

## Computer-based Teaching and Assessment in Topics on Basic Physics

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### Abstract

This paper describes an experience in computer-based teaching and assessment in three topics in basic physics. A module is developed for each topic using the Authorware courseware authoring tool. The first module is on fundamental particles, the second on binding energy, and the third on atom density calculation. These modules are also installed on the web.

Each module has four components: 1) definition, 2) example, 3) review questions, and 4) quiz. Students can see their performance on review questions interactively and have the option to repeat them, and receive on-line feedback on their score. Similarly, their performance on a quiz is evaluated on-line and feedback is provided to them. In addition, their score on each quiz as well as the time they spent taking the quiz are sent back to the instructor and stored in a permanent file. The courseware provides an overall assessment, in graphical format, of the average performance of all students who took a quiz, as well as each individual student's performance. These modules are taught as supplementary parts of a course in Fundamentals of Nuclear Engineering at the University of Missouri-Rolla Nuclear Engineering Department. The experience has been positive with more than 80% of the students supporting the value of the interactive and self-pace learning of these modules.

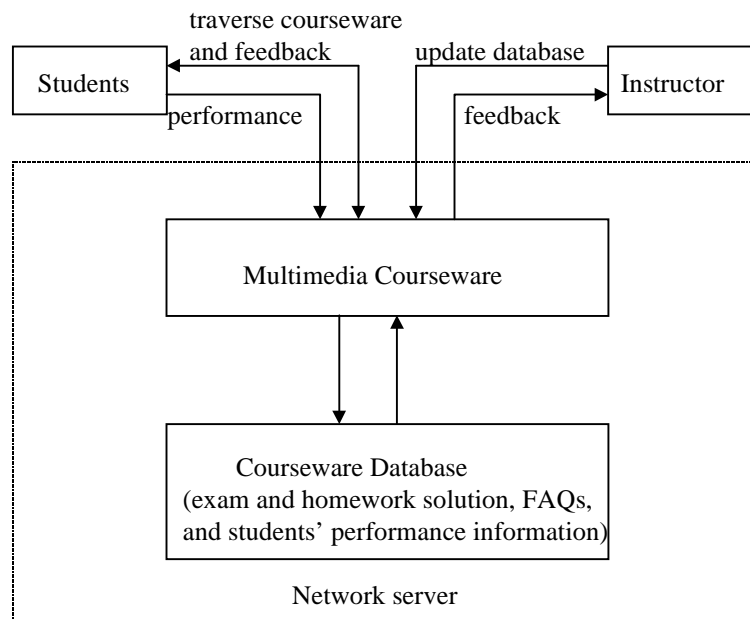
### 1.0 Introduction

Computer-based instruction, incorporating interactive multimedia and network technologies, provides a powerful method to boost teaching effectiveness and student learning rate. In contrast to simple sequential text instruction, computer-based interactive multimedia courseware presents information as a combination of text, graphics, sound, video, and animation. The visual learning environment, the hyperlink capability, and the self-pace learning of interactive multimedia courseware hold great potential for significantly enhancing students' learning and retention of presented material, and stimulating interest<sup>1-6</sup>.

To provide the students with these benefits an interactive Multimedia Courseware (MC) is developed in which three modules in basic physics, Fundamental Particles, Binding Energy, and Atom Density are included. MC is helpful for both the students and the instructor. Students can learn complex and abstract material in a concise, visual, and interactive fashion. The instructor can stay informed of students' strengths and weaknesses based on their performance and feedback questions. This paper describes the components of a computer-based authoring tool and the experience in utilizing them in teaching topics on basic physics<sup>7-8</sup>.

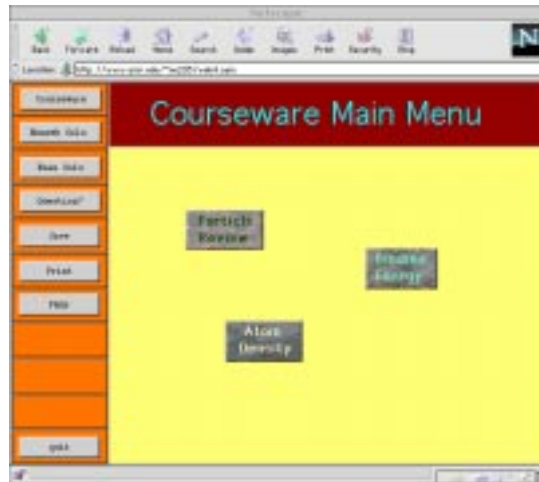
## 2.0 Multimedia Courseware Description

Multimedia Courseware is originally developed for Macintosh using Macromedia Authorware version 3.5 software<sup>9</sup>. It is installed on the nuclear engineering department's Novell Network server which allows students to access the software at any time from virtually any location on campus. After development it is installed on the web using Schockwave and Afterburner software. Figure 1 provides an overview of the structure of Multimedia Courseware. MC assigns different rights to instructor and students based on login information. Students can traverse all the MC modules content and have the right to access appropriate databases, such as frequently asked questions (FAQs), and solutions to the homework and exams.



**Figure 1.** MC structure

A student can not access the scores of other students. However, the instructor can access detailed performance information for each student. Students and the instructor are presented with different menu bars granting them access to different functions and information. Figure 2 shows the three modules on fundamental particles, binding energy and atom density. In an effort to parallel the effect of traditional classroom education, an on-line communication facility is included. Students' on-line questions can be dropped directly in the drop box of the server and the instructor can respond by e-mail or by adding the answers to the FAQ database for the common use of students. When there is a new question by a student, the instructor receives a warning message in both text and sound format.



**Figure 2.** Main menu of MC

It is challenging but critical to design each module such that it will be an effective learning tool, yet one that is not monotonous and dull. To address this challenge, each module is designed with four parts: basic concepts and principles, examples, review problems, and a quiz in a “tutorial-style”. Figure 3 shows the main menu of each module. Basic concepts and principles are presented first. Students may proceed sequentially or skip ahead to more challenging material depending upon their individual learning rate. Figure 4 shows the format of a typical example in each module.

One major advantage of computer-based training over simply reading a textbook is the ability to connect related concepts with hyperlink or “hot text”. Hyperlink is simply a text that is highlighted, uses a different color, or is otherwise offset from normal text, and when clicked with a mouse or other pointing device brings up an explanation of the highlighted text or takes the user to another screen which is related to the highlighted text. Hyperlinking inter-related material makes it easy for users to quickly review or learn other concepts that are essential to the subject matter that they are currently learning. Using hyperlinking is especially important for MC design. For example, as shown in Figure 5, the three primary interactions of gamma ray, Compton scattering, photoelectric effect, and pair production are explained using a combination of text, equation, graphics, and hyperlink.



Figure 3. Main menu of each module



Figure 4. A sample of examples in a module

As students proceed through the training modules, it is important for them to interactively participate in the learning process in such a way that they are apprised of their mastery of the material. If they simply navigate through a multimedia module without interacting and receiving this important feedback, it is unlikely that they will benefit significantly from having done so. With this in mind, each module makes use of multiple-choice review questions immediately following each topic. A time limit is set for each question, and the student is allowed to change his/her answer until the time limit expires. Figure 6 shows an example review question. Based on the final score of review session or quiz session, the student is encouraged to proceed or review certain topics ( Fig. 7 ).

It is, of course, important to the instructor to be apprised of students' performance and this software makes it easy to do just that. In addition to other useful information such as number of times a student uses the system, MC compiles the results of individual student's performance on the review questions and quizzes in the modules.

The quiz questions are also timed but, unlike the review questions, students cannot change an answer once entered. Students may, however, re-enter the system and retake the entire quiz again, in which case only their highest score is recorded for review by the instructor. This creates motivation and incentive for the students to utilize the modules and learn the subject matter.

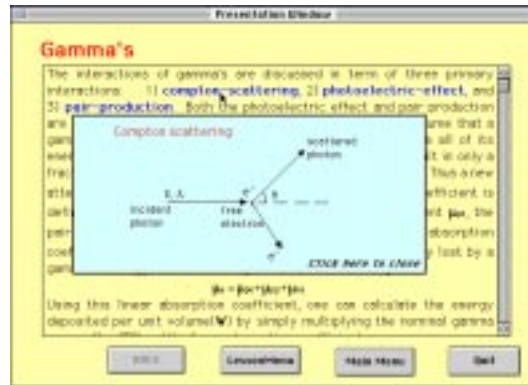


Figure 5. Cross-reference information

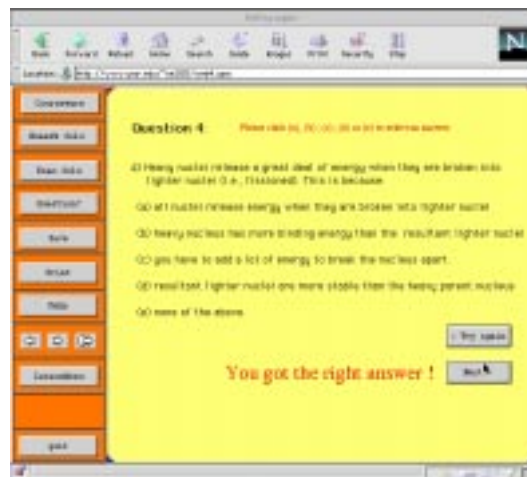
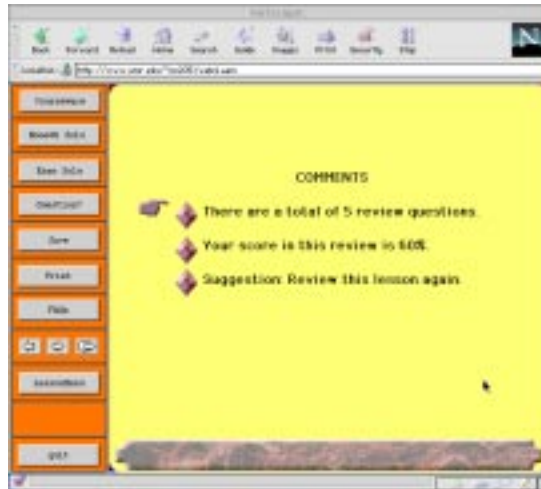


Figure 6. An overview of a review question structure



**Figure 7.** Score and feedback on review questions

### **3.0 Assessment and Feedback**

While computer-based instruction is generally regarded among educators as innovative, a more important consideration is the impact on the students who use it. They can actually know how well they are doing on each topic, thus they can concentrate on the area needed to catch up. Questions can be sent directly to the instructor, instead of stopping by the instructor's office during office hours or completely forgetting what to ask after a couple of days of putting off an office visit. Answers to electronically submitted questions can be quickly obtained by e-mail or from the frequently-asked-question database.

The survey concerning the MC was conducted in a "free-form" manner. The information obtained from the survey indicates that 80% of the students found this courseware to be quite helpful to them. Students indicated that the software was easy to operate, convenient, time limits were appropriate, etc. An added benefit realized from developing MC is that it encouraged the students and faculty to work closely to achieve a common goal, that is, to enhance the learning of the subject matter.

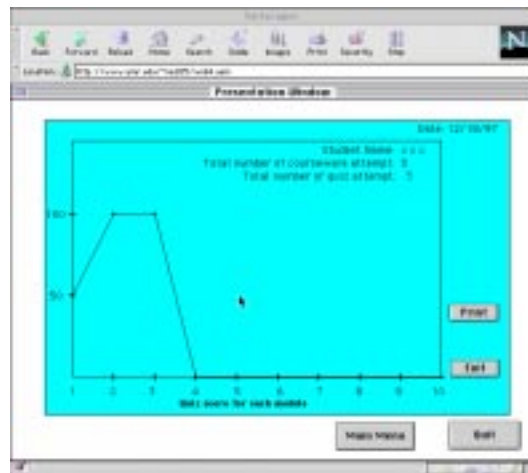
A major benefit of this system is that MC apprises the instructor of students' performance. The activity of each student is presented to the instructor both in the form of text and graphics. The courseware also presents the performance of all students for each module in a graphic format. Figure 8 is an example of the assessment mechanism of the MC in a graphic format for each individual student.

### **4.0 Conclusions and Further Work**

After two semesters experience with the MC, it is concluded that computer-based multimedia courseware is a successful and effective educational tool. MC has allowed the students to

concentrate on learning the content in an invigorating environment, instead of the sequential presentation of a traditional textbook. Traditional classroom instruction is simulated by using an interactive model, quizzes, and on-line communication between faculty and student. The self-paced learning, cross-reference information, and a vivid interactive mode has helped the students grasp the content with ease. At the same time, feedback information provided by the MC has given the instructor the ability to customize the in-class instruction to the particular needs of the class.

Further research work is in progress. An interactive problem solving mechanism which can handle both multiple choice and digital entry has been developed. A new algorithm using fuzzy logic techniques, which can simulate a grader and give partial credit for a partially correct solution, is under development.



**Figure 8.** Assessments of MC on individual student's performance

## 5.0 Acknowledgements

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## 6.0 Biographies

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