efficient than in a traditional classroom, thus making it a well regarded functionality by instructors with high relation to their sense of accomplishment.

From the linkages with consequences in the HVM of Figure 3, threaded discussions with its highly regarded simple user interface and interactivity is found to be an important functionality of an e-learning system that facilitates the exchange of knowledge and the management of students' learning situation. Some respondents feel that an e-learning system without threaded discussions will not be effective in delivering e-learning. Although the threaded discussions functionality is not as interactive as the online forum, it makes the content of learning more focused. As the content in threaded discussions goes through longer period of time with more depth and breadth, instructors sometimes get inspired from the discussions to arrive at new innovated ideas. Further, the way the content in threaded discussions is organized makes it a useful feature for knowledge search in a topic-oriented learning environment. Thus, threaded discussions function has high number of linkages with linked consequences.

4.2 The values important for continued usage of system

The studies of [4, 5, 7] point out that an important factor influencing users' continued usage of an information system is the values accrued to users. However, prior studies do not clearly report what values influence users' decision to remain using the e-learning system. Our research finds that sense of accomplishment, self-fulfillment, and fun and enjoyment of life are the most important values to instructors derived from using the e-learning system. Malmberg [22] discovers that the values of sense of accomplishment and self-fulfillment obtained from teaching are the internal motives that drive instructors to continue their professional growth and the pursuit of teaching profession. When instructors use a well designed e-learning system that gives them sense of accomplishment, self-fulfillment, and fun and enjoyment of life, their internal motives to continue using the e-learning system in their instruction are strengthened. Hence, to ensure the continued usage of the e-learning system, system designers can use our research results to develop the functionalities that enhance the values of instructors.

4.3 Determining dominant perceptual orientation

The HVM in Figure 3 identifies the most critical functionalities that should be the focus of system design, and illustrates the relation between the functionalities and users' values. The HVM helps a system designer base the development of the system on those relations or attributes recognized as the most important ones. To this end, Tables 5 and 6 provide a summary of linkages where the "To" column describes the number of linkages linking to this element, and the "From" column shows the number of linkages emanating from this element.

--- Insert Tables 5 and 6 About Here ---

We observe from Table 5 that the three most important functionalities of the e-learning system are e-syllabus (31.23), threaded discussions (28.20), and online forum (27.20). That is, in order to solve pressing instructional issues and make teaching more efficient, the e-learning system should first provide an environment for fulfilling the needs of instructional presentation (e-syllabus), then a good communication room for learning (threaded discussions), and finally an area for instructor and students to interact with each other in real time (online forum). In contrast to the attributes of Table 5, Table 6 shows that maintaining interactivity (50.14), assistance to learning (34.15), and information sharing and distribution (31.10) are the three most important consequences of using an e-learning system. Given that it is relatively difficult for instructors to manage students in an online environment, interactivity is a major functional requirement for instructors in using the system. With the e-learning system providing good communications function, instructors are then concerned with how to use the system to help make students' learning more effective. Finally, instructors care about whether the e-learning system takes advantage of the information sharing and distribution, a feature typically lacking in traditional environment that motivates instructors to adopt the e-learning.

The foregoing analyses show the most important attributes, consequences, and values in using an e-learning system from the perspective of instructors. However, it is difficult to discern which chains linking various elements in Figure 3 are more important. To find which chains are more critical than others, we summarize all twenty six chains found in our study in Appendix 3. The chain number 17 in Appendix 3 has the highest number of linkages with 120 direct links and

68 indirect links. This is the chain in HVM starting from threaded discussions (A1), to information sharing and distribution (C24), then to assistance to learning (C16), and finally to the sense of accomplishment (V1). This finding implies that threaded discussions is the consensus most important functionality of an e-learning system that brings about information sharing and distribution, which in turns aides students' learning for students and achieves sense of accomplishment for instructors. Making use of this finding, the e-learning system designer should include threaded discussions as a required function. In addition, the designer should think of other functionalities that will promote information sharing and distribution to enhance instructors' sense of accomplishment, thereby ensuring instructors' continued usage of the e-learning system.

Chiu [4] and Chiu et al. [5] indicate that usefulness, quality, and values are three major factors for the continued usage of an e-learning system. Our research embodies these three nevertheless conceptual factors. That is, the values influencing continued usage of an e-learning system are sense of accomplishment, self-fulfillment, and fun and enjoyment of life. Further, our foregoing analyses of the attributes and consequences of the HVM exemplify the quality and usefulness dimensions of an e-learning system. In sum, our research provides a useful blueprint for the system designer to develop an e-learning system with functionalities to promote the continued usage of instructors.

5. Concluding Remarks

Many theories and techniques concerning requirements analyses and system design of e-learning systems have been proposed in the past. These theories and techniques attempt to identify all possible functional requirements without considering the users' cognitive structure toward system usage, and thus fail to identify the most critical functionalities required by the users. Consequently, the e-learning system is designed with many functionalities and tools not used by the users, creating cognitive burden for the users and hindering their willingness to continue using the system.

While an overwhelming majority of information systems research on e-learning has focused analyses largely on the student level, our research provides a fresh complimentary perspective from the instructors. A major contribution of this research is to apply the means-end chain method to analyze instructors' cognitive structure toward e-learning system usage in order to systematically identify the required critical functionalities. To help design a successful e-learning system, our study embodies the general factors described in prior literature that influence the usage of an e-learning system (e.g., usefulness, personal values, and motives to use the system) and further illustrates the embedded relations therein.

Another contribution of this study is to show that the functionalities of an e-learning system need to be simplified to meet the instructional environment required by instructors. Our research finds that only six functionalities of an e-learning system form effective means-end chains, including electronic whiteboard, e-syllabus, online roll call, threaded discussions, assignment management, and online forum. Hence, we recommend that the e-learning system be designed to allow instructors to use these six functionalities in an intuitive way. Other more advanced functionalities can be turned on by users when needed. Such design will not only meet the requirements of different users but also make the design of user interface simple and useful.

Our research is not without limitations. The subjects of our study use the Wisdom Master pro e-learning system to offer college level courses taken by K-12 teachers to fulfil their professional growth certification requirements. The cognitive structure of instructors might be in some way influenced by the complexity of the instructions correlated to the academic level at which the instructors deliver their instructions. The means-end-chain (MEC) theory and the laddering method for revealing means-end-chains have some inherent restrictions. Cohen and Warlop [6] point out that "laddering is far from neutral in the types of responses it elicits" since laddering cannot reflect consumers' thinking of brand and products by systematically probing for successively higher level goals and values. When incorporated into the Theory of Planned Behavior (TPB) model in [18], the means-end-chain derived from laddering was shown to explain a small variance in self-reported behavior. Since MECs only represent respondents' cognitive structure, they cannot be used on their own to predict behavior. Le Page, et al. [18] also find that MEC is better at predicting attitude towards behavior than at predicting behavior. Another limitation of MEC and laddering is that when respondents have little knowledge about a product and when they are asked to move to a higher level of abstraction, they may come up with ladders only to fit the interviewer's requirement [35].

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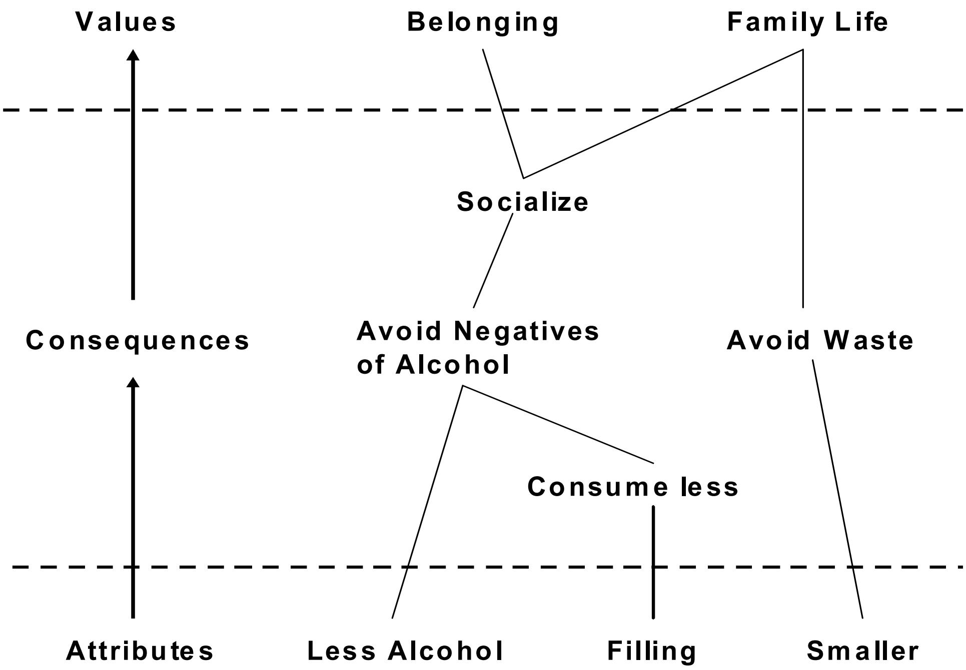

Figure 1. Hierarchical Value Map (HVM) of Wine Cooler Category [28]

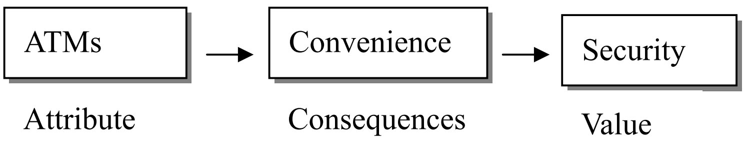

Figure 2. An example of A-C-V ladder

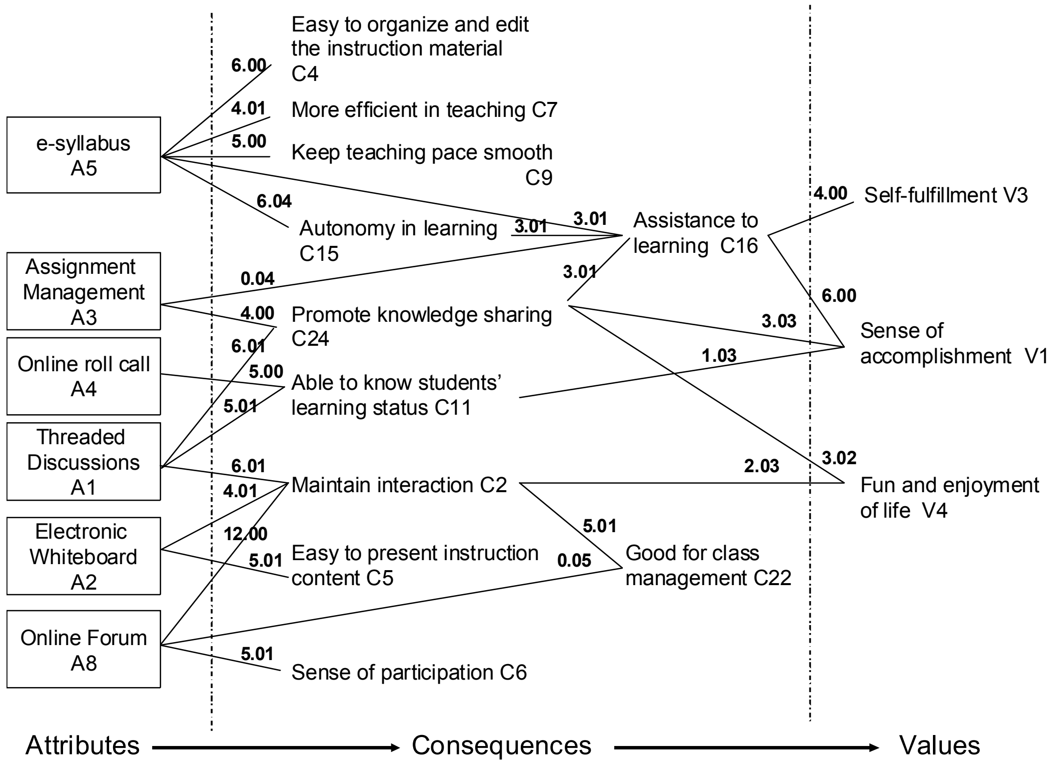

Figure 3. The hierarchical value map (HVM) of a successful e-learning system

Table 1. Background of subjects

Age	Mean	36
	Range	25~54 years old
Gender	Male	64%
	Female	36%
Years of teaching	Mean	9.4 years
Frequency of offering online courses	Once	16%
	2~3 times	55%
	4 or more times	29%

Table 2. Content Codes Summary

Values					
V1	sense of accomplishment	V4	fun and enjoyment of life	V7	sense of security
V2	self-respect)	V5	active learning	V8	sense of belonging
V3	self-fulfillment	V6	self-growth		
Consequences					
C1	useful	C9	keep the teaching pace smooth	C17	more engaged in learning
C2	maintain interaction	C10	more effective teaching	C18	enrich teaching
C3	more accessible for both student and instructor	C11	able to know students' learning status	C19	good for assessment
C4	easy to organize and edit instructional material	C12	easy to communicate	C20	increase the fluency of teaching
C5	easy to present instructional content	C13	More alternative learning methods	C21	foster the inspiration of teaching
C6	sense of participation	C14	learning flexibility	C22	good for student learning management
C7	more efficient for teaching	C15	autonomy in learning	C23	digital instruction material
C8	save time in preparing instruction material	C16	assistance to learning	C24	information sharing and distribution
Attributes					
A1	threaded discussions	A6	ftp	A11	online assessment
A2	electronic whiteboard	A7	web template for instruction material	A12	bbs
A3	assignment management	A8	online forum	A13	online questionnaire
A4	online roll call	A9	online messenger	A14	Email
A5	e-syllabus	A10	video-recording tool for instruction		

Table 3. A-C Summary Implication Matrix

A\C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
A1	1.00	6.01	1.02	0.01	1.00	0.02				2.00	5.01	1.01		1.00	3.00	0.02	1.01				0.01			6.01
A2		4.01	1.00		5.01	2.00				1.00		0.02	2.00	1.00	1.00	0.01				0.01				
A3		1.00								0.01	3.00				1.00	0.04	1.00		2.00		0.01			4.00
A4		1.00									5.00						1.00		0.02				1.00	
A5	2.00			6.00			4.01	1.02	5.00	1.00	0.02			2.01	6.04	3.01		0.01		0.03				1.00
A6	1.01			0.01			2.00	1.01										2.00					2.00	
A7								1.00										1.00						
A8		12.00	0.01	2.00		5.01				0.01	1.00	1.01		1.00		1.02	1.00				1.01	0.05		2.01
A9		1.00								1.00							2.00							
A10								3.00										0.01						
A11											2.00				1.00	0.01								
A12	1.00											1.00												
A13							0.01									1.00							1.00	
A14		1.00		1.00											1.00									

Table 4. C-V Summary Implication Matrix

V\C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
V1	2.00	0.02	0.01	3.00	0.02		1.01	2.00		2.01	1.03	1.01			1.01	6.00	2.00	2.00		1.00				3.03
V2	1.00	0.01					1.00			1.00														
V3	1.00	0.03	0.01		0.01	1.00	1.01		1.00			1.00				4.00								0.01
V4		2.03				3.00	1.00				2.01					2.00	3.00			0.01				3.02
V5		0.01				1.00																		1.00
V6				1.00								0.01							0.01		1.00			2.02
V7				0.01		1.00	1.00										1.00	1.00		0.01				
V8		3.00							0.01	0.01					1.00		1.00							

Table 5. The number of links between attribute and elements

	Code	Function	To	From
Attributes	A1	threaded discussions	28.20	0.0
	A2	electronic whiteboard	17.07	0.0
	A3	Assignment management	12.07	0.0
	A4	online roll call	8.02	0.0
	A5	e-syllabus	31.23	0.0
	A6	ftp	8.04	0.0
	A7	Web template	2.01	0.0
	A8	online forum	27.20	0.0
	A9	online messenger	4.01	0.0
	A10	video-recording tool for instruction	3.01	0.0
	A11	Online assessment	3.01	0.0
	A12	Bulletin Board System	2.01	0.0
	A13	Online questionnaire	2.01	0.0
	A14	Email	3.01	0.0

Table 6. The number of links between consequence and elements

	Code	Perceived results	To	From	Sum
Consequences	C1	useful	5.00	8.03	13.03
	C2	maintain interaction	22.12	28.02	50.14
	C3	more accessible for both student and instructor	2.02	5.03	7.05
	C4	easy to organize and edit instructional material	8.01	15.05	23.06
	C5	easy to present instructional content	4.03	8.01	12.04
	C6	Sense of participation	9.01	11.03	20.04
	C7	more efficient in teaching	7.03	9.03	16.06
	C8	save time in preparing instruction material	4.01	8.03	12.04
	C9	keep teaching pace smooth	3.02	5.00	8.02
	C10	more effective teaching	8.02	9.04	17.06
	C11	able to know studetnts' learning status	10.04	18.03	28.07
	C12	easy to communicate	3.02	7.04	10.06
	C13	more alternative learning methods	1.01	2.00	3.01
	C14	learning flexibility	1.00	7.01	8.01
	C15	autonomy in learning	9.04	18.04	27.08
	C16	assistance to learning	15.00	19.15	34.15
	C17	more engaged in learning	7.00	9.02	16.02
	C18	enrich teaching	6.02	5.02	11.04
	C19	good for assessment	1.01	4.02	5.03
	C20	increase the fluency of teaching	2.02	3.04	5.06
	C21	foster the inspiration of teaching	1.00	4.03	5.03
	C22	good for student learning management	0.00	6.06	6.06
	C23	digital instruction material	3.00	4.00	7.00
	C24	information sharing and distribution	16.08	15.02	31.10

Appendix 1. Detailed Coding Results

No	Item	A	C	V
1	threaded discussion	6	0	0
2	electronic whiteboard	6	0	0
3	sense of accomplishment	0	0	6
4	maintain interaction	1	3	2
5	easy to present instructional content	1	5	0
6	self-respect	0	1	5
7	assignment management	6	0	0
8	online roll call	6	0	0
9	e-syllabus	6	0	0
10	ftp	6	0	0
11	keep teaching pace smooth	1	4	1
12	bbs	6	0	0
13	online questionnaire	6	0	0
14	foster the inspiration of teaching	0	6	0
15	Sense of participation	0	6	0
16	more accessible for both student and instructor	0	6	0
17	Sense of Belonging	0	1	5
18	alternatives for learning	0	3	3
19	more efficient in teaching	0	4	2
20	online messenger	6	0	0
21	easy to organize and edit instructional material	1	4	1
22	easy to communicate	0	4	2
23	online assessment	6	0	0
24	autonomy in learning	0	3	3
25	self-fulfillment	0	0	6
26	video-recording tool for instruction	6	0	0
27	enrich teaching	0	5	1
28	useful	1	4	1
29	online forum	6	0	0
30	promote knowledge sharing	0	3	3
31	digital instruction material	1	4	1
32	email	6	0	0
33	self-growth	0	2	4
34	increase the fluency of teaching	0	5	1
35	good for learning	0	4	2
36	more engaged in learning	0	4	2
37	good for assessment	0	6	0
38	fun and enjoyment of life	0	0	6
39	active learning	0	2	4
40	more efficient for teaching	0	3	3
41	save time in preparing instruction material	0	3	3
42	good for student learning management	0	5	1
43	more effective teaching	0	3	3
44	able to know student's learning status	0	5	1
45	sense of security	0	0	6
46	web template for instruction material	6	0	0

Appendix 2. Complete Linkage Data

A\C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	V1	V2	V3	V4	V5	V6	V7	V8	to
A1	1.00	6.01	1.02	0.01	1.00	0.02				2.00	5.01	1.01		1.00	3.00	0.02	1.01				0.01			6.01	0.02			0.02	0.01	0.02			28.20
A2		4.01	1.00		5.01	2.00				1.00		0.02	2.00	1.00	1.00	0.01				0.01								0.01					17.07
A3		1.00								0.01	3.00				1.00	0.04	1.00		2.00		0.01			4.00				0.01					12.07
A4		1.00									5.00						1.00		0.02				1.00										8.02
A5	2.00			6.00			4.01	1.02	5.00	1.00	0.02			2.01	6.04	3.01		0.01		0.03				1.00	0.03	0.02	0.02				0.01		31.23
A6	1.01			0.01			2.00	1.01										2.00					2.00		0.01								8.04
A7								1.00										1.00							0.01								2.01
A8		12.00	0.01	2.00		5.01				0.01	1.00	1.01		1.00		1.02	1.00				1.01	0.05		2.01	0.01			0.03			0.01	0.02	27.20
A9		1.00								1.00							2.00											0.01					4.01
A10								3.00										0.01															3.01
A11											2.00				1.00	0.01																	3.01
A12	1.00											1.00																			0.01		2.01
A13							0.01									1.00							1.00										2.01
A14		1.00		1.00											1.00																	0.01	3.01
C1								1.00																	2.00	1.00	1.00						5.00
C2	1.00		2.00	0.01		3.00				1.00		2.00				2.00						5.01		1.00	0.02	0.01	0.03	2.03	0.01			3.00	22.12
C3						1.00						1.00													0.01		0.01						2.02
C4							1.00								1.00	1.00		1.00							3.00					1.00	0.01		8.01
C5										1.00						2.00				1.00					0.02		0.01						4.03
C6	0.01	1.00										1.00									1.00						1.00	3.00	1.00		1.00		9.01
C7	1.00																0.01			1.00					1.01	1.00	1.01	1.00			1.00		7.03
C8							1.00									0.01		1.00							2.00								4.01
C9							0.01	1.00							1.00												1.00					0.01	3.02
C10			1.00													1.00	1.00			1.00		1.00			2.01	1.00						0.01	8.02
C11				3.00												1.00			2.00					1.00	1.03			2.01					10.04
C12				1.00																					1.01		1.00			0.01			3.02
C13					1.00					0.01																							1.01
C14															1.00																		1.00
C15				0.02						1.00	2.00			1.00		3.01									1.01							1.00	9.04
C16	1.00						1.00								1.00										6.00		4.00	2.00					15.00
C17																									2.00			3.00			1.00	1.00	7.00
C18	0.01				1.00											1.01	1.00								2.00						1.00		6.02
C19																					1.00									0.01			1.01
C20																	1.00								1.00			0.01			0.01		2.02
C21																														1.00			1.00
C22																																	0.00
C23				2.00										1.00																			3.00
C24		1.00								1.01					1.00	3.01					1.00				3.03		0.01	3.02	1.00	2.00			16.08
from	8.03	28.02	5.03	15.05	8.01	11.03	9.03	8.03	5.00	9.04	18.03	7.04	2.00	7.01	18.04	19.15	9.02	5.02	4.02	3.04	4.03	6.06	4.00	15.02	27.23	3.03	9.09	16.15	2.02	4.04	4.05	5.05	

Appendix 3. Summary of All Chains

No.	Path	To	From	Sum
1	A5→C4	39.24	15.05	54.29
2	A5→C9	38.26	9.03	47.29
3	A5→C7	34.25	5.00	39.25
4	A5→C16→V3	46.23	28.24	74.47
5	A5→C16→V1	46.23	46.38	92.61
6	A5→C15→C16→V3	55.27	46.28	101.55
7	A5→C15→C16→V1	55.27	64.42	119.69
8	A3→C16→V3	27.07	28.24	55.31
9	A3→C16→V1	27.07	46.38	73.45
10	A3→C24→C16→V3	43.15	43.26	86.41
11	A3→C24→C16→V1	43.15	61.40	104.55
12	A3→C24→V1	28.15	42.25	70.40
13	A3→C24→V4	28.15	31.17	59.32
14	A4→C11→V1	18.06	45.26	63.32
15	A1→C24→V1	44.28	42.25	86.53
16	A1→C24→C16→V3	59.28	43.26	102.54
17	A1→C24→C16→V1	59.28	61.40	120.68
18	A1→C24→V4	44.28	31.17	75.45
19	A1→C2→V4	50.32	44.17	94.49
20	A2→C2→V4	50.32	44.17	94.49
21	A2→C2→C22	39.19	34.08	73.27
22	A2→C5	21.10	8.01	29.11
23	A8→C2→V4	49.32	44.17	93.49
24	A8→C2→C22	49.32	34.08	83.40
25	A8→C22	49.32	6.06	55.38
26	A8→C6	36.21	11.03	47.24