Web Portal for Basic Engineering Courses with a Problem Database and Integrated Communication

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Abstract

This paper presents the use of a web-based teaching and learning environment for both dynamics and statics courses. The web portal or system incorporates communication, electronic media, problem database, course content, animations, simulations, collaboration tools, security and testing features to enhance its usefulness for engineering education. This paper covers the overall website features plus its security, communication and testing features.

The system has an online database of over 1000 problems for instructors to use for homework, quizzes and tests. The problem sets can be customized with random problem order, random answer order for each problem, and random parameter values for some problems. The instructor for the class can also choose between four answers (three wrong and one right) or include a fifth choice of “none of the above”. Depending upon the class requirements, any combination of problem generation features can be incorporated. The system, in all cases, remembers the degree of variation assigned to individual student for a particular problem in a given assignment.

The communication features of the web site include a discussion web-board and true web-based collaboration drawing boards. Both these features incorporate security since they recognize and only allow users of a particular class to login and use the system. Thus no anonymous messages can appear on the discussion board or class drawing board. The system has a four-tier authorization system for each of the main users; students, teaching assistants, instructors, and portal administrators. As a further security feature, there is a single login of any user so that the site cannot be entered without user verification.

I. Introduction

The use of Internet and electronic media for technical teaching purposes has grown tremendously over the past few years. New and interesting teaching methods are being developed and implemented almost monthly due to the versatility of the Internet. In particular, the Internet allows convenient collaboration between students [1] for both engineering education and design [2]. Computers and electronic media can also be used to supplement traditional methods of instruction, such as lectures and textbooks, with simulations, animations and even on-demand video [3]. It would be hard to say that these new media types and networks are not useful in teaching engineering education or for technical training. However, to use the Internet or

electronic media for any type of education actually involves a tremendous amount of creativity just to develop new material. This creativity is time consuming and then it takes more time to implement it. So many of the basic questions being asked today in most engineering schools include; does one develop one's own multimedia material or use others? How does one integrate it into the classroom or should it be used outside of the classroom? If embraced, where does one find the time to use it? How does one include new media when the curriculum is already overflowing? What current material should be eliminated? These and other questions are at the heart of implementing electronic media into engineering education.

This paper proposes a web portal to assist both students and professors in learning and teaching basic engineering education. This portal needs to be many things to many people. It must save the professor time in administering the class. The student must have access to new and exciting media with simulations and animations. The instructor must have access to as many problems as in a standard textbook to assign to students. The portal needs to help grade and give feedback to the students. There needs to be collaboration tools, such as drawing tools and discussion boards, so that students can help each other [4]. Each class needs to be independently managed by the instructor. The portal needs to be easy to use and menu driven. And finally, it needs to be free (one of the hardest but most important conditions to meet).

Yes, that is a long list of requirements for any web site, CD-ROM, or other computer-based learning system must fulfill to be successful. May that is one reason why electronic media in any form has not be universally implemented. Individual instructors have developed interesting animations, simulations and even CD-ROMs or web sites, but they generally have not been used outside how there class or school. What is lacking is a complete system that fulfils the needs of the average instructor and student.

Commercial book-publishing companies have ventured into this area, but have one major difficulty. If it is free, how can they justify its development and implementation? They can't, and so they simply put up a web site with material that will supplement a hundred dollar textbook. For example, the current edition of the Hibbler Statics and Dynamics textbook published by Prentice-Hall currently provides a selection of old problems that students can view if they purchase a workbook that supports the textbook [5]. However, that system lacks course content, collaboration tools, testing and grading features, and electronic media such as animations and simulations. It also faces a major drawback of no student teacher interactivity that is necessary for the success of any online course [4]. On last note, the site cannot be accessed without a password that can only be obtained through purchasing the workbook.

II. www.eCourses.ou.edu Web Site Portal at the University of Oklahoma

In an effort to provide professors access to the benefits of the Internet and electronic media, and at the same time, provide students with the convenience and learning opportunities of the Internet and electronic media, a web portal has been developed and implemented at the University of Oklahoma (www.eCourses.ou.edu, see Fig. 1). This portal or learning system, tries to cover all of the listed requirements in section I so that it can be used in part or all by any instructor in the country (or world). The portal also addresses the critical issue of security and communications.

The web site is not only for the University of Oklahoma but any school or individual instructor that would like to set up a class at the web site. The class is managed and controlled by the instructor, independent of all other classes. It is similar to someone opening an email account at Yahoo.com or Hotmail.com and then managing his or her email. Granted, managing a class is more involved, but the concept is still the same. The instructor can “turn on” any aspect of the portal that will suit their needs. They can get access to the full e-book that contains hundreds of pages of animations, simulations, text and graphics. Or they can use the database of problems with the automatic grading and solution posting. They could also integrate the streaming lectures on each concept or topic in the course. For the students, they can utilize the collaboration drawing tool or discussion boards. These and other features have been integrated into a web portal that is managed completely through the web.

Because the system is on the web, any one can access the web site and set up a class. The web also permits distance learning and collaboration. Potentially, this portal can be used by other universities to deliver courses to remote areas without the expense of developing their own system and course content. This can be a rather large investment in time and resources (the eCourses portal took 8-9 man-years to develop for the current statics and dynamics courses). Like a textbook, electronic media must be shared and used by thousands to justify the development time and cost. The authors of this paper envision a day when there will be four to five good web portals for engineering education that instructors can use to help teach their classes.

As previously noted, the engineering education portal at the University of Oklahoma is open to any instructor at no cost. There are also no forms to sign or restrictions on the use of the content. In order to prevent students from setting up their own class and viewing all the problems in the database, the authors do request some type of proof that an instructor is truly an instructor. This can be done with a simple email or telephone call.

The primary purpose of the remaining portions of this paper will focus on examining the design and implementation of the Internet portal and all the different types of electronic media used in the statics and dynamics course. A previous paper discussed the portal content [6].

Fig. 1. eCourses.ou.edu Web Portal Entry Page

III. Operation of the Course Management System

The portal currently consists of two courses; statics and dynamics (Fig. 1). A third course, Mechanics, is being developed for Fall 2002. The system permits the creation of multiple class for each course by different instructors. Each instructor can set up a new class under a course by entering a unique key number issued to them by the administrator. The key number is used for security purposes to prevent non-instructors from accessing the problem database. The instructor however requires no installation on their local machine to use this system. As the instructor sets up a class, their information is entered into an online database and they are registered with the system.

In order to handle multiple instructors and create customized web pages based on user request, server-based Perl (Program Extraction and Report Language) is used. HTML (Hyper Text Markup Language), basic code for building web pages, is embedded into Perl for creating dynamic web pages. The ability of the system to create dynamic web pages allows each web page to be unique for different classes. All data required to be displayed and processed is stored in an online database. A discussion regarding Perl, Access, SQL, and ODBC is given below and is explained to give an overview of the server-based support system in developing this architecture [7].

CGI-Perl Scripting

In a complicated Internet-based framework, not only client-side interactivity is required, but also server-side programs are needed to allow the user to exchange data with the server. The entire

on-line system takes advantage of CGI (Common Gateway Interface) scripting which is a server-based means of transferring data between a server and a client. In this system, Perl programming language is used for the CGI scripts. Perl is an interpreted language mainly used for managing specified text files, taking information from the text files, and printing reports. Perl scripts allow the user to submit data via a homework, quiz, or test page to be processed on the server. The processed results are then posted through Perl scripts back to the client.

A complex backbone of Perl scripts allows the system to interact with the user and the system database. Perl can obtain data from HTML form pages, process the data, and then sends the results back to the user. The scripts are responsible for taking the information from HTML forms, store information into the database, retrieve information from the database using SQL commands and process it at the server and then display the new web pages back to the user. Perl scripts actually construct and display the respective web pages through code rather than through links to existing HTML documents. This is valuable not only to ensure grade confidentiality, but also to protect the security of the upcoming homework and quizzes, as well as the integrity of the system as a whole.

SQL and ODBC

Structure Query Language (SQL) allows users to access data in relational database management systems, such as Oracle, Sybase, Informix, Microsoft SQL Server, Microsoft Access. SQL statements are used to perform tasks such as add or update data on a database, retrieve data from a database, allow users to define the data and manipulate it. Open Data Base Connectivity (ODBC) is an Application Programming Interface (API) that allows abstracting a program from a database. Regardless of the database type being used, all of the calls are to the ODBC API. Since the portal uses a Microsoft Access database, Perl extension module "Win32::ODBC" is used to access the ODBC API in this portal.

Fig. 2. List of Instructors under a course

IV. Class Management Features for the Instructor

The first task of that the management system must perform is to set up an independent class for a given professor. On the main course page for both statics and dynamics, there is a link for the instructor to set up a class (Fig. 2). After the class information is entered, including the key number for the portal administrator, the new class is listed on the main page as shown at the top left in Fig. 2. This list is dynamically created with input from the database so the administrator does not have to edit any web page in the system. In fact, once the key number is issued to the instructor, the administrator of the portal does not have to modify any part of the system or database.

Both the student and instructor access the class by clicking on the class link. A user ID and password that was determined by the individual when setting up their account, must be enter to get access to the class. Students set up their own student accounts after the instructor has entered their user ID into the class database. In order for the Instructor to manage their class, add students, manage scores and assign homework's and quizzes, an additional framework of web pages was created just for the instructor. Access to those pages is restricted to the instructor only. The Instructors Class management system is divided into two sections, the Main menu (Fig. 3) and Admin menu (Fig. 4).

When the instructor logs into the system, main menu appears on the screen. The instructor can switch between main menu and admin menu at any given time. The main menu consists of features that any user would see when logged on. It allows the instructor to see the title page of their class, Course info, information about the website, syllabus for the class, edit their username and password, link to the e-book, utilities that have been released, the current server time, log onto the discussion board, post messages under the web-board and view the assignments to see all the questions that have been added. The admin menu provides the instructor with tools to manage a class so that it will be similar to managing like they would do with a non-web based class.

Fig. 3. Main Menu for the Instructor

Fig. 4. Admin Menu for the Instructor

Managing Students

An important activity for an instructor is the managing of student accounts in their class. This system provides the ability to edit individual student information, make changes to their scores, overwrite the student's password, delete student accounts and send email to individual student. Individual student scores, as well as the performance of the entire class, can be viewed. The class

scores are displayed in a similar spreadsheet format. The scores are from the homework, tests, and quizzes that are assigned and graded online by the server when these assignments were submitted. Outside homework scores are not included in the listings. Each student (or the whole class) can be sent an email through the web portal. It should be noted that the student manages his or her own email address in the system.

Managing Assignments

Another key feature to this system is the ability to manage assignments. This feature allows instructor to choose problems from a database of questions through a web page. The instructor can choose from a database of over 1000 problems for assignment sets (Fig. 5). This is similar to choosing the questions from the back of a book. All the information related to assigning the problem, choosing problems, locations of the problem are stored in the database. Once a particular problem is chosen for an assignment, the system remembers the allocation of the problem to a particular set of assignment and it cannot be re-used again for that class by the same instructor. Another useful feature is the ability to set the date and time for a particular assignment to be released. Based on these times, the assignment problems, solutions, grades and submission details are released. Other features include homework set editing, viewing of assignment solutions, score distributions, editing assignment schedules and deleting homework sets.

Fig. 5. Web page for selecting problems from the database

Managing the Class

In order to customize the appearance and utilities of the class, this section provides the instructor with tools to set up the class syllabus, customize the grades distribution for assignments, edit

admin info and class info, change the news that appears in their title page and release or hide the utilities.

Syllabus manager is a module embedded into the system that allows the instructor to set up a syllabus for their class. It asks the instructor the information about the number of weeks the class is going to span (Fig. 6), the starting date of all weeks (Fig. 7), allocate chapters to weeks (Fig. 8) and the system produces a tabulated syllabus (Fig. 9) for the class. The system automatically constructs links in the syllabus to online mini-lectures using streaming video [3] and e-Book content on the web. These links help guide the student to the correct course material so that they do not have to search the web site.

Fig. 6. Select Weeks

Select Week Starting Dates			
Week No.	Starting Date		
1	Jan	15	2002
2	Jan	22	2002
3	Jan	29	2002
4	Feb	5	2002
5	Feb	12	2002

Fig. 7. Starting Dates

NO	CHAPTERS	WEEKS
1	Particle General Motion	
1.1	Position, Velocity, Acceleration	1
1.2	Line Motion: Acceleration with time	1
1.3	Line Motion: Acceleration Constant	1
1.4	Curvilinear Motion: Rectangular Coordinates	1
1.5	Curv. Motion: Normal/Tangential Coordinates	2
1.6	Curvilinear Motion: Polar Coordinates	2

Fig. 8. Select Weeks

Schedule				
WK	From (mm-dd-yy)	Lecture(s)	Content	Topic
1	01-15-02	Lectures	1.1	Position, Velocity, Acceleration
			1.2	Line Motion: Acceleration with time
			1.3	Line Motion: Acceleration Constant
			1.4	Curvilinear Motion: Rectangular Coordinates
2	01-22-02	Lectures	1.5	Curv. Motion: Normal/Tangential Coordinates
			1.6	Curvilinear Motion: Polar Coordinates
			1.7	Relative Motion
3	01-29-02	Lectures	2.1	Rectangular Coordinates
			2.2	Normal/Tangential Coordinates
			2.3	Polar Coordinates

Fig. 9. Starting Dates

In addition to the course material, the portal also has various tools that can be turned on and off by the instructor for student use. These are self-contained applications that help the students to calculate matrices, vectors, cross products, trusses and beams. The utilities can be released or hidden by the instructor. Figure 10 shows the customization system for the utilities. The instructor can also view them before deciding to release them or hide them. Currently, there are five tools, but in the future more tools will be added. The tools run directly over the web and no downloading is required.

Utilities Customization		
Please select the tools that the students have access. The system will remember the last changes made.		
Utility Name	Release	Hide
3X3 Matrix Solver	☒	☐
Unit Vector Calculator	☐	☒
Cross Product Calculator	☐	☒
Truss Analysis Tool	☐	☒
Beam Analysis Tool	☐	☒
		<input type="button" value="Submit"/>

Fig. 10. Utilities Customization System

Managing the class TA

The system offers the flexibility to set up a teacher assistant (TA) account from within the “Admin Menu” of the instructor. The TA account is similar to instructor account but the instructor has the ability to turn off some of the privileges (Fig. 11). The selection process is done by simply checking yes or no on each privilege the instructor would like grant to the TA. The TA account does not have to be used or set up if not required.

TA Privilege(s) Customization System		
Selection Window		
Manage Student	Status	
Account	Always selected	
Score report	Always selected	
Log info	Always selected	
E-mail to students	Always selected	
Manage Course	Yes	No
Homework	☒	☐
Quiz	☒	☐
Test	☐	☒
Example	☐	☒
Manage Class	Yes	No
Syllabus manager	☒	☐
Grades distribution	☒	☐
Edit admin home page	☐	☒
Utilities admin	☐	☒
Change news	☐	☒
Edit course info	☒	☐
		<input type="button" value="Submit"/>

Fig. 11. TA Privilege(s) Customization Screen

V. Communication Between the Instructor and Students

Research has shown that for the success of an online course, interaction between the instructor and students is necessary [4]. The system has two main built-in features for communications between different students and between the instructor and students. The web-board (Fig. 12) provides a discussion forum so that questions can be posted and drawing-board (Fig. 13) allows students and the instructor to interactively draw diagrams over the web. Both these features only allow users of a particular class to login and use the system. Thus no anonymous messages can appear on the discussion board and drawing-board.

This web board works like and provides the same utility as other commercially available web discussion boards or news groups. Previously a commercial web board was used, but it could not be integrated into the over all system. This caused two problems. First, the students needed to login with a second user name and password. Second, a new web board group had to be created by the web site administrator when a new class was set up by the instructor. With the new integrated system, a user only logs in once and the administrator does not have to manually set up a separate discussion group. The web board has the features like automatic addition of forms as soon as the assignments are added to the class bearing the same name as that of the assignment, no anonymous message hosting and only instructors and TA's can edit and delete messages.

Web Board	Topics page	Topic reply	Post new topic
Forums	Author	Topic: Problem 3 in Homework 2	
General			
Course questions	Mandeep Thukral	Do we need to change the value of force from Force/length to Force/area?	
		Posted on 1-14-2002 at 13:31:54	
Homework			
Homework-1	Brandin	Yes we need to convert the value of force from force/length to force/area.	
Quiz		Posted on 1-14-2002 at 13:34:25	
Test			
	Edit this message		Delete this message

Fig. 12. Web Board

The collaborative drawing board permits both students and instructors to communicate with pictures. Any member of the class can interactively draw on the screen (a web page) and all others that have that page pulled up can see the drawings. The objects in the drawing can be moved and resized. This is not a painting tool but a vector-based drawing tool similar to a simple CAD application. The tool is not downloaded, but runs directly on the web page. The drawing board has been customized to meet our system requirements. Due to the presence of multiple classes, it is important that members of one class do not see members of other classes. The drawing board, also integrated with the single login system recognizes the user and allows them access to the drawing board.

Fig. 13. Discussion Board

VI. Problem Database and Built in Testing

One of the more time consuming activities for any instructor is the creation of problem sets and then grading those problems. In order to assist the instructor in managing their class, an online database of problems of about 1000 problem can be accessed and assigned to a homework, quiz or test problem set. All problems are multiple-choice questions. The solution is also part of the database and can be released to the students after the problem set is due. This eliminates the need for instructors to post solutions on bulletin boards that are many times inconvenient to students. The problems appear on the web page similar to the examples in Figs. 14a and 14b. Once a problem has been added to a problem set, the system does not permit the same problem to be used again (Fig. 14b).

Problem 4_1_e_3

A car weighing 2,500 lb is driven into a barrier at 5 mi/hr. The duration of impact is 0.5 s and the car bounces back from the barrier at 1 mi/hr. What is the magnitude of the average horizontal force exerted on the car during the impact, also, what is the average acceleration of the car during the impact?

$v_1 = 5 \text{ mi/hr}$ 2500 lb

a. -1,370 lb and -17.6 ft/s²
 b. -1,920 lb and 22.3 ft/s²
 c. -1,200 lb and -32.3 ft/s²
 d. -1,470 lb and 90.4 ft/s²
 e. -1,780 lb and 49.4 ft/s²

[Add this question](#) [View solution](#)

Fig. 14a. Add Question

Problem 1_1_e_2

The bus velocity is known to be $v = (t^2 + 4t) \text{ ft/s}$. Determine the acceleration of the bus after 3 seconds. The bus starts from rest.

v a

a. 10 ft/s²
 b. 7 ft/s²
 c. 3 ft/s²
 d. 9 ft/s²
 e. 12 ft/s²

This question is already being used in Homework 1 as question number 1

[View solution](#)

Fig. 14b. Question Already Added

After a homework, quiz, or test has been set up, the posting date/time, due date/time and solution posting date/time must also be set. The due date/time and solution date/time can be different to allow the instructor time to review the grades and problems before the students can view the solutions and scores.

The system can also variable the problem order and the answer order for a given problem. These two features help reduce the comparison of answers between students during tests and quizzes. The instructor has the choice to turn either feature on or off before the problem set is released to the students. Currently, a new feature is being developed to also vary the problem parameters so that each student gets questions of same level of difficulty but with different value of parameters, thus making problem comparison between students even more difficult.

In addition to varying problem order and answer order, the instructor can also add a fifth answer choice (e), none of the above, to all questions. This feature is useful for quizzes and tests were the instructor does not want the students to know that one of the answers is correct.

The system, in all of the above cases remembers the degree of variation assigned to individual students for a particular problem in a particular assignment. All record keeping is stored in an online database.

VII. Web Security for Online Classes

Security is an important aspect of any web site open to the public. Several features have been incorporated into the system to insure a secure site. One concept is the use of session files on the server and not cookies on the local computer. Session files are temporary text files on the server that are created as soon as the user logs onto the system and terminated when the user logs off. This minimizes cookie information being used for the wrong purpose. This also allows the user to access the web site on any computer, and all information will be stored only on the server and not the local computer.

Another important security issue is passing program parameters within URL commands. Any user information should not be passed to other web pages through URL lines since that information is seen on the screen. Even hidden variables on web pages can be view by looking at the page source code. Care was taken to prohibit any confidential data from being visible in the URL or within the HTML code itself.

Another important security feature incorporated is the single login system. It makes the user to enter their information only once. As soon as the information is entered, the system recognizes the level of the user and releases material appropriate for that level. Advantages of a single login system include nonmembers cannot view any content of a class, no anonymous messages can be posted on the web-board and drawing board because the username stamp is associated with anything done by the user and the student does not know what all utilities have been released by the instructor.

Summary

A web portal for basic engineering courses has been developed to help instructors manage online engineering courses. The system tries to mimic what all a typical professor would do in a traditional class, such as assign problems, reading sections, and grade homework. It also adds the advantages of electronic media with online collaboration, automatic grading, simulations,

animations, discussion web board, and streaming lectures. At the University of Oklahoma in the School of Aerospace and Mechanical Engineering, both statics and dynamics are being taught using this portal. The portal is a self contained system that contains all necessary material to teach both courses, including an e-book, mini-lectures in QuickTime and Flash format, online problems and solutions, engineering tools and drawing board.

The system has been set up to support multiple classes of both statics and dynamics. Each class is independent of each other and has no bearing on the activities of the other. All classes do use the same content databases. For security reasons, the web portal has been developed around a single login system. The system has the ability to recognize the user and release information accordingly. Also, username, passwords and other user information are passed as session files from one web page to the other.

The web site has a built in testing system that allows the instructor to set up assignments and tests from a database of over 1000 problems. To enhance the testing feature and overcome the shortcomings of proctoring a computer-based test, features such as problem and answer order randomization has been incorporated. As studies have noted [8], collaboration and interactive tools are important in the success of online courses and distance education. The current system has incorporated both discussion groups and drawing tools to help with the interaction between students and between students and professors.

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Biography

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