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Internet-based, Interactive Software for Industrial Engineering Education

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Abstract

New and developing electronic communication tools are rapidly changing the ways in which educators educate and students learn. Collaborative learning environments utilizing various interactive electronic technologies are now being used in all levels of education, including K-12, industrial training and higher education. This paper focuses on the application of educational technologies and the Internet for industrial engineering education. In particular, an online review system developed by the University of Oklahoma for the morning and afternoon session of the Fundamental of Engineering Exam for Industrial Engineering is presented and demonstrated as an effective use of the these new electronic communications tools and networks. This work forms a part of the Fundamentals in Engineering Review project carried out by the University of Oklahoma. The online review is web-based and can be freely accessed over the Internet. Currently, all topics in the morning General Exam are completed and both the Industrial Engineering and Mechanical Engineering Specific Exams are complete. The review system uses all forms of electronic media including graphics, animations, simulations, text and 3D visualizations. There is also a random generated exam to help the user practice taking the exam. The practice exam is graded instantly and reported to the user through web.

This online professional engineering exam review also lays the foundation for the complete curriculum of Industrial Engineering on the Internet. Existing for students who cannot attend classes regularly. Furthermore, this online program can also be used to promote and propagate the field of Industrial engineering to prospective students and therefore can be utilized as an effective recruitment tool by Industrial Engineering schools. This paper elaborates on the technology used to deliver the online review system for Industrial Engineering.

1. Introduction

The education and training sector is facing an increasing number of people who wish to undertake further education beyond high school. One strong reason for this increased demand for higher education is the change in the work environments from product-based system to

knowledge-based system. This increased demand has resulted in larger class sizes, high student to faculty ratios and a decrease in interaction between the students and the instructors.[1] Also in the past decade, there has been an increase in the number of students coming to the United States from different countries for higher education. This increases the cultural diversity in the classroom and an instructor might find it difficult to cope with the learning styles of people from different backgrounds. In this pool of students there is also a mixture of working professionals who are studying part time and need flexibility with the class timings.

Internet-based learning offers an effective alternative to address the above problems. Internet-based learning offers several advantages as compared to conventional classroom based learning. Internet-based learning uses the information processing ability of the computer by adapting to the needs of the student and removing the rigid form of traditional learning. Internet has also extricated the geographical barriers between the students and the instructor without significantly changing the quality of learning experience.[2] In fact geographical independence has decreased the delay in distributing classroom material and instructions since they are immediately posted on the web by the instructor. This also minimizes distribution difficulties of making copies and mailing the course material to the students. The Internet has the added benefit of ensuring platform independence with respect to the software used for web-based learning since the software works equally well a Macintosh, Windows or other operating system. Internet also allows students and instructors to easily collaborate with each other as individuals or in a group.

Along with these advantages of the Internet, there are problems. One such obstacle was pointed out by CISCO systems CEO John Chambers. He mentioned that the main roadblock to e-learning is lack of infrastructure and content rich applications, as well as a mindset in some cultures that is not ready to accept education not bound by a master/novice framework.[3] Although most universities students have free LAN connections, off-campus students have to pay substantial fees for high bandwidth Internet connections to receive internet-based education. This difficulty may lead to student anxiety about extensively using the web for online courses and needs to be addressed. Another common concern about online learning systems is the lack of face-to-face discussions with instructors or students. Both these can be minimized with organizational changes and developing effective Internet-based collaboration tools.

2. The FE Project

In the spring of 1998, a project was initiated at the University of Oklahoma (OU) to take advantage of the Internet and new multimedia technologies to help students (and others) to prepare for the Fundamentals of Engineering (FE) examination that is required of all students and practicing engineers to obtain the professional engineer's certification. The exam is used as the first step in the professional licensing of engineers and was developed to measure minimum technical competence. The exam is also one of the tools which is effective in assessing engineering education for ABET which is responsible for the specialized accreditation of educational programs in engineering, engineering technology and engineering-related fields. The national council of Examiners for engineering and surveying (NCEES) generates, conducts and scores the examination.[4] The Fundamentals of Engineering examination is administered twice a year in April and October. The examination is divided into a morning four-hour session and an afternoon four-hour session. There are 120 questions to be answered in the morning section and

60 questions in the afternoon section.[5, 6] Generally students in their senior year take this examination. The afternoon session is a discipline specific examination where five disciplines chemical, electrical, industrial, mechanical and civil are covered. A general exam is also included for those students who do not fall in the five categories.[5, 6] Most topics in the afternoon exam cover the third and fourth year of the engineering curriculum in that specific discipline.

The initial phase of the FE online review project was concerned with developing web-based system for the general morning exam session. The second phase of the project, which is presented in this paper, deals with the continuation of the project and covers the afternoon session for Industrial Engineering and Mechanical Engineering. There are numerous books manuals and video courses covering the FE reviews along with one web-based review developed by ASME (www.asme.org/pro_dev/fevid.htm) that were identified by the authors. The cost of a video review course offered by the University of Maryland is $595 and it is available only for the morning session of the FE exam. The web-based review developed by ASME review just the afternoon topics for Mechanical Engineers and costs $89. The ASME review package uses HTML based graphics and text to present the review material with no animations or simulations. Figure 1 shows the snapshot of the ASME online program.

Fig. 1. Snapshot of the ASME review site

Most individuals conduct their reviews using textbooks that they used in school, encyclopedia like Industrial engineering handbooks, or FE review manuals. The cost of these handbooks and review material is expensive and a student might find it costly to replace his or her existing textbooks. Also the FE exam given every year has different questions although the format of the questions remains the same. The major disadvantage with the textbook based structure is that once the students take the exam from the book they are not left with any other exams for practice. The FE project was initiated considering all the above factors. The test case for the Industrial engineering afternoon session is not only aimed at providing a complete review for the FE test but also a foundation for creating an Internet-based Industrial engineering curriculum.

The School of Industrial Engineering at the University of Oklahoma has made it mandatory for all the undergraduate students to take the FE exam before they graduate. Undergraduate students are already overloaded in their final semester due to their senior design project and there is a rush to take additional hours needed to graduate. An Internet-based review would be useful for all undergraduate students since this would allow them to access the information at anytime regardless of their schedules. The graduate students in Industrial engineering who have completed their undergraduate work at universities that do not require the FE or have received their degree outside the United States may also have a need to take the FE exam. For instance, after completing their master's degree many of them are working in the industry and are finding that a professional engineer's certification would help them in their work positions. These working engineers also need convenient access to review information but yet it is not possible for them to return back to school or visit the University libraries for the current literature. An internet-based FE review with up-to-date content will not only help the current students but also help working engineers by allowing them access to a comprehensive review process that fits their schedules.

A pre-project survey was conducted to evaluate whether an Internet based review system would be effective. The questions asked and a compilation of the responses obtained from 10 students is presented in Table 1. The ten students who were surveyed were either in their senior year or Masters program in Industrial Engineering. The sample size of students is small but this is attributed to the fact that there are only 8 students in the Industrial Engineering senior design class. Though the responses are subjective and do not provide a truly quantitative indication they do provide useful insight for determining the feasibility of the project. One of the questions was to determine whether it was important to have an on-line review system. 60% of the student's responded stating that it was important and 40% suggested it was very important. Another question was to determine if user interactivity was required and 70% of the students suggested it was very important. All the students surveyed it was necessary to have help sessions along with the electronic media and a reference textbook for preparing for the exam.

	1	2	3	4	5
		Responses (%)			
Importance of Online FE Exam		-	-	**60**	40
Importance the following items would have on an on-line review		-	-	-	
Simulations		20	-	30	**50**
Textual Content	10	-	20	50	20
Equations		-	10	60	30
Animations		20		30	**50**
Sound		30		40	30
Graphics		10	30	-	**60**
User Interactivity		10	10	10	**70**
On-line timed testing		-	20	30	**50**
Ability to view old tests		-	20	20	**60**
Randomly generated test questions simulating an actual exam		-	-	30	**70**
Ease of navigation system		10	-	20	**70**
Accuracy of content		-	10	30	**60**
Completeness of content		-	20	30	**50**
Depth of the content		-	20	40	**40**
Convenience of use		-	10	30	**60**
Ability to submit questions on-line		-	20	40	**40**
Chat room		10	40	30	20
News groups		20	40	30	10
Bulletin board		20	10	50	20
Access to experts (Professional engineer)		-	20	30	**50**

Scores are based on the following: 1 - Not Important, 2 - Scarcely Important,
3 - Moderately Important, 4 - Important, 5 - Very Important
Ten students (seniors and masters) participated in the survey

Table 1. Analysis of the pre-project survey

One of the beneficial aspects of an Internet-based review is the use of interactivity in the system, which would stimulate the interest of the user to learn. This has prompted the development and use of multimedia technology in the FE review. Multimedia movie animations and audio narrations are used to help explain concepts, which are hard to understand or visualize. JavaScript applications are used to add interactivity so that the user understands the usage of formulas and is able to practice them immediately without using a pencil, paper and a calculator. Certain concepts, which would actually require the student to visit a workshop or a factory manufacturing shop, are modeled using Virtual Reality Modeling Language (VRML). This has helped to simulate the reality in 3D, which is important in understanding many engineering concepts. The figure shown below (Fig. 1) shows a 3D robot modeled in VRML.
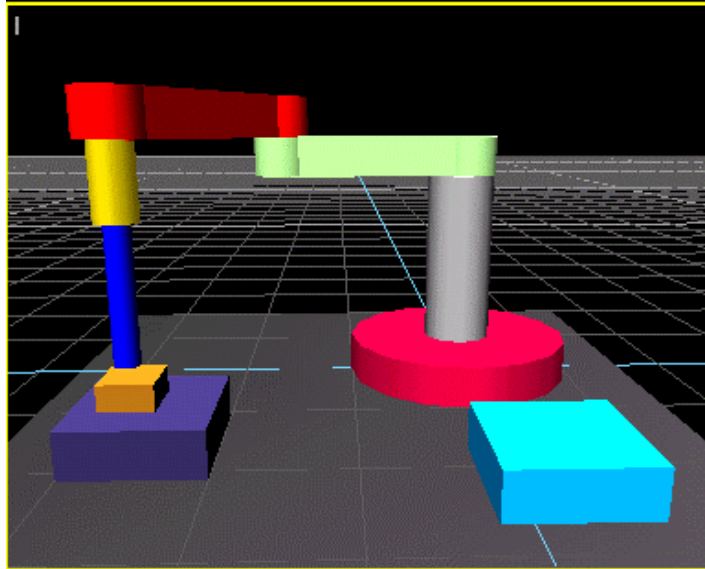
Fig. 2. A SCARA robot modeled in VRML.

3. Organization of the Industrial Engineering Section in the FE project

The complete undergraduate Industrial Engineering curriculum along with the currently available FE literature was taken into consideration while developing the topics for the afternoon exam. The NCEES engineering curriculum assessment was also considered while finalizing the topic breakdown structure. The complete syllabus was then broken down into 21 different topics called modules. Each module was then divided into three different sections; basics, examples and problems. Standardization has been one of the prime considerations while developing these modules. This has been specifically done so that once the students get accustomed with the structure of the first module in the review they need not spend time to get familiarized with the structure of the next module. The size limit for each page in a module has been set to 100 kilobytes to minimize the download time for users with modem speeds less then or equal to 56.6 kbps. In addition, keeping with the same standards as that of the morning session, the modules are required to fit the screen width of 800 pixels so that most users would be able to view the modules without the need to scroll sideways.

4. Overview of the software used

To develop the Internet-based FE review, various multimedia development tools and technologies were used. The software programs utilized range from basic HTML editors, which was used to create the web pages to advanced programs like VRML and Macromedia Director, which were used to build interactivity. The following paragraphs give a brief overview of the packages used and some common terms the students may encounter when they use the review.

4.1 Hypertext Mark Up Language (HTML)

HTML is primarily used as a document layout and hyperlink specification language. HTML defines the syntax and placement of special, embedded directions that aren't displayed by the browser, but tell it how to display the contents of the document, including text, graphics, animations and other media.[7] The language also helps in making a document interactive through special hypertext links, which are used to connect documents.

4.2 Macromedia Flash 3.0

Macromedia Flash is a vector graphics editor and an animation tool used for drawing graphics and creating animations in a compact file size. The small file size allows easy and fast for downloading which increases the usability of the program to home uses with standard modem connections.[8] Flash also allows the developer to add interactive controls within the animations. The compressed exported Flash files, called shockwave flash files, are then embedded directly into the web page. Flash has been used throughout the FE review as one of the main animation tools.

4.3 Virtual Reality Modeling Language (VRML)

VRML is one of the methods by which 3D models or virtual worlds can be created on the Internet. VRML worlds are versatile since they support interactivity, animation and user modification. They can be embedded as hyperlinks to other Internet documents. Furthermore VRML file formats are platform independent and thus all computers (PC , MAC, UNIX etc) that use a web browser can use and view VRML models with a VRML player.[9] VRML is less complex as compared to other 3D CAD programs and can be easily published on any web site. VRML has been used in FE review to create 3D worlds mainly for simplifying manufacturing environments in the modules.

4.4 Macromedia Director 7.0

Macromedia Director is a multimedia authoring program which is used in FE review to build interactive multimedia simulations. Director has been used to create design applications in the modules such as allowing the user to design a pressure vessel. Director files are saved as compiled director Shockwave files that can be viewed and operated from a web browser. Shockwave is a general technology that puts Authorware, Director, and Flash files on a web page and that enables animation, audio, and interactivity to be added to static Web pages with text and graphics.[10, 11] For Netscape-compatible browsers, Shockwave is a program plug-in and for Microsoft Internet Explorer, Shockwave is an ActiveX extension to the browser. The plug-in and ActiveX controls enable the user's browser to interpret and display the Shockwave movies. Since Shockwave was designed specifically for Internet use, it reduces the file size tremendously without the loss of quality. The Shockwave plug-in is free to download for Netscape Navigator (version 2.0 or later) or Shockwave ActiveX control for Internet Explorer 3.0 and 4.0 from Macromedia's web site. If the user has a Windows 98 operating system, the Shockwave ActiveX control is preinstalled in the Internet Explorer 4.0 and Shockwave plug-in is preinstalled for Netscape Communicator 4.5.

4.5 JavaScript

JavaScript, a programming language, is integrated into web browser and can make the web page respond directly to user interaction with form elements that consist of input fields, text areas or buttons. JavaScript also enables distribution of small collections of databases and provides a friendly interface to them.[12] A snapshot of an application created in JavaScript is shown in Fig. 3.

Fig. 3. Snapshot of a JavaScript application

5.0 Layout of the Modules

The FE review program was designed and implemented for Internet access to allow wide use and access. Students can access the review site for free from the engineering media lab's website at http://www.eml.ou.edu/fie. There are two links provided on the page, one can either use a shockwave pull down menu or the HTML link (Fig. 4 and Fig.5). The shockwave pull down menu is visually more appealing but takes more time to download the file and requires a shockwave plugin. The material, which can be accessed by the user, remains the same irrespective of the choice of the menus.

Fig. 4. Shockwave Pull down menu option

Fig. 5. HTML Pull down menu option

Once the user selects the afternoon industrial review icon, he or she is lead to the main page of Industrial Engineering review, which is shown in Fig. 6. Simultaneous presentation of the topics main page and the list of modules are made possible through the use of JavaScript.

Fig. 6. Industrial Engineering Modules

The user can now choose to view any particular module in the review session. The full list of modules as well as the morning exam review topics are available for the user to help in navigation to various areas of the site depending on his or her choice.

5.1 The Basics Page

The basics page for one of the modules, Computer Integrated Manufacturing, is shown in Fig. 7. The basics section is divided into sub-topics, which explain different fundamental concepts in the main topic. The basics page is structured so that the student finds all the relevant information and equations pertaining to that topic.

Since this is a review site, the material covered in the basics page is comprehensive. The users are expected to know the abbreviations for all the equations beforehand though in some places they might be mentioned. Although the material is comprehensive it is complete with respect to the required material for successfully answering the test questions. Furthermore the page also contains simulations, movie animations, audio narrations, graphics, VRML models and interactive JavaScript applications. All these enhance the quality of information and help the user develop a dilettante interest in the subject.

Fig. 7. The basics page

The graphics are generally created using the existing graphics software. Some illustrations are obtained from copyright-free sources such as clip art databases. An image editing software is then used to convert the graphics into a Graphics Interface Format (GIF) or a Joint Photographic Experts Group (JPEG) image. Only these two formats are used because they give smaller file sizes as compared to the other available ones.

The Flash shockwave movies included in the page are aimed at providing a visual illustration to the user and thereby increasing the understanding capacity of the user. The animation movies are activated in a separate window so that the user can separately read the linked text as well as watch the related animation.

The simulations created in Macromedia director are also exported as Shockwave files. The main advantage of director simulations over animations is that they add user interactivity but are more complex to build as compared to Flash movies.

The VRML 3D worlds are created using Cosmoworlds and they simulate 3D factory environments. One problem with VRML worlds is that the file size can be large. To minimize the file size, they are compressed in gzip format so that the download time is reduced. The worlds are inserted in the basics using JavaScript and they open up in windows similar to the animations and simulations.

The JavaScript applications are small chunks of code, which convert mathematical formulas into calculators. These calculators can then be conveniently used for calculating equation parameters. This helps the user to understand the formulae in a better way as they can run the applications with different values for the equation parameters as well check answers for the problems they have solved. Thus the need to use a conventional calculator is reduced.

5.2 Examples

Once the student completes studying the basics for a particular topic he or she can review typical example problems that are solved in the example section page. One of the solved examples is shown below in Fig. 8
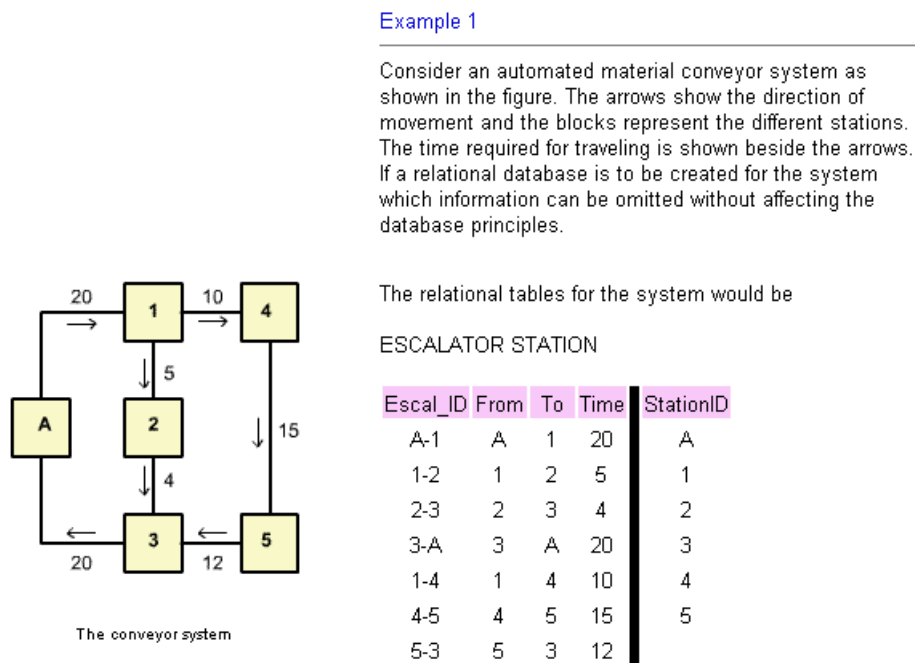
Fig. 8. The examples section

The examples also make use of graphics to captivate users attention. The solved example problems provide the user with an in-depth explanation on how the theory explained in the basics section is being put to use. Here the user can observe how the equations from the basics page are being used.

5.3 Problems

The third section for each topic presents problems for the user to solve. This section consists of six problems as shown in Fig. 9. The figures or pictures, which represent the problems and make them attractive to the user, are linked to the respective problem statements. Each problem appears in a separate window. All the problems are multiple-choice questions similar to the real exam. The correct answer shows the steps involved in arriving at the correct solution.
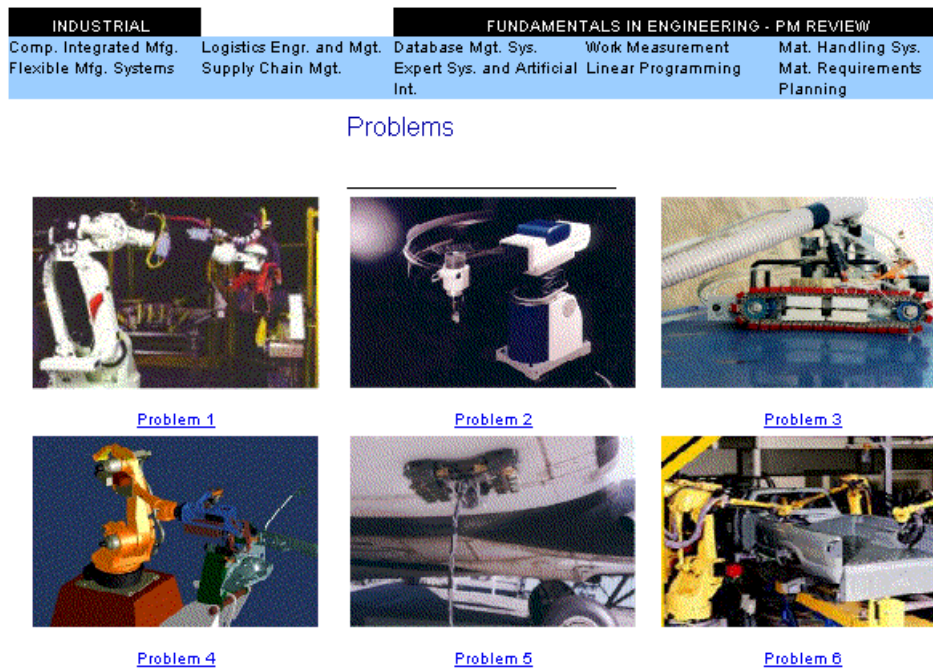

Fig. 9. The problems page

Figure 10 is an example of one of the practice problems which pops up in a separate window when the user clicks on a link in Fig. 9. The problem has in built controls such as the back button, which help the user navigate through the problems section. All the problems are multiple-choice questions similar to the real exam. The correct answer shows the steps involved in arriving at the correct solution

Problems - Microsoft Internet Explorer

Problem 1

An axle supplier for a car manufacturing unit had the following demand (given in the table below) for axles in the past eight months. Calculate the seven month moving average and exponential smoothening (alpha = 0.10) for future sales forecasting.

Month	Demand
Jan	4500
Feb	4230
March	4600
April	4500
May	4400
June	4320
July	4450
August	5000

Correct Answer.

Moving Average. Calculate the average of the first seven months

Average

$$= \frac{4500 + 4230 + 4600 + 4500 + 4400 + 4320 + 4450}{7}$$

$$= 4428.57$$

Consider the next month

Average

$$= \frac{4230 + 4600 + 4500 + 4400 + 4320 + 4450 + 5000}{7}$$

$$= 4500$$

Exponential smoothening

$$4428.57(1-0.10) + 5000(0.10) = 4485.71$$

Thus sales forecast by moving average is 4500 and exponential smoothening is 4485.71

BACK

Fig.10. Separate window for the practice problem

6.0 Summary

The development of Industrial engineering FE review was started in fall of 1999 and was completed in the spring of 2000. The review is one example of an Internet-based distance education program. All students can access the review site free of cost. The review has been structured in such a way that the user is introduced to the material in a step-wise manner. The technology used to develop the review incorporates the latest tools in multimedia and Internet based software.

The online review will not only serve for the FE examination but can also be used as a recruitment tool for the University of Oklahoma's Industrial engineering department to attract more students. The review can be considered as the first step in building a complete on line Industrial engineering curriculum.

The FE review for Industrial engineering can also be used to assess the ability of undergraduate students as they complete each year of study. At the University of Oklahoma, this online review will be used for future ABET accreditation needs to assess students' learning. In addition to course materials, student projects, sample assignments and interviews students, faculty and administrators, the FE review can also serve as a tool for ABET accreditation.

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Bibliography

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