Interactive Multimedia: An Alternative to Manufacturing Laboratories

Thomas J. Crowe, Elin M. Wicks, and Herman Budiman
University of Missouri - Columbia

ABSTRACT
To ensure the continuation of important laboratory experiences, a new approach to manufacturing process laboratories is undertaken. A multimedia software package is being constructed to allow students to explore a virtual industrial park. The industrial park is composed of five virtual companies: a machine shop, a welding shop, a materials lab, a sheet metal shop, and a foundry-forging company. Through an interactive and non-linear presentation students may visit any or all of the companies. Within each company students may meet the employees, examine the products, investigate the manufacturing equipment, explore the manufacturing processes, and scrutinize the underlying theoretical manufacturing principles.

INTRODUCTION
Almost without exception Industrial Engineering, Mechanical Engineering, Engineering Technology, and Vocational-Technical Education undergraduate curricula include a required course covering the theoretical and practical fundamentals of manufacturing processes. Often described as the oldest of all engineering courses, these courses attempt to teach topics such as machining, welding, forming, casting, forging, and materials analysis. These manufacturing courses are generally structured in the traditional engineering lecture-laboratory format; that is, several subject-focused lectures followed by an associated hands-on laboratory experience. Student participation is usually minimal in the lectures but emphasized in the laboratories.

In recent years, however, the balance between the passive lectures and the active laboratories has been changing. Manufacturing process laboratory equipment is becoming increasingly expensive to acquire, update, and maintain. As existing equipment becomes outdated and inoperable, more of the instructional load is shifting to the lecture portion of the courses. Unfortunately not only is the laboratory experience being lost, but it is being incrementally replaced by more of the student-passive lecture medium.

There are documented cases of universities choosing to spend large sums of money to upgrade their laboratories and there are documented cases of universities begrudgingly choosing to eliminate this topic from their curricula. We believe the ideal would be to keep and, in fact, enhance the topic without the large expenditures. To address these deteriorating conditions we are using the multimedia virtual industrial park.

GOALS AND OBJECTIVES
The goals and objectives of developing a multimedia software package to allow students to explore a virtual industrial park are:

• To use information technologies to improve instruction by promoting student–active hands–on learning experiences;
• To broaden the educational impact on students and professionals in instructional programs by developing a package that has the potential for widespread use in many educational settings: undergraduate university courses, extension education, secondary-school practical-arts classes, community college courses, corporate retraining, apprentice training, and equipment vendor instructional programs;
• To increase the safe accessibility of manufacturing laboratories for students with all levels of physical abilities;
• To develop a commercially viable software package that can be used at any location either via the World Wide Web or through stand-alone CD-ROM installations.

GENERAL APPROACH
As used with personal computers, multimedia is defined as a combination of text, graphics, animation, and video that is controlled, coordinated, and delivered to a computer screen³. Visual materials developed in combination with text can help overcome difficulty of retaining information⁴. According to Jonassen², because an individual’s knowledge structure is unique due to unique experiences and abilities, the ways in which individuals prefer to access, interact with, and interrelate information is also distinct. Students should be encouraged to explore information and restructure it in ways that make more sense to the learner². For our multimedia software package we are going one step further into multimedia and hypertext - we are creating a package in a non-linear format which allows the user to explore the information within the program in any order and at their own pace.

THE VIRTUAL INDUSTRIAL PARK
Over the past year we have successfully storyboarded, designed, and implemented what we call the skeleton of our system. Some would call this skeleton the “theme” of the package because it formalizes and implements the backbone of the package, striving for a consistent look and feel with a common presentation thread. In addition to collecting, processing, and programming the images, drawings, audio, and video of general items of the industrial park (items not specific to any one of the five virtual companies), the skeleton determines how the user will interact with the package.

The following paragraphs illustrate the theme of the program. This software package is modeled after an industrial park. The virtual industrial park consists of five major companies: a machine shop, a welding shop, a material lab, a sheet metal shop, and a foundry-forging company. Within each company, the student may investigate the manufacturing methodology. For example, in a machine shop, the student can learn about drilling, milling, or turning (lathe). Going down another level, the student may explore the equipment, tools, operations, products, and theory for each methodology.

From this level onward educational information becomes more detailed. In the drilling equipment division, for example, a list of images of all types of drilling machines is displayed. The image list enhances the student’s interest in learning more about a specific topic and it helps the student to identify particular machines. As the student selects one machine (e.g. horizontal drilling machine), the program will display a larger image together with explanatory text and voice over about a particular machine. Sometimes a video is included for a more complex
illustration. This way, the student can really investigate as if she/he is in a real laboratory. The program certainly does not end at this level. There are many more levels deep into the program depending on each topic. In our previous example of drilling machine, the student can continue to learn more about a specific part of the horizontal drilling machine, such as motor, belt, etc., again complete with image, video, text and voice explanation. Of course, the above navigation works the same way for tools, processes, products, and theory for all methodology in all companies. The student can easily navigate to a different topic at any level.

The program allows three different ways of navigation: vertical, horizontal, and diagonal. Vertical navigation leads a student from the very top level to the very bottom level of the program. An example of vertical navigation path is as follows: machine shop - drilling methodology - drilling machine - horizontal drilling machine - motor - and so on. This example is as explained in the above paragraphs. Vertical navigation is driven by hypertext and images within a topic. Vertical navigation leads to a related topic or subject.

Horizontal and diagonal navigation is guided by a consistent toolbar, using a familiar set of buttons, throughout the entire industrial park. Different from vertical navigation, horizontal and diagonal navigation may lead to other topics at the same level (horizontal) or at an entirely different level (diagonal). For example, the student may jump from company to company (horizontal), methodology to methodology (horizontal), tool division to process division within a methodology (horizontal), or tool division to an entirely new company (diagonal).

This software is designed to allow the student to control the program. Flexible navigation enables the student to review any part of the program multiple times or skip others that she/he already understands. While working with the program, the student will be free to move within different companies at will. We have designed a non-linear skeleton through which users may visit any or all of the companies in any order.

CONTINUING POTENTIAL
The prototype package includes a full and complete implementation of the skeleton of the system along with a full and complete implementation of one of the five companies of the industrial park (the machine shop). The prototype was demonstrated to approximately 1200 high school students, teachers, college students, and professionals during the College of Engineering’s annual Engineers’ Week Lab Tour open-house at the University of Missouri - Columbia. The prototype system has been widely demonstrated and has been very well received.

During the first year of this project, several opportunities arose to present our prototype system to potential users and customers. The interest level and feedback received from these demonstrations was most enthusiastic. Examples of this interest include: Cincinnati Milacron, Inc., University of Missouri System Outreach and Extension, McGraw-Hill, Inc., four universities, and one trade-school. All of which requested more information about either acquiring a CD-ROM version of the final product or about accessing the final product via the internet. These contacts show the strong potential for widespread application of the virtual industrial park as it can be adapted for use in many additional educational settings such as secondary school practical arts classes, university extension education, community college
courses, corporate retraining, apprentice training, and equipment vendor instructional programs. As we transition from a planning stage to a development stage, the next logical step in our work is the refinement of the package into a viable commercial software package.

**CONCLUSION**

The costs associated with acquiring, updating, and maintaining manufacturing laboratories are continually increasing. These increases are leading to shifts in student learning experiences. Students are now having fewer hands-on laboratory experiences and more minimal participation lectures. To compensate for these shifts we are developing an interactive multimedia software package. Beyond the obvious capital investment advantages, the benefits of a multimedia virtual industrial park are many, including:

- It promotes student-active hands-on learning experiences - more learning occurs in a student-active, one-on-one laboratory environment;
- The industrial park can be used at any number of local and remote locations simply though software installation on a properly equipped personal computer and, potentially, universally over the World Wide Web;
- The industrial park safely increases the accessibility of the manufacturing laboratories for students of all levels of physical ability while decreasing University liability exposure;
- The multimedia software package has the potential for widespread applications as it can be adapted for use in many educational settings in addition to undergraduate engineering;

This interactive multimedia software package will provide an active learning experience for students in one of the oldest of all engineering courses.

**REFERENCES**


**THOMAS J. CROWE** is an assistant professor of Industrial Engineering and a member of the Manufacturing Systems Research Group at the University of Missouri - Columbia. His research interests include dynamic business process modeling, strategic manufacturing management, and manufacturing curricula reform.

**ELIN M. WICKS** is an assistant professor of Industrial Engineering and a member of the Manufacturing Systems Research Group at the University of Missouri - Columbia. Her research interests include manufacturing system design and analysis, engineering economics, multi-attribute decision making, and production planning / control.

**HERMAN BUDIMAN** is a graduate student in the industrial engineering department at the University of Missouri - Columbia. Mr. Budiman's masters research focused on an integrated, customizable methodology for the design of cellular manufacturing systems.