DEVELOPMENT OF COMPUTER BASED EDUCATIONAL MATERIALS THROUGH THE NORTH CENTRAL COLLABORATION FOR EDUCATION IN NDE

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INTRODUCTION

The North Central Collaboration for Education in NDE/NDT (NCCE) is working to develop computer based educational materials as part of a project to enhance NDE education. The NCCE is a cooperative effort between Iowa State University, and four community colleges with two-year NDE technician education programs. The two-year institutions participating in the program are Cowley County Community College in Arkansas City, Kansas; Ridgewater College in Hutchinson, Minnesota; Northeast Iowa Community College in Peosta, Iowa; and Southeast Iowa Community College in Milford, Nebraska. The three-year program is aimed at enhancing education in nondestructive evaluation and improving articulation between community college technician training programs and university technical degree programs. Each of the collaboration members has responsibility for the completion of an education improvement project, which has been selected for its widespread appeal to NDE educators. Many of the efforts to improve NDE education have evolved into the development of computer-based materials and tools. This paper will discuss the rational for these development efforts and report on progress.

NEED FOR EDUCATIONAL MATERIALS IMPROVEMENT

Much of the material used to educate students at grade levels beyond primary school is largely text and lecture based, which have significant limitations. While reading is a very important learning mode, not all students learn effectively from reading. Some students respond better to visual and audio stimuli of lecture but often get lost in the material or lose interest in the presentation. In this type of a learning environment, students have limited opportunity to ask questions or may be uncomfortable asking a question in front of the class. It is well known that many questions go unasked. A better and increasingly more common way that teachers are addressing some of the weaknesses that some students have in their knowledge base is through classroom discussion. Students may posses different pieces of knowledge and often answer each other's questions. When several students are

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unsure of a concept, they are more likely to ask for assistance from the teacher. This social component of learning is very important according to education experts.

Another problem with older text and lecture based methods is that they were almost completely based on the concept that knowledge was analogous to a set of building blocks. One piece of knowledge is learned, then another and another. The method of learning was largely memorization and few other learning skills or problem solving skills were developed. It is true that everything that a student learns must build upon prior knowledge. However, all students learn at different rates and all bring to a class a different level of prior knowledge. Also, students often only remember portions of what they have previously studied and commonly have misconceptions about what they have learned. In a lecture, an instructor cannot simple teach to the middle of the class because students at the lower end will be lost and students at the upper end will not be challenged. Starting with material that is best for students at the lower end, penalizes the upper 2/3rds of the class.

Cognitive researchers also report that learning is closely tied to particular situations. The knowledge that is gained in one situation is not as easily transferred to another situation as one might think. If a student is taught a basic scientific principle, such as wave propagation, but not taught how this principle applies to everyday life; they will have difficulty drawing a relationship later. Making a connection to real-world situations is a major focus of much of the recently developed educational materials. The challenge is to maintain intellectual rigor while providing students experiences that relate to real-world applications.

Today, it is known that there is much more to learning than just the accumulation of many little bits of information. Learning skill and problem solving skills are arguable the most important products of the education process. Students must learn to investigate, experiment, relate information and draw logical conclusions. The learning process is much improved when students are challenged to seek answers and are driven by a curiosity to learn. In addition, students should individually be able to select the level of material that is best for their knowledge level. They should also be able to conveniently review previously studied materials to refresh their memory and correctly construct their knowledge base. Finally, the learning environment should be one that includes a mix of teaching methods and provides some entertainment value to hold the students' interest.

BENEFITS OF COMPUTER-BASE TRAINING

Computer technology introduces much new capability to the teaching process and overcomes many of the limitation of text and lecture-based learning. One of the major advantages of computer based education is that it can provide an environment that encourages students to explore and experiment. This leads the student to learn through the process of self-discovery and constructionism, which are the most efficient and long-lasting mode of learning. In a presentation at the 1997 American Society for Nondestructive Testing Fall Conference, Richard Bossi of the Boeing Company noted that studies have shown a 50% improvement in information retention with a 38-70% increase in the speed of lesson completion using CBE materials. [2] When students are actively seeking information and are curious about the answer to a question, they are more likely to remember what they have learned.

Computer based education materials can combine text, graphics, audio and video to address all modes of learning. CBE can include animations and interactive tasks that can better illustrate and explain the concepts being taught. The animations and interactions

also help to hold the student's interest. With the immediacy of results from interactive applets and other computer tools, a student can attempt different scenarios to experience a variety of situations in very little time. Simulations can be done that would otherwise be too costly or time consuming to do outside the computer environment. In addition, since there is very little risk involved in doing something dangerous or producing an incorrect result in a computer environment, students can be given complete freedom to experiment. This not only improves the learning process as mentioned above but also helps students to overcome their fear of failure. They learn that it is okay to be wrong when it is part of the learning process.

The materials can easily be packaged such that the student has access to both very basic information and advanced materials. Since computer based education is largely self-paced, students can spend as much time as necessary to understand the material. Some student may need to spend considerable time understanding basic information. Other students may move quickly through the basic information and focus their time on the advanced materials. With embedded links and pop-up windows, a student can easily get to the support information when needed. Those students that have a solid knowledge foundation to build-on can choose to ignore the support material. New terms that may be difficult to find except in special scientific dictionaries and would normally go undefined can be easily introduced with pop-up definitions.

Another advantage of computer-based materials is that the information can be easily updated and made widely available. Materials can be continually updated to keep instruction current and easily restructured to meet changing needs. By making the materials web-based or at least downloadable from the Internet, students can have immediate access to the very latest updates. As the materials are used, suggestions for improvement from educators and students using the material can be incorporated to increase the effectiveness of the material.

Since computer-based materials can be transferred with ever increasing ease, they are finding much use in the area of distance education. Many post-secondary schools are trying to reach more off-campus students and are using methods such as video, television and Internet courses. Since computer equipment is almost always available at remote teaching sites and other laboratory equipment is almost always absent, computer-based materials are being used to provide off-campus students with some interactive learning activities. Some of the computer simulation programs can serve to partially replace lab exercises. Simulation programs can also be used on-campus to replace some lab activities, improving learning, reducing equipment requirements and cutting laboratory consumable expenses.

NCCE COMPUTER-BASE EDUCATION IMPROVEMENT PROJECTS

NDE Inspection Simulation Models

One of the projects being worked on by NCCE is to introduce NDE inspection simulation modules into the classroom. Iowa State University has worked for a number of years on the development of computer NDE simulation programs primarily as engineering problem solving tools. These programs allow physically accurate NDE inspections to be simulated using a computer aided design (CAD) model of a part. Three simulation models have been developed by ISU, one each for x-ray, ultrasonic, and eddy current inspection. The x-ray radiography inspection simulation model (XRSIM) is the first being developed

into an education program. The program was developed on a workstation platform and had to be ported to a personal computer to make it usable in more college classrooms. The program was first modified to run on a PC in a Linux operating system so the collaboration participants could start using the program. The code is currently being rewritten to run in a Windows95 environment and to add a 3D graphical user interface. This version of the code will make the program transferable to virtually all college classrooms and the 3D graphic greatly improve the "realness" of the simulation.

Using XRSIM, the student must first set-up a shot by loading in a CAD model of a part, position the part relative to the x-ray source and the film, and select the x-ray generator and film type. The student must then adjust the generator settings and the exposure time to produce the desired exposure. Once the part set-up and generator setting selections are complete, the program generates a simulated radiograph in only a few seconds compared to twenty or thirty minutes when film developing is involved. The student can view a number of simulated radiographs at once so that side-by-side comparisons are possible and a densitometer feature allows students to collect quantitative information about the images.

The other part of this task is the development of instructional material that will allow the program to be used effectively in a classroom setting. Materials have been written for ten x-ray inspection exercises that collaboration participants have identified as being of highest interest. These training modules include a demonstration of the effect that kilovoltage has on image contrast; the development of exposure charts; calculation of time, distance, and amperage; calculation of radiographic density conversion; and a demonstration of defect to source relationships.

The benefits of replacing a portion of the student's hands-on laboratory activities with simulation exercises include improved learning, reduced learning time and cost savings. One of the main advantages of the program is that it provides a hands-on learning environment were results are produced very quickly. The ability to produce quick results is important for several reasons. First, it will allow instructors to expose students to a greater number and variety of problems and allowing the students to discover the effects of variables for themselves. Quick results also reduce the many distractions unrelated to the primary learning exercise that can confuse the results and even the purpose of the exercise. Results are not complicated by unnecessary variable such as film processing artifacts. The simulator also records all the variables used to produce images. This allows the instructor to quickly trouble shoot problems that students are having with their exercises.

Since the program uses a CAD model and does not require a real part, inspections can be simulated that would be impossible or too costly to develop outside of the computer environment. Flaws of various shapes and sizes can be easily introduced into the CAD model to produce a sample set for probability of detection exercises. Use of the program will also save money because students can make all the usual mistakes while learning the basics, and correct them before actual exposing film. In addition to reducing consumable costs, the use of the simulator could reduce equipment costs since the students will spend less time using expensive x-ray systems.

Radiographic Film Viewer

Another of the computer-based education product being developed is a radiographic film viewer and image set. The film viewer is a Java applet that will display 12-bit digital radiographic images. The viewer will have the capability of adjusting the backlight intensity so the user will be able to best view the image details of interest. The viewer is

also being developed with a magnifier feature that will allow sections of the image to be viewed at two-times magnification. The viewer will display any radiographic image in a TIFF format.

The image set is being produced from a collection of the radiographs used in the NDE programs of the collaborating institutions. The radiographs are being scanned using a high quality, commercial radiograph scanning system. The digital image files will be distributed on a zip drive or CD. The viewer and a few sample images will be available over the Internet.

Students will benefit from having a much larger set of images to practice radiograph interpretation. Another benefit of the project is that there are no film storage issues associated with digital images. Without special handling and storage, film radiographs lose their image quality quickly and they need to be reproduced on a regular basis.

Internet Educational Materials

Collaboration participants are also working to compile and present NDE information in the form of a course over the Internet. The project is organized along the outline of SNT-TC-1A [3] but incorporates much more of the scientific principles that drives NDE than is currently included in most NDE courses. The material targets students in community college NDE programs but also includes advanced material that is well beyond that normally included in a two-year program. An important feature of this material is the interactive Java applets that have been included to better illustrate key concepts. The applets are interactive allowing student to experiment. Some of the applets serve as very simple simulators that allow students to experience performing an inspection and to see what the results should be produced. The applets also serve as calculators for commonly used NDE formulas. Since the site will be a source of up-to-date information, it will also serve as a resource for technicians, engineers and managers working in industry. The Internet site also serves as a distribution mechanism for the collaboration as materials developed by the other participants are being incorporated into the course. For example, tools such as the radiographic film viewer discussed above will be worked into the material to make them widely available for use. The first module, on ultrasonic inspection, is drafted and on the Internet. Comments are being collected from educators and material experts from around the world to make the material more effective. The course can be found on the Internet at "http://www.cnde.iastate.edu/ncce/Intro_CC.html."

Materials for Junior and Senior High School Students

The fourth computer based education project being worked on by the collaboration is the development of materials for junior and senior high school students. These materials will explain the basic scientific principles used in NDE while subtly introducing students to the field of NDE. The impetus for this project was that NDE instructors wanted materials to make students at the high school level aware of NDE as a career field for recruitment purposes. The National Science Foundation, on the other hand, was not interested in recruitment materials but were interested in funding projects to improve math and science education at all levels. Therefore, it was decided to develop materials that would do both. By focusing on explaining basic scientific principles, and not solely on NDE, the material will have wide spread appeal to science teachers and reach more students.

Through a series of workshops with high school educators and career counselors, it was learned that students often make course selection decision at the junior high level that affect their future options to pursue careers in science related fields. Efforts to increase the

pool of students who are prepared to pursue a college education in science, engineering or technology must begin at the junior high levels. The type and quality of science and mathematics educational experiences at the junior and early high school levels are major factors in students liking science. The educational materials need to be made more interesting at an early level when students are making decisions about whether to take additional science and math courses. It was suggested that the material be made suitable for students at the junior high level. Teachers felt that the material could be produce in a way where it would be useful to a number of grade levels. Teachers at the junior high level may only use parts of the material but like having the more advanced material available to challenge top performers. Teachers at the high school level like having the basic materials included to refresh the memories of their students and make sure all understand the basics before attempting the more advanced concepts. The teachers also suggested making the material as entertaining as possible for all levels of students.

The objective of this project is to develop and widely distribute multimedia materials that teach scientific principles and make a connection with real-world uses in NDE and other areas. An important goal of this project is to deliver a suitable curriculum that will stress the importance of math and science, and at the same time increase the student's awareness of NDE as a career option. The subjects included in the materials include sound, radiation, magnetism, electricity and capillary action. These subjects correspond to the following NDE inspection methods; ultrasonic, radiography, magnetic particle, eddy current, and liquid dye penetrant.

The "learning cycle approach" was used throughout the material. Pictures, video and other media are used to gain the students' attention and get them thinking about why the concepts being taught are important. Next, interactive experiments let the students explore and observe the behaviors of things such as magnetic and sound energy. The students are asked questions that query them about what they observed in the experiments before explanations are offered in a discussion section. Talking characters are used to help the students get through long sections of text. The students are asked to apply the principles learned by performing an NDE inspection to finish the lesson.

The first lesson on magnetism is complete and posted on the Web at http://www.cnde.iastate.edu/ncce/titlepage.html. Feedback from educators on this material has been very positive. NDE instructors have commented that the materials may even be useful to some students in the NDE technician training programs. The second lesson, which covers sound, is nearly complete. Additional workshops are planned to review the information and further refine it. Once all lessons have been developed and evaluated, the material will be made freely available on CD, in addition to over the Internet

SUMMARY

The North Central Collaboration for Education in NDE/NDT is developing a number of computer-based training materials that will speed learning, and improve comprehension and problem solving skills. Advanced computer technology is being used to overcome many of the limitations of past teaching practices. The primary goal of this project is to enhance learning in NDE technician training programs at community colleges. However, materials are being developed for the benefit of students at the junior high and high school levels. Much of the material will prove useful to students in NDE programs at universities and to NDE practitioners working in industry.

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