

Content Development for eLearning in Engineering Education

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Abstract

In last ten years or so the traditional chalkboard teaching has been supplemented by audio visual aids like overhead/ slide projectors and videos. The phenomenal growth of Internet has brought in a new teaching media - elearning. The declining cost of Personal Computers, easy and cheaper access to Internet, and improved quality of multimedia software has made it attractive option for both teachers and students. Multimedia courses over the Internet will have the potential to serve a dual purpose by enhancing the learning experience for resident students, while opening the educational experience up to distance students.

The content development for web-based courses has to be treated differently than the traditional classroom teaching. Just posting of lecture notes, assignments and the solutions does not help the student in elearning. The content needs to be interactive acting like a virtual teacher. The content development for online engineering education for undergraduate and graduate courses would also need different treatment.

A course on Engineering Mechanics for the first year engineering students based on Interactive Virtual Tutor (IVT) system and a course on Bridge Engineering based on Internet Knowledge Base (IKB) format for graduate students has been developed. The methodology adapted in Interactive Virtual Tutor and Internet Knowledge Base is explained in this paper.

Keywords

Internet, eLearning, engineering, virtual tutor, knowledge base.

Introduction

Engineering education has been traditionally imparted through the lecture-tutorial-laboratory paradigm. Education technology in the last few years has tried to make teaching more effective by supplementing the chalkboard teaching by audio visual aids like overhead/ slide projectors and videos. These are, however, passive teaching tools. Recent advancement in computer multimedia has brought in a new teaching media. Multimedia education has several advantages,

most noticeably; the instruction can be interactive and self-paced to meet the needs of each student.

Multimedia has great potential in engineering education (McCuen and Chang 1995; Melsa 1997). The possible applications of multimedia are almost unlimited given its current capabilities (Wallace and Weiner 1998). The success of multimedia application to engineering education, however, lies in the development of good computer based teaching packages (Davey-Wilson 1994; Easa et al. 1998; Saatchi et al. 1998).

It is a well-accepted fact that there is a need for Engineering Education software (Denton 1998). The increasing power to cost ratio of personal computers and improved quality of multimedia software has made it within the reach of teachers (developers) and the students (users). Educational software can offer pedagogical improvement on the traditional lecture-tutorial-laboratory paradigm (Burton 1998). Multimedia based education software or courseware has several advantages. Multimedia is better than the traditional methods because it stimulates various senses (Riggs et al. 1998; Josshope et al. 1998). The interactive multimedia courseware allows the student to explore in sequential manner or to move about different topics, reviewing a topic several times if necessary and skipping others. This approach is known as nonlinear access and gives the students the freedom to proceed at their own pace (Koehn 1995). The courseware can be designed to meet the needs of each student with different levels of understanding. From students' point of view, multimedia takes away the boredom of passive lecture notes and brings in diversity through interactive nature of the media.

Offering multimedia courses over the Internet has become the most recent option in computer-assisted instruction. With combined emphasis on learner-centered and distance education, development of multimedia-rich courses that can be accessed over the Internet has become not only an attractive and creative option for faculty, it is now a suggested or even required course of action. Such courses will have the potential to serve a dual purpose by enhancing the learning experience for resident students, while opening the educational experience up to distance students.

The range of possibilities for the use of the Internet in education is becoming more widely recognised. Web based courses are proliferating and, for universities, offer cost savings in infrastructure and a far wider potential student base. Developments in Internet technologies continue to improve the means of sharing information globally and universities can no longer rely solely on their earlier advantage of exclusive access to the resources for assisting students to gain a higher education qualification. Recent years have seen tremendous growth in the number of web-based courses globally. However, majority of these courses consist of lecture notes, assignments and schedule.

Content Development

Content development for online learning has to be addressed differently than for classroom teaching. The content needs to be interactive acting like a virtual teacher and not merely a fancy electronic page-turner. The students should be able to solve the problems interactively, and if necessary guided intelligently.

Engineering education deals with both undergraduate and postgraduate education. It is also desired to provide continuing education to professional engineers to upgrade their knowledge. The content for online education for undergraduate and postgraduate students needs to be designed keeping in view their requirements.

The undergraduate studies generally follow the lecture-tutorial-laboratory paradigm. Tutorial work is an essential component in the consolidation of students' understanding of the lecture materials. The online courseware shall, therefore, be developed to supplement the classroom teaching. The system has to be user friendly and should act like virtual tutor to provide guidance to students outside the classroom.

The mode of teaching at postgraduate level and continuing education is usually through lectures and at times with laboratory. The online course content, therefore, has to be quite comprehensive and more effective than a book or lecture notes.

A course on Engineering Mechanics for the first year Engineering students based on Interactive Virtual Tutor (IVT) system was developed. For postgraduate students, a course on Bridge Engineering based on Internet Knowledge Base (IKB) format has been developed. The methodologies adapted in Interactive Virtual Tutor and Internet Knowledge Base are explained.

Interactive Virtual Tutor

Most of the web-based courses currently available are electronic versions of course material. The evaluation is limited to multiple-choice questions. Some of the websites do offer list of questions, which a student can attempt to solve and then check with the solutions available on the websites. This type of approach neither uses the full potential of Internet technology nor helps the student in beyond the classroom learning.

It was thus decided to develop a computer based interactive virtual learning system to supplement the classroom teaching. The main aim was to provide the students with a self-paced interactive learning system, which would act like a virtual tutor.

The following objectives were kept in mind while deciding on the framework of the system:

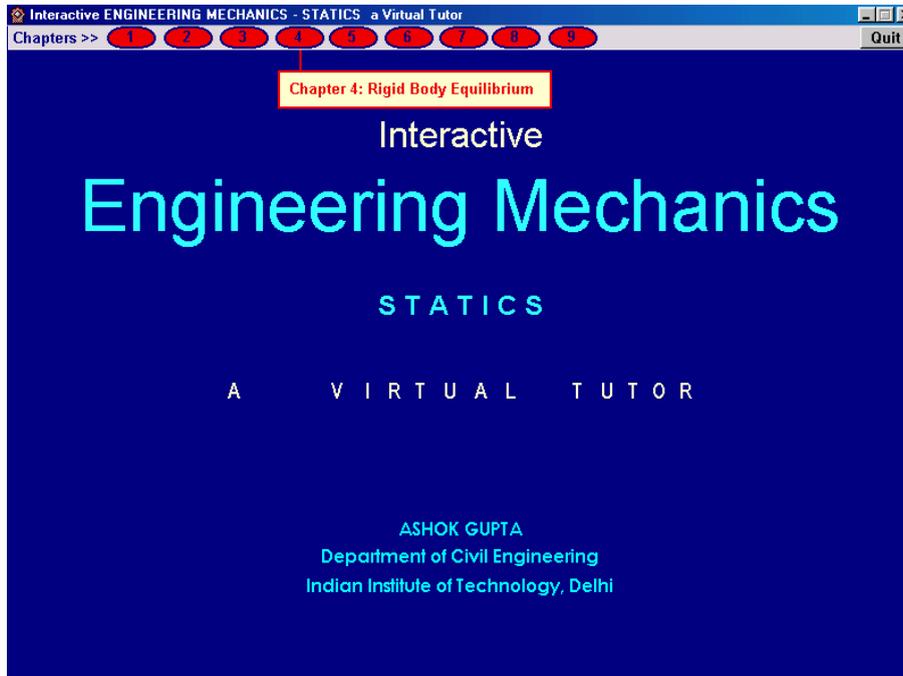
- The system should be user-friendly. If the students have to learn how to use the system, it will probably never be used.
- The students should be able to use the system at their own pace i.e. they will not be forced to go through a certain fixed path. They should be free to go through different chapters, topics and/or problems allowing them to proceed at their own pace and level of understanding.
- The system should be intelligent and interactive and not merely a fancy electronic page-turner. The students should be able to solve the problems interactively, and if necessary guided intelligently.
- The system should be intelligent enough to mimic the actual tutoring by providing helpful hints to the students in solving the problems.
- The system should be easily portable and accessible.

The learning process not only covers conceptual skills, but also reinforces both cognitive and procedural skills. The system allows the student to learn the concepts through examples and then acts like a virtual tutor providing hints and guiding the student towards the correct solution. The system does not give away the solution hence reinforcing the process of learning.

Engineering Mechanics

The interactive virtual tutor approach was used to develop Engineering mechanics Course having the following modules:

Chapters: The course has been divided into nine chapters. Each chapter has a list of *Topics*, *Examples*, *Multiple Choice Questions (MCQ)*, *Problems*, and *Frequently Asked Questions (FAQ)* modules.



Topics: In the *Topics* module, various topics of the chapter are listed. The students can click on any chapter to review the basic concept. A special effort has been made to put up just the right amount of information ensuring there is no overload of text. Each topic is linked to example problems. The student can go through the examples if he desires to.

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Chapters Topics Examples MCQ Problems FAQ Print Quit

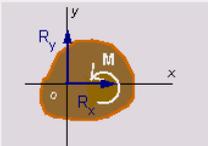
Chapter 4

1. Introduction
2. Free Body Diagrams
3. Equilibrium in Two Dimensions
4. Two and Three Force Members
5. Equilibrium in Three Dimensions
6. Rigid Body Constraints
7. Summary

3. Equilibrium in Two Dimensions

A body is said to be in equilibrium if the resultant of the force system that acts on the body is zero, that is the resultant force and moment are both zero. The absence of resultant force on a body that is initially at rest means there is no tendency of the body to translate or rotate.

We have seen in the earlier chapter that any force system can be reduced to a resultant force **R** and resultant moment **M**. The reduction of system of forces is simplified if the the forces are resolved into rectangular components. The force-couple system at o is then given by:

$$R_x = \sum F_x, R_y = \sum F_y \text{ and } M_z = M = \sum M_o$$


The basic equations of equilibrium for a planar or a two dimensional structure are :

$$R_x = \sum F_x = 0, R_y = \sum F_y = 0 \text{ and } M_z = M = \sum M_o = 0$$

The forces include both applied and the reaction forces provided by the supports. It may be noted that o can be any arbitray point which may lie either on or off the structure. Although the above equilibrium equations are the most commonly used two alternative sets of three independent equations may also be used.

1/2

Next Page

Examples: The examples in a chapter are also listed separately. A student may just like to revise the concepts by going through the examples before attempting to solve the problems.

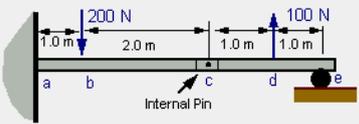
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Chapters Topics Examples MCQ Problems FAQ Print Quit

Chapter 4

1. Introduction
2. Free Body Diagrams
 - E4.1 E4.2 E4.3
3. Equilibrium in Two Dimensions
 - E4.4 E4.5 E4.6
4. Two and Three Force Members
 - E4.7 E4.8
5. Equilibrium in Three Dimensions
 - E4.9 E4.10
6. Rigid Body Constraints
 - E4.11 E4.12
7. Summary

E4.6 A beam is subjected to a force system as shown. Determine the support reactions.



Solution:
Draw the Free Body Diagram of the Beam.

There are Four unknown reactions and two internal forces
 M_a, R_{ax}, R_{ay} and R_{ey}, C_x and C_y

We have three equations of static equilibrium for each member : Six unknowns - Six equations

Start with the member (ce) which has three unknowns.

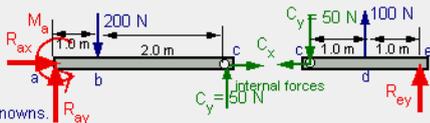
$$\sum F_x = 0, \sum F_y = 0 \text{ and } \sum M_c = 0$$

$$\sum F_x = 0 \Rightarrow C_x = 0; \sum M_c = 0 \Rightarrow R_{ey} \times 2.0m + 100N \times 1.0m = 0 \Rightarrow R_{ey} = -50 \text{ N}$$

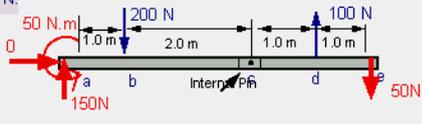
$$\sum F_y = 0 \Rightarrow 100 - 50 + C_y = 0 \Rightarrow C_y = 50 \text{ N.}$$

Study Free Body Diagram of Member ac

$$\sum F_x = 0 \Rightarrow R_{ax} = 0; \sum M_a = 0 \Rightarrow C_y \times 3.0m - 200N \times 1.0m + M_a = 0 \Rightarrow M_a = 50 \text{ N.m}$$

$$\sum F_y = 0 \Rightarrow 200 - 50 + R_{ay} = 0 \Rightarrow R_{ay} = 150 \text{ N.}$$


The solution can be verified by studying the free body diagram of complete structure and satisfying the three equations of equilibrium.



Multiple Choice Questions: This module will help the students in testing his understanding of the concepts. An explanation is also given along with the correct answer.

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Chapters Topics Examples MCQ Problems FAQ Print Quit

Multiple Choice Questions : Click on the Correct Answer

Q1 : A body is said to be in equilibrium if :

1. The resultant force is zero.
2. The resultant couple is zero.
3. The resultant force and couple are zero .
4. None of the above.

Q2 : Coplanar equilibrium equations can also be written as :

1. Two force and one moment equations.
2. Three moment equations.
3. Both 1 and 2 are true.
4. Both 1 and 2 are false.

Correct !

Q3 : In a two force member, the forces are :

1. Equal and in opposite directions.
2. Equal and Collinear.
3. Equal, opposite and collinear.
4. None of the above.

Q4 : In a three force member, the forces are :

1. Concurrent.
2. Equal and Collinear.
3. Concurrent or parallel.
4. Parallel.

Correct !

Q5 : A rigid body is partially constrained if :

1. Number of reactions are less than number of equations of equilibrium.
2. Reactions are parallel.
3. Reactions are concurrent
4. Both 2 and 3.

Q6 : A rigid body is improperly constrained if :

1. Number of reactions are more than number of equations of equilibrium.
2. Reactions are parallel.
3. Reactions are concurrent
4. Reactions are parallel or concurrent.

Problems: The problems are listed in this module. The students can go to any problem by clicking on it. The students are expected to solve the problem step by step.

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 - P4.7 P4.8 P4.9
 - P4.10 P4.11 P4.12
4. Two and Three Force Members
 - P4.13 P4.14
5. Equilibrium in Three Dimensions
 - P4.15 P4.16 P4.17
6. Rigid Body Constraints
 - P4.18 P4.19
7. Summary

P4.11: The structure is subjected to a force system as shown in Fig. Determine the support reactions.

$R_{ax} =$ N
 $R_{ay} =$ N
 $R_{cx} =$ N
 $R_{cy} =$ N

They are to work out and input the numerical value. If the value is wrong, the system acts like a virtual tutor and tries to guide the student towards correct solution without giving away the solution.

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Chapters Topics Examples MCQ Problems FAQ Print Quit

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 - P4.18 P4.19
7. Summary

P4.11: The structure is subjected to a force system as shown in Fig. Determine the support reactions.

$R_{ax} = \rightarrow 90$ N
 $R_{ay} =$ N
 $R_{cx} =$ N
 $R_{cy} =$ N

Wrong! Study the free body diagram of part ab.

It is expected that this pedagogical approach will reinforce the learning process of the students. If the student still fails to get it right, he is advised to revise the chapter / topic. The student can go to the relevant topic by clicking on *Topics*. As the topics are linked to the example problem, the students can re-study the example problem if they want to. The students can come back and continue with the problems.

Frequently Asked Questions (FAQ) : It has been seen that most of the students have a set of common questions. This module lists the expected frequently asked questions. Every question is linked to explanations for better understanding.

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Chapters Topics Examples MCQ Problems FAQ Print Quit

Frequently Asked Questions

What is Free Body Diagram ?
 A free body diagram of a body is a sketch of a body which represents it as being free or isolated from its surroundings. This diagram shows all applied forces, moments and reactive forces. By using the free body diagram, we can examine the body for equilibrium. It is, therefore, very important to have a good understanding of the concept of free body diagrams for solving problems in mechanics. [More>>>](#)

What are equations of equilibrium ?
 The basic equations of equilibrium for a planar or a two dimensional structure are

$$R_x = \sum F_x = 0, R_y = \sum F_y = 0 \text{ and } M_z = M = \sum M_o = 0$$
 and for three dimensional structure:

$$\sum F_x = 0, \sum F_y = 0 \text{ and } \sum F_z = 0$$

$$\sum M_x = 0, \sum M_y = 0 \text{ and } \sum M_z = 0$$
[More>>>](#)

What is a two force and three force member?
 When a member or body is subjected to forces at two points, the forces have same magnitude and line of action but opposite sense. When a member is subjected to forces at three points, the forces are either concurrent or parallel for member to be in equilibrium. [More>>>](#)

What are partial and improper constraints?
 When the number of reactions are less than the number of equations, the body is said to be partially constrained and unstable. If the number of reactions are equal to or more than the number of equations, but are either concurrent or parallel, the body is said to be improperly constrained and unstable. [More>>>](#)

The system has been designed to be user friendly. The system allows the students to go through any chapter, topic or question any number of times and skip whatever they are not interested in. The problems are designed to be solved via intelligent interaction between the students and the system. The students are encouraged to learn by solving the problems through given hints without being given the complete solution.

Internet Knowledge Base

The wide spread use of Internet based World Wide Web presents an opportunity, which allows developers to provide a knowledge base on any particular domain which consequentially is of immense use to a large group of end users.

This concept of providing domain knowledge base through the medium of Internet can be termed as Internet Knowledge Base (IKB). The main thrust of this concept is to represent explicitly human expertise (knowledge) on a particular domain (area of expertise), which thereby can be used for general problem solving by drawing proper inferences. It is important to represent and disseminate knowledge using the Internet in such a way so that users are able to seek, find and interpret knowledge that is relevant to their specific interests. The success of such knowledge base depends upon the data quality and usage of innovative and creative ways to engage the attention and interest of the end user.

Internet Knowledge Base can be an excellent source for providing knowledge, technical documents and user support information on the web. IKB offers many advantages to the users such as:

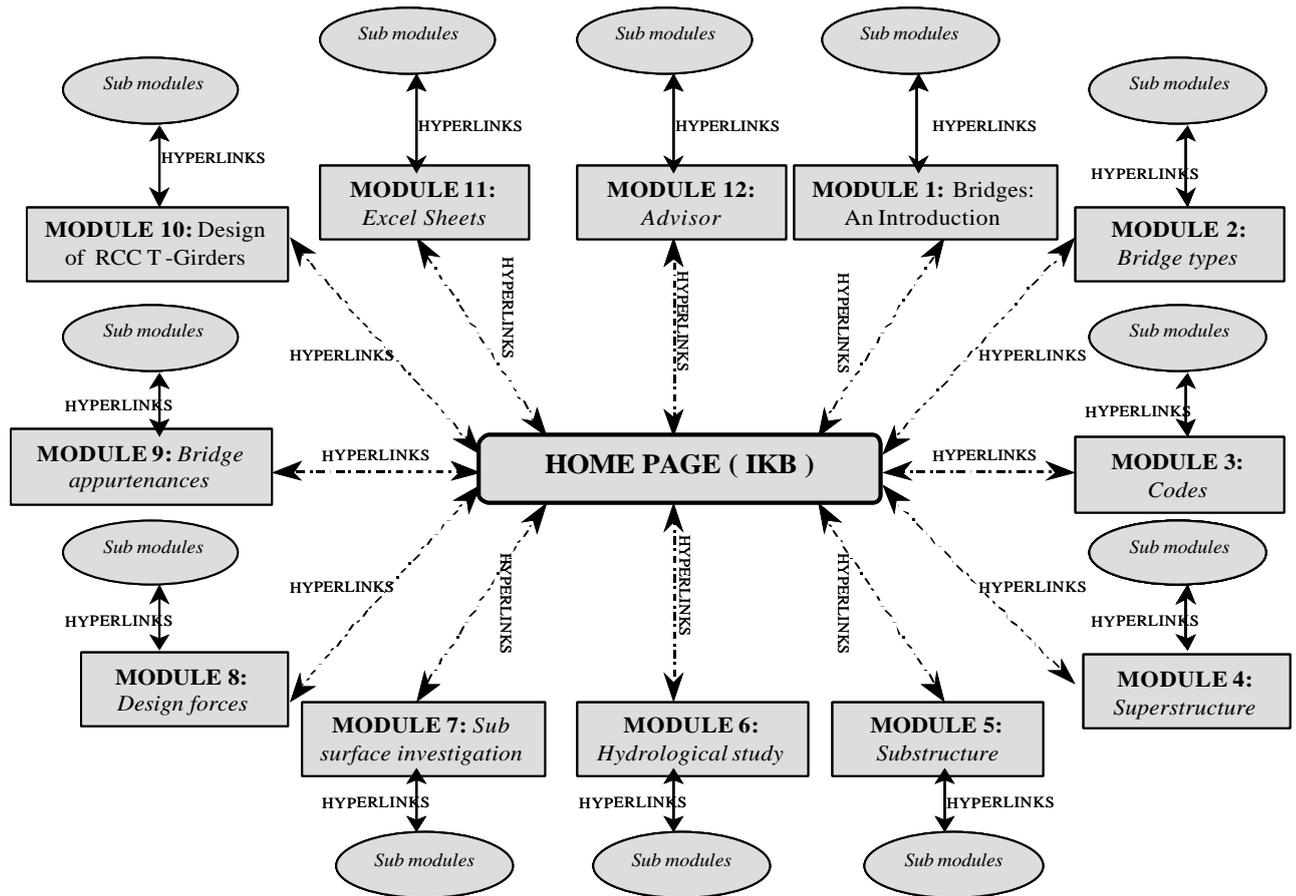
- Information on the web is cheaper to distribute and easier to maintain
- User will have up to date information, available to them anytime, from anywhere in the world.
- The information is searchable making for faster access
- A knowledge base supplements traditional task based documentation and context sensitive help by providing recovery information and possible alternative solution to specific problem through inbuilt query systems, which work on a database.
- Knowledge bases are like " treasure houses " where everyone can contribute to knowledge and everyone can benefit.

The ultimate goal is to provide an intelligent integrated knowledge base system providing the knowledge needed for solving problems of a range of complexities.

An Internet Knowledge Base has been developed for Bridge Engineering for postgraduate and professional engineers.

IKB for Bridge Engineering

The main thrust is on the design methodologies of the different bridge components and presenting the design methods through MS Excel spreadsheets. A set of modules compiled in this course cover a selected number of topics on bridge engineering.



Excel Spreadsheets

The module includes in a compiled form all the spreadsheets provided in the different modules. The spreadsheets can be downloaded and used for understanding the effect of various parameters for analysis and design of a bridge.



Advisor (Query System)

The advisor module adds a new because it provides a certain degree of interaction with the user. The main idea behind this advisor module is to present a query system which is related to a specific aspect of bridge designing. Basically this query system consists of an excel spreadsheet which uses macros. This spreadsheet has been linked to a database. The present query system deals with the preliminary design aspects of bridge decks. Based on a fixed set of input data, which is provided by the user, this query system gives the possible, alternatives of the possible deck types meeting the user requirement.

The screenshot shows a dialog box titled "INPUT DATA" with a close button (X) in the top right corner. The dialog box has a light blue background and contains three input fields arranged vertically. Each field has a label on the left and a text box on the right. Below the input fields are two buttons: "SUBMIT" and "CANCEL".

SPAN (m)	30
DISCHARGE (cumec)	300
HEIGHT (m)	4.0

SUBMIT CANCEL

RESULTS			
POSSIBLE ALTERNATIVES			
	DECK TYPE	DECK DEPTH (m)	CLEARANCE (m)
ALTERNATIVE 1	RC BOX GIRDER	2.5	clearance okay
ALTERNATIVE 2	PSC BOX GIRDER	2	clearance okay
ALTERNATIVE 3	PSC T-BEAM	2.5	clearance okay

OK

Lessons Learnt

The main lesson that I learnt during this work is that good content development requires a major initial time investment of the teacher. It is possibly this reason that most of the course material on the web is electronic version of lecture notes. For posting lecture notes and assignments, the teacher does not require the knowledge of authoring tools or the information technology. A MSWord file can be saved as HTML file. However, if the course has to be interactive, the teacher is the best developer because of his/her familiarity with the course. The teacher not only has to design the content but also requires good understanding of authoring tools. The time investment is usually at the expense of research and publications. Therefore, there is a need for the Universities to recognize the effort and the importance of online web based courseware.

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