Strategic Assessment: Using Influence Diagrams to Design Distance Learning Courseware

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Abstract
Web-based distance learning programs are widely available. A few distance education platform and standards were developed or proposed. The importance of distance learning courseware brought the attention to teachers, administrators, and system developers. Among current software systems, it is hard to realize strategic assessment of student learning performance. Since one of the drawbacks of distance education is the load that an instructor needs to spend in courseware design, as well as to analyze student performance based on course contents and test outcomes, it is worthy to investigate an automatic mechanism to help an instructor to produce effective courseware. Thus, distance learning program can proceed efficiently. In this paper, we develop a mechanism for the construction of course structure based on influence diagram. The mechanism can be implemented as a decision support system for the instructor to analyze the relation among course units and test units. The overall value of a courseware can be systematically analyzed.

Keywords: Decision support system, Distance learning, Influence diagram, Conceptual graph, Automatic assessment, Courseware, Virtual university.

1. Introduction

Recent research interests of multimedia and communication include telemedicine, tele-conference, E-Commerce, and distance learning. Among these new research areas, it is possible that distance education and E-commerce systems rely on operating research and decision support methods, such that strategic suggestions can benefit both the service providers and the customers. For instance, in E-commerce, decision support technologies are used in intelligent negotiation of autonomous agents, which helps Web shoppers to seek for best buy goods. On the other hand, recommendation systems for E-commerce companies may use statistic or neural network methods to find out potential customers and non-popular products such that the overall revenue will be increased. The success of some E-commerce cases benefit from the new decision support technologies. Thus, decision support and operating research will be very important for these new research directions. On the other hand, distance learning became one of the most important revolutions in college education. Several advantages of distance learning programs include flexibility, convenience, content precision, and the automatic assessment of student performances. Distance learning systems require good communication facilities such as broadband networks and video conference systems. On the other hand, course contents and student performance assessment are as important as the instruction deliver facilities. Distance education includes the distance learning programs in traditional universities, as well as E-Learning portals. Conventional universities uses distance learning programs to attract students in continuous education. E-learning portals are Internet-based companies/organizations with practical distance education programs to help small and middle size companies in employee/customer training or adult education. However, distance learning contents are hard to build. In addition, current authoring techniques are not designed only for distance learning. It is hard to use current authoring systems, such as Authorware, Director, or the like to control the progress and performance of students. Thus, many distance learning platforms, such as Blackboard [20], LearningSpace [21], and WebCT [19] were developed. However, these systems hardly allow intelligent mechanisms to allow an instructor to monitor student performance. Even some of the systems provide statistic information for the instructor, it is hard to find an automatic method which guides students from time to time in their learning process. In addition, student assessment by the above systems is nearly related to course contents in most cases, as it should be in typical classroom. Therefore, it is important to investigate a strategic assessment method, based on the content of courses, to help both the instructors and the students.

Contents of distance learning courses use multimedia resources, such as text, pictures, audio/video clips, and animations. HTML, as a standard representation language, was used to organize course materials on the Web. Recent standards also include the control of media synchronization in SMIL (Synchronized Multimedia Integration Language), and the enhancement over HTML (i.e., the XML language). Standard formats of distance learning contents including SCORM (Sharable Course Object Reference Mode) were also proposed. Among these standards, formats, and mechanisms, it is hard to find techniques to evaluate the effectiveness of a courseware. Also, it is hard to design strategic methods based on current approaches, to help the instructor in terms of measuring the effectiveness of course contents. In this paper, we propose a revised influence diagram, for designing course structure, which organizes both the instructional materials, as well as tests. Influence diagram is superior to decision tree for many reasons. The diagramming method can be used to build a decision support system. We argue that the design of a courseware as well as its utilization (i.e., the instruction sequence) is a decision problem. A well-constructed courseware should maintain an effective course structure, with an appropriate number of tests. It is important to maintain this course structure based on our strategic method such that the instruction can proceed in a maximum efficiency. We discuss some distance learning systems and projects in section 2. We also discuss some representation of courseware in section 3. The revised influence diagram is given in a formal definition (section 4). We proposed a design of our system in section 5, which is followed by our short conclusion.

2. Related Work

Distance Learning research project has different focuses. Some emphasis on communication and group collaboration tools, while others uses intelligent techniques. WAILE [2] is a Web-based Intelligent Learning System, which provides intelligent tools to support distance learning. Group discussion tools are proposed in CHEER [4]. In CHEER, the concept of virtual discussion room is realized by allowing users to choose whatever communication software they need. As a consequence, different applications have different combination of communication facilities. In a paper presents Virtual University (i.e., VLE [1]), students' classrooms are dynamically located. The discussion also points out that, active data is another challenging research issue for distance learning systems. In the MMU project [3], virtual university structure is divided into three levels: Micro University, Virtual University, and Macro University. Micro University can be a software system, which assists an individual to learn from his/her digital documents. Virtual University offers such documents to many students via Web technology and digital communications. The aggregation of Virtual Universities is a Macro University. A join project to integrate many existing Virtual University software systems is currently developed by researchers from USA, Japan, Taiwan, and other countries. Distance Learning can be carried out by satellite communications in a remote area. The technique issue and the evaluation of educational benefits of a satellite-based distance learning environment are discussed in [5]. CORAL [8] is a distance learning environment for technical communication education. The system provides a course browser and a group of communication tools. Similar approaches using WWW techniques and Java applets are found in [11, 10]. Distance learning systems with interactive classroom and CSCW systems are proposed [6, 7]. Laboratory-based distance learning systems are discussed in [13, 14]. The discussion of virtual university administration and operation issues is found in [9, 17, 18]. The benefit and trend of virtual university are also discussed.

In addition to research papers, distance learning systems or software products were developed [19, 20, 21]. WebCT [19] was initially developed at UBC, Canada. The system offers a wide range of products and services for high level education. Available tools and functions of the system include Administrator, Assignments, Calendar, Chat, Languages Tool, Mail, Manage Students, Quiz and Survey, Self Test, Student Presentations, Student Tips, Syllabus, Track Students, Webcourse

Builder, and Whiteboard, which are available on different operating systems and hardware platforms. WebCT has a strong partnership with many organizations or companies, which build add-on tools such as test tools, course material exchange tools, and others. Another famous distance learning system is the Blackboard e-Learning software platform [20]. Hundreds of distance learning courses are also implemented. The system can also be integrated with student management system or other ERP system, and a secure authentication function. Statistic data shows learning status to the instructor as well as to students. LearningSpace [21] is a complete learning management and delivery system. As a part of the IBM Mindspan Solutions Services, the LearningSpace system supports self-based, collaborative, and virtual classroom learning. A comprehensive tracking and reporting function is also implemented to record student performance.

3. Course Structure Representations

Unlike traditional textbooks, a distance learning courseware is usually represented as hypermedia documents. The most common hypermedia representation relies on HTML, which is widely used by Web browsers. The advantages of HTML include its portability and simplicity. HTML-based Web browsers (such as IE and Netscape) are available in different platforms. Portability accelerates distance learning courseware. Also, since HTML is text-based, it is small in its size. However, references to multimedia resources increases the size of a distance learning courseware.

However, HTML has its drawback. It is hard to control media synchronization. For instance, in a HTML program, it is hard to embed dynamic media, such as video and audio, and to control inter-stream synchronization. To overcome the problem, SMIL (Synchronized Multimedia Integration Language) was developed. Similar to HTML, SMIL is a text-based language allows the description of media synchronization, as well as properties such as the hypertext feature of HTML. S-MIL was used in the applications of E-Commerce and distance learning.

HTML, SMIL, and their extension (i.e., XML) are general purpose Web languages. Even distance learning courseware can be implemented on Web using these languages, course documents are different. For instance, course units are reusable and sharable objects. And, there is a strong relation between course content and tests (such as quizzes and assignments). Fortunately, the Sharable Course Object Reference Model (SCORM) was developed. SCORM defined three types of standards: the course structure format (CSF), the run-time environment (RTE), and the meta-data (MD). CSF is based on the XML standard. CSF is similar to a blueprint, which is portable in different platform. Reusable units of the CSF can be shared among its users. RTE defines the requirement of course contents. The requirement allows these contents to be adapted in different distance learning platform. Thus, exchange of course units among different platforms is possible. Meta-data (MD) defines the properties of a courseware. MD allows the system designers to develop mechanism for searching and retrieving course units. Thus, MD and course units are co-existence objects. In addition to SCORM, the Universal Learning Format (ULF) was developed. ULF is based on the SCORM standard, as well as other international formats such as IMS (Instructional management System), IEEE LOM (Learning Object Metadata), ADL (Advanced Distributed Learning), Dublin Core, and vCard.

3.1 Conceptual Graph for Representing Concept Relations

Representation of courseware, or standard formats are practical solutions to distance learning platforms. From the theoretical perspective, educational theory also contributes to distance education. Conceptual Graph (or Conceptual Map) [12] can be used as a theoretical representation of the structure of course contents. Dependency relations (known as the epistemological order) and course units are used in the graph with weighted values. Thus, the aggregation of dependency relations forms a topology, called the Conceptual Graph. Conceptual Graph helps courseware designers to organize course units. Each of these units has a primary concept to be presented.

An example of Conceptual Graph illustrates the knowledge topology of programming a word processor is given in figure 1. Static array and dynamic memory

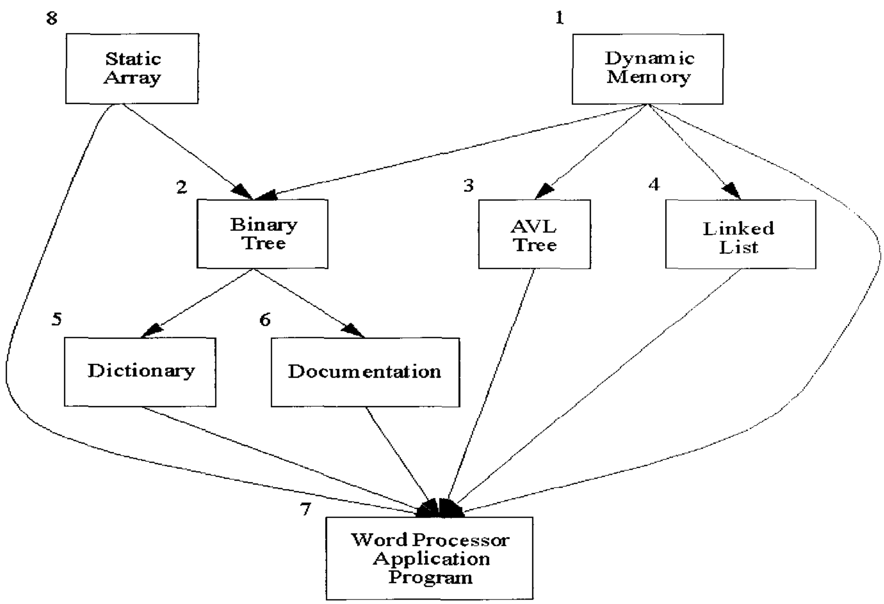

Figure 1: A Conceptual Graph shows the topology of writing a word processor program

are two basic concepts for programming. In addition to these two memory strategies, one should learn binary tree, AVL tree, or linked list structures. Yet, these structures are built based on memory strategies. But, different strategies can be chosen to justify the pros and cons of computation time and space requirement. Then, concepts of building electronic dictionary and documentation are presented before the final application program can be constructed. This conceptual graph explains the dependency relations of course units. A distance learning course can be constructed according to the graph. However, the prerequisites of each course unit will depend on the topology, with different weights. Thus, a conceptual graph will have each edge (or link) assigned with a weight.

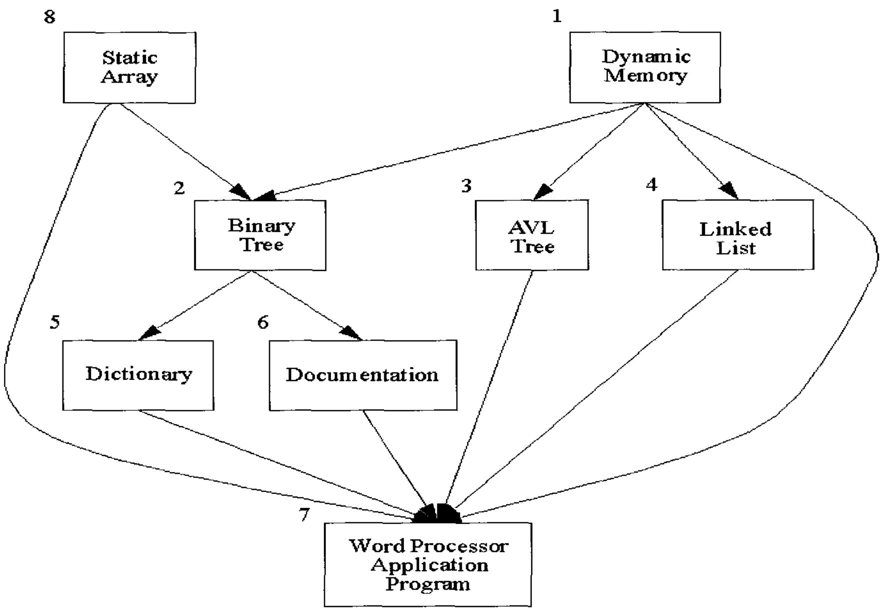

Figure 2: A Conceptual Graph shows the weights of dependency relations

The input links of each course unit (or concept unit) in the graph have a sum of 1.0, except node 1 (the Dynamic Memory unit) and node 8 (the Static Array unit). These weights are useful if an instructor wants to find out which portion of the prerequisites should be tested (e.g., given a quiz) before the next concept unit should be presented. In the case that an individual student fails the test, a remedial lecture can be given. It is possible to construct a relevance feedback system, based on the performances of a group of students, to alter the weights. Thus, the conceptual graph reflects the learning pattern of a group of students. Before we discuss the influence diagram, which is also a graph-based topology with different types of nodes and links, we should present a formal definition of the conceptual graph.

Conceptual graph is a weighted directed acyclic graph (DAG), $G = (C, L)$, where C is a set of course units (or concept units), and L is a set of weighted directed links, with C and L satisfies the following conditions:

$$\forall l_{ij} \in L \bullet l_{ij} = \{c_i c_j \mid \forall c_i c_j \in C, i \neq j$$

$$\forall l_{ij} \in L, i \neq j \bullet \exists W_{ij}, 0.0 \leq W_{ij} \leq 1.0 \bullet W_{ij} = Weight(l_{ij})$$

$$\forall c_k \in C, \neg \exists l_{jk} \in L \bullet \forall l_{jk} \in L \bullet \sum_{j-1}^{n} W_{jk} = 1.0$$

The first condition indicates that there is no loop in the graph. The second condition describes the weight function $Weight(l_{ij})$ for link l_{ij}, which returns a real in between 0.0 and 1.0, while applied to a link. Finally, the sum of weights of incoming links toward a node is equal to 1.0 , excepts for the source nodes (i.e., nodes without incoming edges). We will extend this formal definition when we discuss the influence diagram.

4. The Proposed Courseware Diagram

Decision support system is one of the success examples that computer programs can help a manager to make a systematic analysis, and lead to a good decision for overall revenue. Decision problem consists of sub-problems, with influences or dependencies to each other. From a knowledge acquisition prospective, the organization of a distance learning courseware is a decision problem - how does the courseware benefit students in a maximal learning capacity. Thus, we consider several approaches on decision science that could benefit our courseware design. Conceptual graph was initially considered. The graphical representation of conceptual graph and influence diagram are similar, but influence diagram has different types of nodes, including decision nodes. Conceptual graph is primitive. It is worthy to consider influence diagram as a base for our proposal, as we should explain the reasons in the following sections.

4.1 Influence Diagram as a Decision Support Tool

The most common method to formulate a decision problem is the decision tree. A decision tree contains controllable and uncertain variables. It is easy for the decision maker to explicitly see the value of each possible outcome. Decision tree was used in the construction of decision support systems. However, in spite of its popularity, decision tree has several drawbacks:

- Independent relations are hardly exploited.
- A large decision problem requires a highly redundant tree.
- If redundant sub-trees are eliminated, the tree will lead to losses of information.

- Tree structure forces decision maker to think forward. But, backward reasoning seems to be more attractive.
- Un-experienced practitioners confuse decision with probabilistic expansions. This may lead to a wrong structure of the formulated problem.

Consequently, for large decision problem, a symmetric decision tree is hard to construct and visualize, even with computers. Therefore, decision tree can only be used in smaller decision problems in general. Nevertheless, *influence diagram* was developed with theoretical and practical advantages over decision trees. Clear and smaller size of the diagram, with a clear distinction between informational and probabilistic nodes, allows exploited independent relations. Influence diagram grows linearly (as opposed to growing exponentially of decision trees) so that larger decision problem can be represented.

An influence diagram is a singly connected DAG (directed acyclic graph) without loop. Two types of nodes are used in an influence diagram - the *decision nodes* and *the chance nodes*. A decision node is represented by a rectangle or a square, which represents a variable under the decision maker's control. A chance node is represented by an oval or a circle, which denotes a probabilistic variable. Links in an influence diagram are divided into types - the *conditioning links* and the *informational links*. A conditioning link always points to a chance node and represents a probabilistic dependence. On the other hand, an informational link always points toward a decision node and denotes available information. In addition to the above definitions, the set of decision nodes bust be fully ordered. This is known as the no-forgetting condition. A decision is made with all outcomes of its direct predecessors. Thus, informational links imply a chronological order. However, conditioning links do not imply a chronological order. Another important issue of conditioning link is its direction. In general, representation of a decision problem is not unique. That is, the chance nodes dc not imply orders. A conditioning link between two chance nodes can have a reversec link for the same decision problem. Another important feature of influence diagram is, an influence diagram may have a number of redundant links, which can be deduced from the structure of an influence diagram. Without loss of generality, while representing a decision problem, these redundant links can be omitted.

Nodes (decision or chance) with no successors or predecessors are special ir the diagram. Typically, an influence diagram has a single sink node, which is callec the *value node*. Links toward the value node are also conditioning. A value node can be represented as an octagon, which represents the decision maker's value or the overall decision outcome. Chance nodes without direct predecessors are *called border nodes*. A border node usually represents an independent variable and is important in the construction of an influence diagram.

The mathematical model of influence diagram is similar to the one of conceptual graph. An influence diagram is also a directed acyclic graph (DAG) with no loops, $G = (N, L)$, where N is partitioned into D, C, and V. The set of decision n odes, D, and the set of chance nodes, C, contains zero or more members. And, the set of value nodes, V, is an atomic set (only contains one member, v). The link set, L, is also partitioned to CL and IL for conditioning links and informational links, respectively. The following conditions hold:

The formal definition of an influence diagram precisely defines the diagram.

$$N = D \bigcup C \bigcup V \wedge D \bigcap C = \varnothing \wedge C \bigcap V = \varnothing \wedge V \bigcap D = \varnothing$$

$$L = CL \bigcup IL \wedge CL \bigcap IL = \varnothing$$

$$\forall l_{ij} \in L \bullet l_{ij} = \{n_i n_j \mid \forall n_i n_j \in N, i \neq j\}$$

$$\forall cl_{ij} \in CL \bullet cl_{ij} = \{n_i n_j \mid n_j \in C \vee n_j \in V$$

$$\forall il_{ij} \in IL \bullet il_{ij} = \{n_i n_j \mid n_j \in D\}$$

$$V = \{v\}$$

The first and the second expressions state that the nodes and links are partitioned accordingly. The third expression restricts the graph from loops. The rests denote the definition of conditioning links and informational links, as well as the atomic set of the unique value node. However, influence diagram is not completely suitable for the modeling of a distance learning courseware, as we should discuss the differences in a revised diagramming technique in the next section.

4.2 Courseware Diagram - a Refinement of Influence Diagram

As we discussed before, the design of a courseware will benefit to the students to receive a maximal learning efficiency. This design can be regarded as a decision problem. Thus, the use of influence diagram in courseware design is natural. However, proper alternation to the diagram is required. We argue that, the following two propositions hold:

- **Decision nodes can be used to represent test units:** In a typical instruction procedure, tests such as quizzes and exams will be given to students to monitor learning performance. According to the outcomes, an instructor needs to suggest appropriate course units for the next lecture, or to design a remedial lecture. Thus, the topology of a courseware can be designed to fit multiple needs, which depend on the decision the instructor makes after a test. Therefore, we believe decision node can be used to represent a test and its evaluation event, before the next step of instruction can be proceeded.
- **Chance nodes can be used to represent course units:** A chance node is associated with a probabilistic variable, which represents the possible influence of the node. When a course unit is learned by a student, there is a degree of understanding associated with the unit, as the probabilistic variable. Therefore, chance nodes can be used to represent course units.

Conclusively, we have two types of nodes, the course units and the test units in the diagram. We call the new definition the *courseware diagram*. In addition to the two types of nodes, the value node (call *the final unit* in courseware diagram) can be treated as a summative evaluation. Summative evaluation gives the semester grade to a student, which justify the learning performance of an individual. Nodes are connected by different links in the courseware diagram. There are six types of connections:

1. From course unit to course unit: **accumulation link**
2. From course unit to test unit: **knowledge link**
3. From course unit to final unit: **knowledge link**
4. From test unit to course unit: **conditioning link**
5. From test unit to test unit: prohibited
6. From test unit to final unit: prohibited

Note that, the final unit is a sink node. There is no out-going link from the final unit. In addition, we forbid the use of the last two kinds of connections, for sack of simplicity. Moreover, it is strange to have two consecutive tests in an instruction sequence, even it is possible in the classroom. Thus, the last two types of links are not recommended. Consecutive course units will accumulate degree of understanding (via accumulation links). Links from a course unit to a test unit or the final unit will be regarded as knowledge information (knowledge links) required for the test. Links from a test unit to a course unit will be a conditioning link.

Course units are represented as ellipses or circles. Test units are represented as rectangles or squares. And, the final unit is represented as an octagon. These shapes are following the convention of influence diagram. However, it is different from the conceptual graph. In a conceptual graph, concept or course nodes are represented as a box. But, course units in a courseware diagram are ellipses. Knowledge links are represented as solid lines with arrowhead. Accumulation links and conditioning links are denoted as dash lines with arrowhead. As an example, figure 3 illustrates a courseware to teach students how to write a word process application program. Note that, course units are enumerated as numbers while test units are enumerated as alphabet characters.

Some features from influence diagram appear in courseware diagram as well. For instance, in an influence diagram, redundant links that can be deduced from the structure can be omitted. Thus, the courseware diagram shown in figure 3 has the following links omitted:

- From Static Array to Binary Tree
- From Static Array to Word Processor Application Program
- From Dynamic Memory to Binary Tree
- From Dynamic Memory to Word Processor Application Program

- From Dictionary to Word Processor Application Program
- From Documentation to Word Processor Application Program
- From AVL Tree to Word Processor Application Program
- From Linked List to Word Processor Application Program

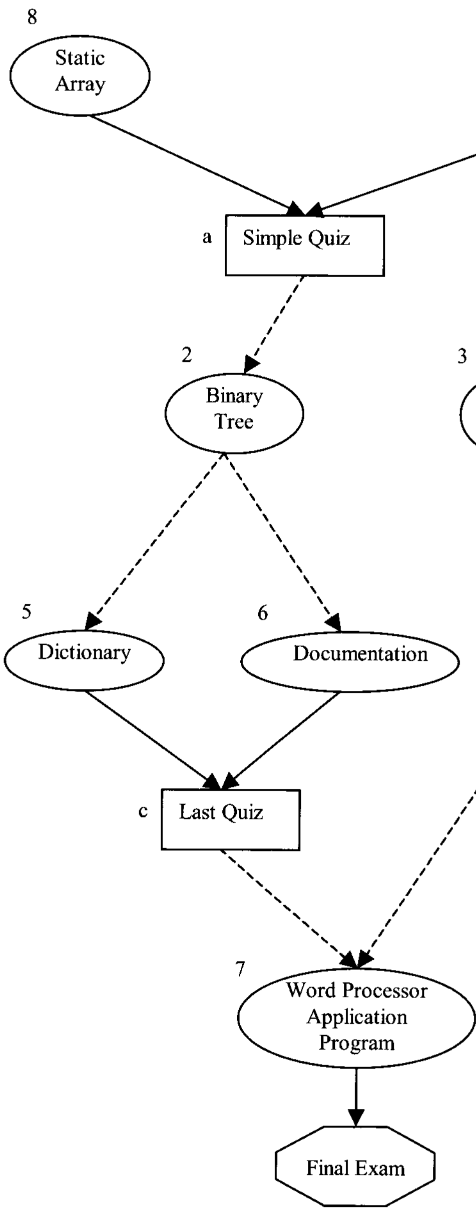

Figure 3: A Courseware Diagram shows how to write a word processor

The elimination of these links will not affect the evaluation of the final assessment. In the courseware diagram (figure 3), each test only has an out-going link. However, it is possible to design a multi-purpose courseware diagram. Depending on the outcome of a test, the instructor may decide whether to give a remedial lecture, which is followed by another test. This process is a part of *mastery learning strategy*. The strategy enforces repeated training, until a test is passed by the student. However, loops (or repeated training) are not allowed in influence diagram. Neither does the courseware diagram. Thus, repeated training can be defined as a limited number of remedial lecture and re-test combinations. For instance, a portion of figure 3 is shown in figure 4. Remedial lectures can be arranged, with extra quizzes. The number of lecture-quiz pairs will depend on the content and the need of students.

The mathematical model of courseware diagram needs to be redefined. A courseware diagram is also a directed acyclic graph (DAG) with no loops, $G = (N, L)$, where N is partitioned into T, C, and F. The set of test units, T, and the set of course units, C, contains zero or more members. And, the set of final unit, F, is an atomic set (only contains one member, f). The link set, L, is also partitioned to AL, KL and CL for accumulation links, knowledge links, and conditioning links, respectively. The following conditions hold:

$$N = T \cup C \cup F \wedge T \cap C \emptyset \wedge C \cap F = \emptyset \wedge F \cap T = \emptyset$$

$$L = AL \cup KL \cup CL \wedge AL \cap KL = \emptyset \wedge KL \cap CL = \emptyset \wedge CL \cap AL = \emptyset$$

$$\forall l_{ij} \in L \bullet l_{ij} = \{n_i n_j \mid \forall n_i n_j \in N, i \neq j\}$$

$$\forall al_{ij} \in AL \bullet al_{ij} = \{n_i n_j \mid n_i \in C \wedge n_j \in C$$

$$\forall kl_{ij} \in KL \bullet kl_{ij} = \{n_i n_j \mid (n_i \in C \wedge n_j \in T) \vee (n_i \in C \wedge n_j \in F)\}$$

$$\forall cl_{ij} \in CL \bullet cl_{ij} = \{n_i n_j \mid (n_i \in T n_j \in C\}$$

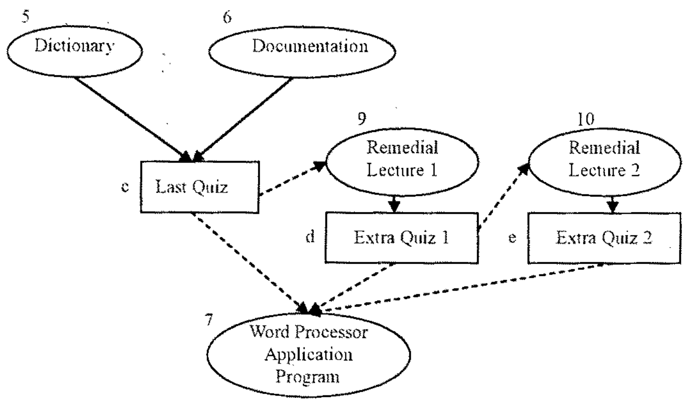

Figure 4: A Partial Courseware Diagram shows usages of test outcomes

The definition above is similar to the one of influence diagram, except that different nodes and links are used, with different restrictions. The evaluation of the overall value of a courseware diagram is similar to the one used to evaluate influence diagram [15]. Based on the method, we designed an authoring system, which allows the instructor to design distance learning courseware following the method of courseware diagram. In the next section, we should present our design.

5. *Software System for Strategic Assessment*

Recent software architecture uses a three-tier approach. That is, the interface of a system is usually run on one computer (possibly with a Web browser). The computation (or the Web site) is installed on another machine, while the database management system is running on the third machine. Web browser is a convenient user interface. It is suitable for end users to exploit interesting information on the Internet, including distance learning materials. We take this approach so that all courseware materials are accessible by students on the Web. However, for the instructor, to implement drag-and-drop user interface, which is a basic function to design a courseware diagram, is hard to be implemented on the Web. Even it is possible to use mobile agent technology, to embed these editing functions in Ap-

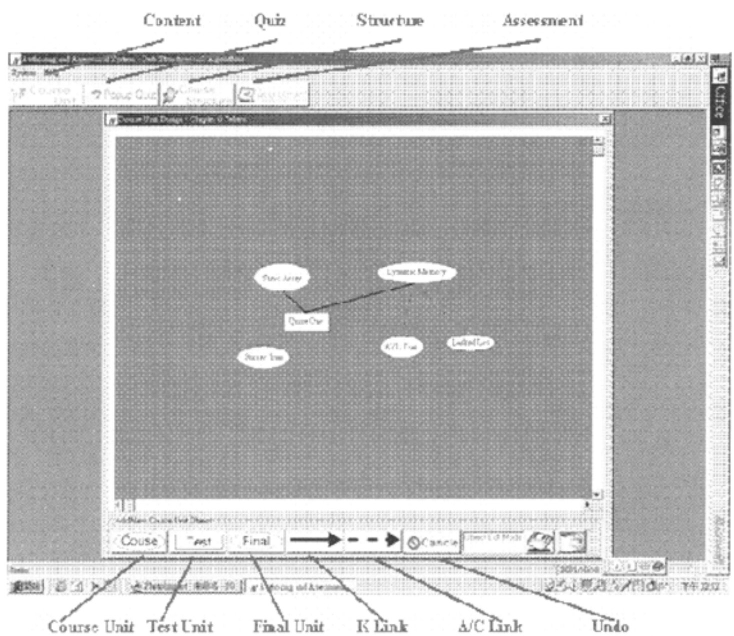

Figure 5: Interface of the Authoring Tool: courseware diagram

plets, such that course editing is enabled on the Web, it is still difficult for the instructors to operate the system in a efficient manner since mobile agents need to be downloaded to individual computers. Thus, the software system that we designed uses a sophisticated window programming mechanism. The authoring tool for the courseware diagrams, the course units, and the test units is a traditional window program. However, the courseware produced is automatically uploaded to a distance learning Web site, which is accessed by conventional Web browsers.

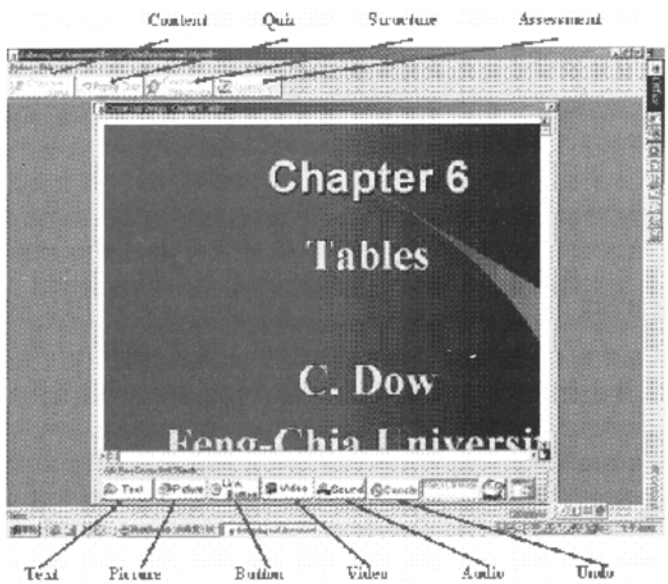

Figure 6: Interface of the Authoring Tool: course unit design

Figure 5 shows the tool for creating and editing courseware diagram. On the to| of the interface, the Content button allows the instructor to design course units, th Quiz button is for test units, the Structure button is for courseware diagram (th structure of the course), and finally, the Assessment button is to evaluate the valu of a courseware design. At the bottom, there are several buttons for creating cours unit, test unit, final unit, knowledge kink, accumulation or conditioning link, and fc the undo action. Figure 6 shows an interface for the layout design of course unit: Typical media such as video and audio, etc., are allowed. Figure 7 contains two wir dows. The upper-left window allows an instructor to design a popup quiz. Sever: types of quizzes, such as multiple choice, fill-in-blank, etc., are allowed. The lowe: right window shows a quiz while a student is using the courseware. We have deve oped a data structure course for undergraduate students using this system.

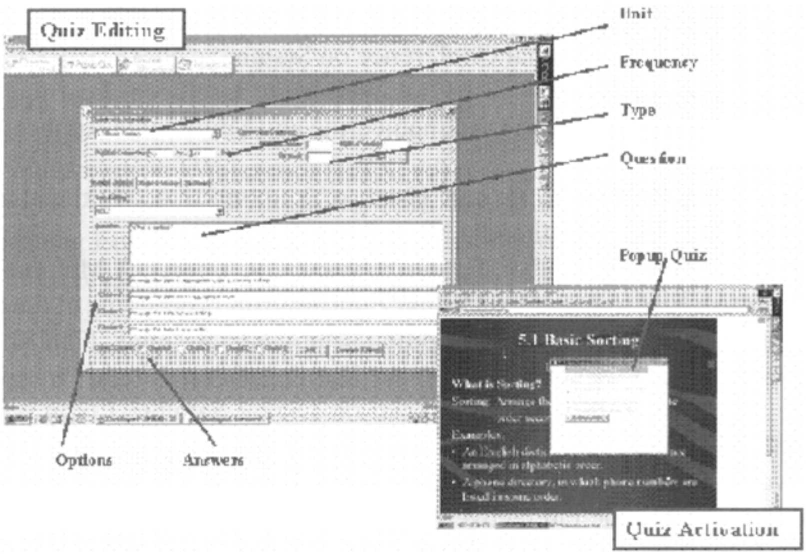

Figure 7: Interface of the Authoring Tool: course unit design

6. Conclusions

Distance learning seems to be a trend of future education. Or, at least distance learning tools will be able to help high level education to move toward another dimension of instruction. Current distance learning tools focus on communication and multimedia presentation technologies. These improvements enable Web-based course materials, video conferencing, video-on-demand lectures, and others. Several standard formats, including platform format and content format were proposed. Yet, assessment of distance learning is still weak.

In this paper, we think of courseware design as a decision problem. We studied conceptual graphs and influence diagrams, and proposed a courseware diagram method. The method can be used in a software system, which allows an instructor to design a courseware as making a decision, which can be computed to justify the maximal efficiency. We are still developing a prototype under windowing system. Assessment of distance learning did not get much attention in the past, especially the systematic mechanisms to evaluate the quality of a courseware. We hope that, the assessment criteria, or standard, can be realized by educators, engineers, and policy makers. Thus, future distance learning will provide better courseware and a more accurate control of education quality.

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