Online Review and Practice Tests for the Fundamentals of Engineering Exam

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Abstract

Within the past few years, the World Wide Web has proven to be a tool of great potential both as an instrument for education as well as for technology application. This is evident with the increase in distance learning sites available on the Internet. This paper focuses using the Internet by students to prepare for the Fundamentals in Engineering Review Project. This project implements the computer-based, distance learning technology to help students and engineers in industry to prepare for the Fundamentals in Engineering Exam (FIE) in their quest to obtain the Professional Engineering License. A common need associated with the FIE exam is a cost-effective method to obtain an adequate review package [1]. In addition, insufficient time to prepare for the exam serves as another problem. This paper elaborates on the methods and technologies used to counter these problems. In general, by having the review online users are able to access the review site at any given time. This allows users to progress through the review at their own rate. In addition, the information presented can be constantly updated to keep up with current standards. Furthermore, instant feedback can be obtained from the users and any mistakes present can be corrected instantaneously. The integration of multimedia technology such as graphics, movie animations, audio narration, and simulations in the review also enables the users to review in an interactive and innovative environment.

1. Introduction

The Fundamentals in Engineering exam is held twice every year in April and November for students in college as well as engineers in industry who wish to obtain a professional certification in the field of engineering. Students in college may elect to take it during the final year of their senior semester or perhaps after graduation. The current exam format consists of two, 4-hour sessions, with question formats covering 15 science and engineering topics. Although there are numerous books and manuals [2,3] geared toward the FIE reviews, none are available on the Internet. This means that newer versions with updated material will render the previous versions inadequate. The newer editions are normally sold at a higher price than previous editions although the updates are minor. In addition, any printing error in the material cannot be corrected and will cause confusion to the user. Furthermore exam questions presented in review books are fixed and users are no longer challenged by these questions after attempting them the first time.

The FIE review project at the University of Oklahoma began in the Spring of 1998 and focuses not only on providing an adequate review package but also to address and to

rectify the problems stated above. By having all the relevant review material and sample exams online, this project can easily cater to the needs of students as well as engineers in industry. This method allows them to access the information at any given time of the day regardless of their schedule. In this way, users are able to work the review process into their schedules instead of having it the other way around. This also allows users to assimilate the material and progress at their own pace.

The online review is particularly beneficial to engineers in industry or to those who have long graduated from college. Since the material is placed online they need not revise the material from their old and sometimes outdated textbooks. The constantly updated and error-checked material will assure users that the material available is of high quality. This also solves the problem for some users whose old textbooks may have already been sold.

The use of multimedia technology in developing the FIE review allows the user to operate in an environment which is not only innovative but appealing as well. By making use of movie animations and audio narration, the user is able to approach the review process from a different point of view rather than just reading from textbooks. Users are now able to make use of visual representations to help foster a better understanding. In addition, the use of simulations in the online review further promotes interactivity to the user as well as making the review process a more enjoyable endeavor.

By having the review online, feedback from users can be obtained to further improve the quality of the review material. Any error can be reported via email or web board sites and the relevant corrections and updates can be performed as the need arises.

Another advantage is that the material supplied by the online review can be directly linked to the courses offered here in the University of Oklahoma. For example the Statics section of the review can be related to the material presented in the online Statics class offered here on campus. In this way, users are provided with additional material to supplement the online review. Furthermore, since regular FIE review literature is used as a guide to develop the online review material, the format of the online review is in accordance to the actual FIE review and can be used to supplement to other review material.

2. Exam Review Web Site Organization

To help the user, the organization of the review web site (www.eml.ou.edu/fie) was split into both a morning session and an afternoon session as shown in Fig. 1. In the morning session 12 topics are covered, including Chemistry, Computers, Dynamics, Electrical Circuits, Economics, Ethics, Fluid Mechanics, Mathematics, Materials Engineering, Mechanics of Materials, Statics and Thermodynamics. The PM session reviews material that is specific for a given field of study, including Chemical, Civil, Electrical, Industrial, and Mechanical Engineering Exams. For the morning section, each of main topics are divided into subtopics that are called modules. Each module is made up of three sections, basics, examples, and problems. There are approximately 100 morning session modules, each with a basic review, example and problem section.

Users can access the review site from the main FIE page at www.eml.ou.edu/fie. Here there will be an option whereby users can decide to navigate through the site using either a Shockwave pull down menu created using Director 7 (illustrated in Fig. 1) or just using a direct HTML link (Fig. 3). Although the Shockwave pull down menu is more visually appealing, download time may become a factor especially for users with modems of 33.6 Kbps or slower. The HTML link, comprising only of text links, has essentially no download time associated with it. Users will have access to all the FIE review material regardless of which option is selected.

Fig. 1 Shockwave Pull Down Menu Option.

If a user elects to use the Shockwave pull down menu option, a menu will appear on the left-hand side of the review site (Fig. 1). This menu contains a complete listing of all the topics available for the review. Each individual topic has its own main page that appears once a particular topic is selected. As shown in Fig. 2, an additional menu list will appear at the top of the topic's main page, presenting all the modules that make up the entire topic. Simultaneous presentation of the topic's main page and the list of modules is made possible through the use of JavaScript. The user can then choose to review a particular module's basics, example or problems page.

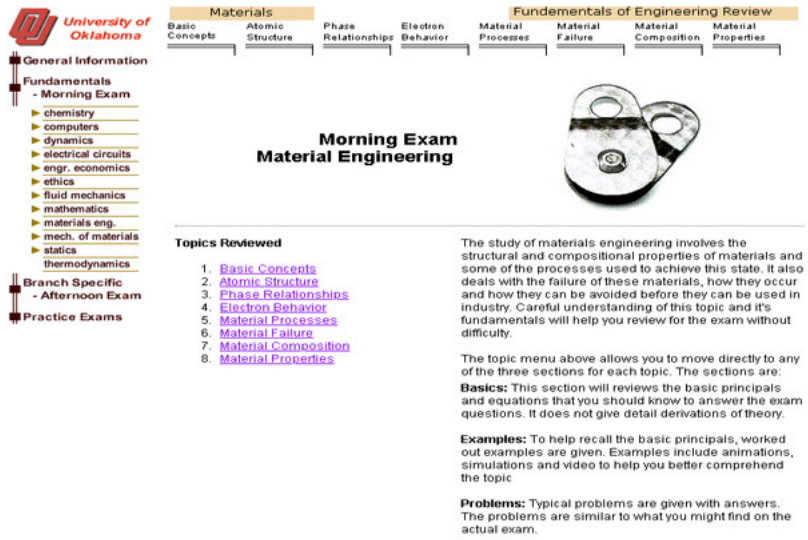

Fig. 2 Shockwave module list with Basics, Examples, and Problems link.

It should be noted that the size limit of each page in a module is set below 100 kilobytes to minimize download time for modem users, in particular users with 56.6 Kbps modems. In addition, the modules are designed to fit into a screen size of 800 x 600 pixels, which means most users can easily access the modules without needing to scroll sideways.

Figure 2 shows a typical main review page for the Materials Engineering module. The page begins with a brief introduction about the topic that is reviewed, providing users with an overview of the material presented. At the top is the list of review modules that make up the entire topic. The user can access any module's Basics, Examples and Problems page, by rolling the cursor over the module's title. In addition, users can also access the Basics page of any module through the use of text links listed to the left of the introduction paragraph.

As mentioned previously, the user has a choice between menu systems. The HTML type links are shown in Fig. 3. Similar to the Shockwave menu structure, the main menu is on the left and contains a complete listing of all the topics available in the FIE review. One more similarity is that the top menu contains a complete list of modules that make up the topic with the text links to each section, including Basics, Examples and Problems sections. Again, through the use of JavaScript, a topic's main page and its relevant list of modules can be shown simultaneously. Although the graphics for the list of modules is different for both the Shockwave pull down menu and the HTML link, users will have access to the same FIE review material.

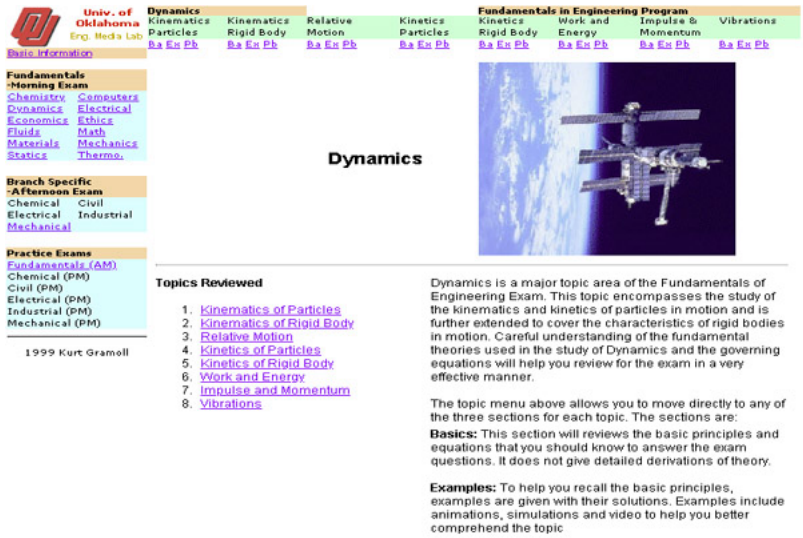

Fig. 3 HTML menu and module list

As seen in Figs. 2 and 3, by having each module divided into Basics, Examples and Problems, the information is fed to the user in a more sequentially organized manner. Starting with the basics page, shown on Fig. 4, the user can access the theory and equations and develop an understanding for the module. The animations in the Basics page (Fig. 5) will present the user with a visual representation of the engineering phenomenon as described by the theory to help improve the understanding of the user. The Examples page, illustrated in Fig. 6, will further improve user comprehension by solving two problems in a detailed manner. Finally the Problems page (refer to Fig. 7), will allow for the testing and application of the user's understanding on the module. This is done by giving the user an option of solving up to six individual problems related to the particular module.

2.1 Basics Page

The Basics page contains all the relevant information and equations pertaining to a particular module (Fig. 4). It should be noted that the material presented here is for the purpose of reviewing and not to teach an entire course. All equations are given without the detailed derivations as users are expected to know them beforehand. The material presented here is aimed at providing sufficient information on the particular module to enable users to successfully answer the exam questions. In addition to the text, this page also contains movie animations with audio narration, and graphics to further enhance and promote user understanding and interface.

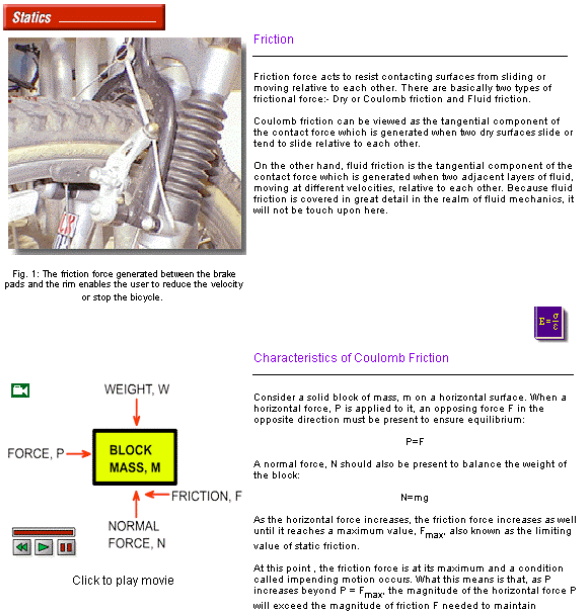

Fig. 4 Basics Page of FIE Online Review

Each page is constructed with graphics, movies, text, equations, and sounds. The layout is discussed in the following sections. The user can browse through the pages in sequence, beginning with the review of the material on the Basics Page, then proceeding on with the application of the material in the Examples and finally try problems on the Problems page.

2.1a Graphics and Movies

Graphics are obtained using either a digital camera, taken directly off the web, or created using existing graphics software. An image editing software is then used to perform any graphics editing as needed. After completing the preceeding steps, the final graphic is then exported as a Graphics Interface Format (GIF) or a Joint Photographic Experts Group (JPEG) image. Although other export formats are possible such as Tag Image File Format (TIFF) or Bitmap, GIF and JPEG formats provide the best quality with the smallest file size requirement. Also, web browsers best support graphics of both JPEG and GIF formats. The site also used Flash ShockWave files. Since Flash files are not pixel-based drawings but vector-based, graphics can be resized inside the web page by the user without the aliasing effects. This is particularly useful characteristic when a large amount of information is needed in a small area since it can be resized without loss of any details. In addition, the compression options available to Flash allows the file size to be kept at a minimum.

ShockWave movies included in the Basics page are also made using Flash 3.0. These movies are animations aimed at increasing the user's understanding by providing a graphical illustration of the information given by the text. The bandwidth required for ShockWave movies are low and hence the file size of the animations can be kept at a minimum while at the same time the quality can be optimized. This low bandwidth means that although a particular module has numerous animations, the download time will not be altered significantly.

Since graphics within a ShockWave Flash animation are vector-based type, the animation window size to be changed without the graphics being pixelated (chunky blocks of colors). By default, the size of the movie window is set at 300x240 pixels (please refer to Figure 5). In some cases, the movie windows are set larger to accommodate animations that contain a high volume of information.

The animations are activated by clicking on a simple, single frame snapshot of the movie as shown in Fig. 4. This picture, generally a GIF, is placed on the Basics page. When the user clicks on the pictures, a separate browser window is opened using JavaScript. The animation is then viewed through that window and not on the main page. This allows the user to view the main page content and the movie at the same time. It also saves download time for the main page since the movie is only downloaded in the separate window if activated. Each movie contains a play, stop, and rewind button, providing user control as shown in Fig. 5. In addition, all movies have a timeline indicator to inform users of the actual movie length. Once the Basics page has been reviewed, users can then proceed to the Examples page using the menu or via an icon located on the Basics page.

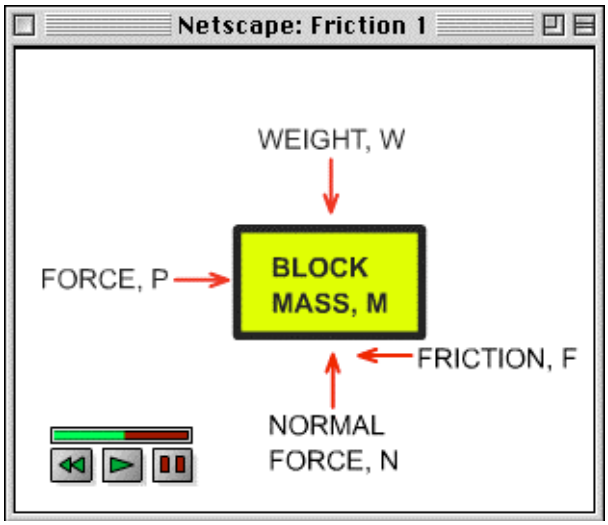

Fig. 5 ShockWave Animation

2.1b Text and Equations

The FIE review material was designed to be used on both the Windows and Macintosh computers. One of the difficulties faced with making the material cross-platform is with the font sizes. The text of a specific font size when viewed using different platforms will produce different results. The same problem, present in the text creation, is also evident in equation editing. After careful research on the possible solutions to this problem, it has been decided that the combination of font sizes used in this review site will be optimized for Windows playback, although computers of a different platform can also be used.

2.2 Example Page

The Example page contains two complete example problems that are worked-out in a detailed manner (Fig. 6). The purpose of this section is to provide the user with an in-depth explanation on how the theory is applied to problem solving.

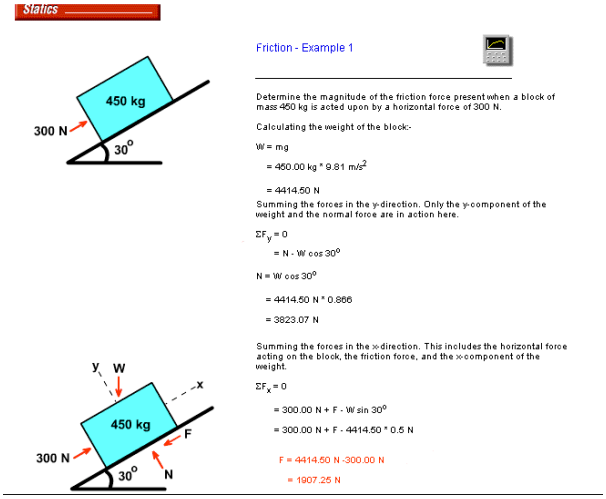

Fig. 6 Examples Page of FIE Online Review

For each example, the relevant theory and equations from the Basics page are applied to a particular problem. In this way, the user is given a comprehensive look on how the equations are utilized. Here the user has the option of testing out his own comprehension of the theory by working out the example problem or just simply review the example problem that is worked out to further improve his understanding.

Each example is carefully worked out in detail. This includes all the relevant diagrams, theory and equation application and the derivation process of alternative equations used. The text of the final answer is designated in red.

A link to a simulation is available on the Example page for some topics. This simulation is created using Macromedia Director 7 and is exported as a Shockwave movie. Again by exporting the simulation in this format, the file size can be minimized while at the same time the visual quality of the final product is optimized.

The purpose of the simulation is to provide some form of user interactivity. Furthermore the simulation also allow users to visualize certain engineering phenomenon as described by the theory, hence increasing their understanding. By allowing users to edit certain numerical parameters within the simulation, they can observe the effects and establish certain engineering relationships associated with the edited parameters.

2.3 Problems Page

Final portion of each module of the online review is the Problems page. In this page, there are 6 problems presented to allow the user to test his understanding of the theory as shown in Fig. 7.

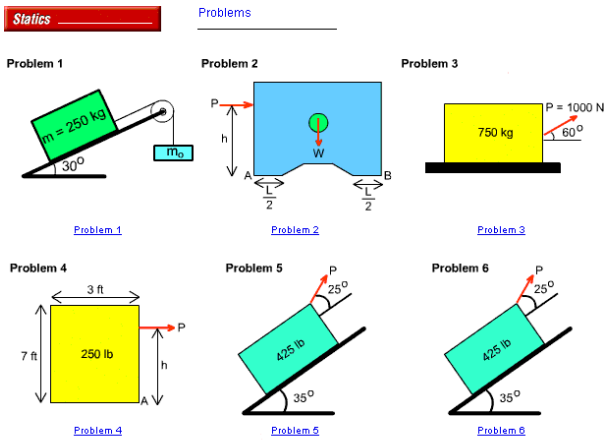

Fig. 7 Problems Page of FIE Online Review

A snapshot picture of each of the 6 problems are placed in a 2 x 3 table. These pictures are linked to their respective set of questions and each question appears in a separate pop-up window. All questions are accompanied by a choice of four answers that the user can select as illustrated in Fig. 8. Each correct answer comes with a step-by-step derivation, together with their respective graphics, and is presented in a detailed and organized manner (Fig. 8).

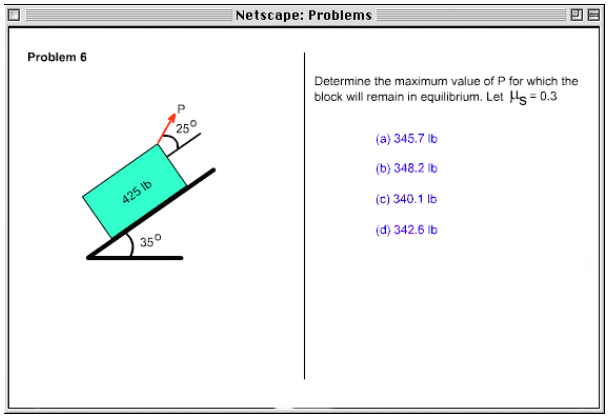

Fig. 8 Pop-Up Window of Individual Problems

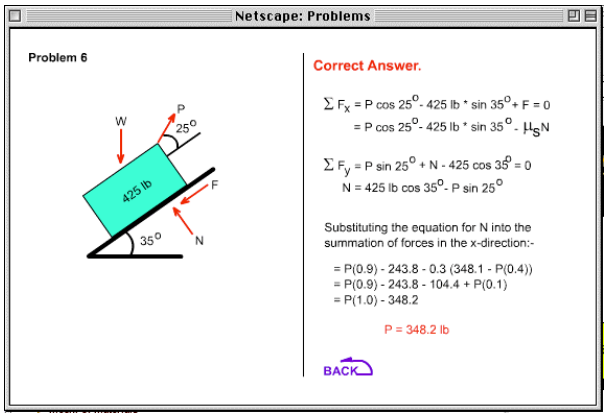

Fig. 9 Solution of Individual Problem

Like the animations in the Basics page, each question is made using Macromedia Flash 3.0 and exported as a ShockWave movie. The size of the pop-up window is set at 560x360 pixels. Again, the size of the window is resizable as the graphics, text and equations of the questions are vector-based drawings.

3. Online Exam

Currently, the online exam presents the users with 10 problems to solve, which is less than the 60 problems in an actual exam (future work will add additional problems). The 10 questions are randomly generated so that there are different problems each time the user visits the test site (Figure 10). The main purpose of the online exam is to supplement the material in the review portion on the program and to familiarize users with the format of the actual FIE exam. When the web site is completed, each module will have a database of 14-18 questions that will be used to generate a full 60 question exam. The entire exam will have a combination of questions from every module and every attempt will be made to approximate the online exam as close as possible to the original FIE exam.

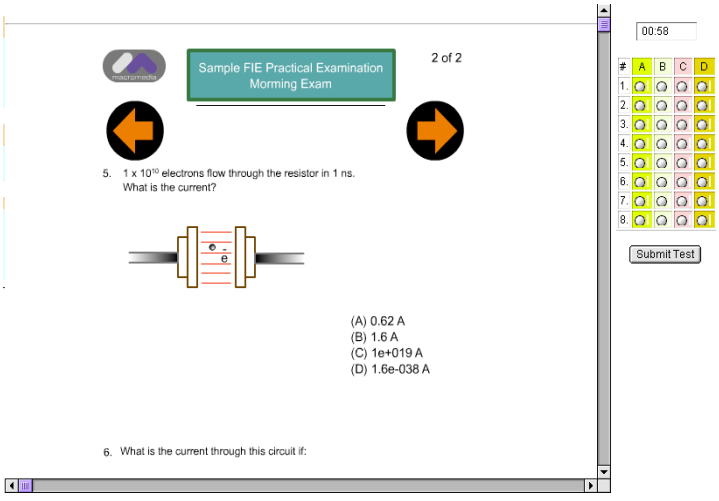

Fig. 10 FIE Online Practice Exam

The problem generation portion of the exam is made possible by a software called Flash Generator by Macromedia, which allow graphics to be generated dynamically. Once a user arrives at the online exam site, a Common Gateway Interface or CGI generated login page will be presented. Here the user will enter his personal identification and password. If the user is there for the very first time, a separate screen will appear in which the user can obtain a new login identification and password.

Common Gateway Interface (CGI) is an Internet term referring to programs or scripts that perform certain functions i.e., searching for files or running applications, when the user clicks on certain buttons, icons or parts of the Web screen. The most common authoring language for CGI is known as Practical Extraction and Report Language or PERL [4].

Upon entering the site, the user has the option of beginning the exam or if the user is revisiting the site, he can choose to view exams previously taken by him. While reviewing the previous exams, the user is presented with the correct answers as well as the answers submitted by him. This allows result comparison and mistake identification to be carried out by the user. The overall score for each exam taken will also be displayed to the user.

Once the user is prepared to attempt the exam questions, he or she will be transferred to a new site to begin the exam. All exam questions are generated using Perl scripts and are presented in sets of four questions each. Perl scripting is also responsible for providing the relevant graphics and list of solutions to each individual question.

The relevant equations pertaining to the solution of an exam question is made in terms of variables rather than fixed numbers. The variables are then set to correspond within a range of numbers. This means that a large number of exam questions can be created. Again through the use of Perl scripts, different sets of questions will be assigned to each user despite the number of users present at any given time.

All questions for the online exam are also randomly generated via Perl scripting. This will ensure that users will continue to be challenged each time they attempt the exam as the questions posed will be different from that encountered in the previous exams. Furthermore, the sequence of answers displayed are also randomly generated to further challenge the user should a question be repeated at random.

Although there is a specific equation that generates the right answer for each question, an alternate equation will also be used to avoid generating and displaying obvious wrong answers. This method will help ensure that users are always required to be careful with their calculations and solution steps leading to their answers.

Through the use of CGI, a timer will be present to monitor the time taken by each user and will automatically terminate the exam once the time limit has been reached.
On the other hand, if a user successfully completes the exam within the allocated time, a submit button can be used to end the exam.

The set of correct answers corresponding to each exam is prepared through the use of Perl scripting. Once the exam has been completed, the submitted answers will be compared with the set of correct answers via CGI. Both the submitted and correct answers will be displayed together with the overall score.

It is hoped that the online exam will provide the necessary feedback needed to verify the validity of the material presented in the review. In addition the feedback from the online exam will also be used as a source of reference to assist in enhancing the quality of the existing FIE material.

4. Summary and Applications

Distance learning has a broad application potential and the FIE online review is just one such example. The concept of distance learning and its ever-broadening technology can be implemented in many different areas of education as well as business and engineering industries alike.

Companies with a need to train their employees in new industrial application methods can make use of distance learning technology in the form of online tutorials. This method not only saves time but also manpower as it makes use of the online tutorial material to handle the teaching. Furthermore by having the tutorial online, the need for huge volumes of handouts can be discarded, thus reducing cost in the process. In addition, personnel trainers are now free to assume the role of guides and to attend to the individual needs of the trainees, thereby optimizing their capabilities and resources.

By having the tutorial online, all relevant information needed is always available long after the training period has ended. The online tutorial now performs the function of a refresher course. Furthermore, the content in the online tutorial can be updated and edited constantly to keep up with ever changing requirements.

The same application of this method in the field of education allows teachers to focus more on the student-teacher interaction instead of just merely imparting knowledge upon the students. In this manner, teachers can help improve the quality of education by assisting students in improving their understanding of the material being thought. At the same time, this method may also help to alleviate, to some extent, the problem of high student-to-teacher ratios, which are evident in some educational institutions.

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