An Interactive Web-based Learning System for Assisting Machining Technology Education

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Abstract—**The key technique of manufacturing methods is machining. The degree of technique of machining directly affects the quality of the product. Therefore, the machining technique is of primary importance in promoting student practice ability during the training process. Currently, practical training is applied in shop floor to discipline student's practice ability. Much time and cost are used to teach these techniques. Particularly, computerized machines are continuously increasing in use. The development of educating engineers on computerized machines becomes much more difficult than with traditional machines. This is because of the limitation of the extremely expensive cost of teaching. The quality and quantity of teaching cannot always be promoted in this respect. The traditional teaching methods can not respond well to the needs of the future. Therefore, this research aims to the following topics;**

(1). Propose the teaching strategies for the students to learning machining processing planning through web-based learning system.

(2). Establish on-line teaching material for the computer-aided manufacturing courses including CNC coding method, CNC simulation.

(3). Develop the virtual machining laboratory to bring the machining practical training to web-based learning system.

(4). Integrate multi-media and virtual laboratory in the developed e-learning web-based system to enhance the effectiveness of machining education through web-based system.

Index Terms—**Group Technology, Interactive Web-based Learning System, Manufacturing Features, Virtual Laboratory**

I. INTRODUCTION

Since the early 1980s, computers have entered the manufacturing educational arena. Increasingly, general purpose tools, such as computer-aided drawing and design packages, computer-aided manufacturing and simulation packages, and computer-aided analysis packages, were developed as valuable computer environments for improving manufacturing productivity [1-2]. The emerging technologies require new knowledge and skills. This places a serious responsibility on engineering educators to provide students with the scientific principles of new technologies, and familiarize them with their impact on the modern manufacturing processes. Manufacturing science includes these technical areas: manufacturing technique, manufacturing systems, design and analysis of manufacturing process planning, material handling, monitoring and control, automated inspection, sensors and interfaces, and management. The manufacturing technique covers: turning, milling, drilling, holing …etc. Much time and cost are used to teach these techniques. Particularly, computerized machines are continuously increasing in use. The development of educating engineers on computerized machines becomes much more difficult than with traditional machines. This is because of the limitation of the extremely expensive cost of teaching. The quality and quantity of teaching cannot always be promoted in this respect. The traditional teaching methods can not respond well to the needs of the future.

The evolution of computer and Internet technologies has made it easy to access learning contents from almost anywhere, anytime, and at user pace [3-4]. In 1994, Bengu [5-6] developed a suite to provide comprehensive engineering education for freshmen in manufacturing processes and systems, and in concurrent engineering. The focus was to develop a support mechanism to deliver the courseware of manufacturing through the www. Since manufacturing education is so vital to the creation of the engineer, Bengu & Swart [7] created a learning process based on total quality management (TQM) and critical thinking (CT) concepts. Their study takes advantage of computer and information technology to enhance the delivery of education through computer-aided teaching and learning tools. A basic proposed framework for the course brings together assembled subject material using various media. In order to achieve the effective use of this new teaching and learning methods, the course proposed includes: on-line lectures, audio-video education tools, interactive computer software, on-line assignments and exams, information about faculty, on-line evaluation tools to obtain student feedback, and to improve teaching quality.

The advance in the optical-fiber network makes real-time transmission of a large amount of data, such as three-dimensional models or video images, possible between remote places. In particular, by connecting virtual environments through the broadband network [8], a three-dimensional virtual world can be shared between remote places.

II. DEVELOPMENT APPROACHES

In order to provide students an e-learning system as realistic as possible and expandable to the entire system, the developed system is based on N-tier architecture, as shown in Figure 1. The application tier side consists of a web server and a Java application server. A presentation tier is a client-side that comprises the HTML, XML, and 3D Web player plug-in. The client, which runs in a Web browser, provides a student interface that handles input (allowing students to enter data, access to course materials, make decisions, and interact with 3D virtual laboratory), and output (displaying results, simulation). The web server performs actions and computations based on student input by using XML and JSP language. The application server reads and writes to the databases by JavaBean, and interfaces with external software packages (CAD/CAM and CAE).

The content of the course is primarily presented with Web pages which are written by HTML. In order to move courses from one system to another, and extract and/or perform automated processing on the documents, standardized definitions for course structures are necessary. To meet requirements, Extensible Markup Language (XML) is used to develop course structures. In order to get cross-platform application, JAVA language is used in programming to develop an interactive Web page. The developed e-learning system can be accessed via the interactive Web page. One of the challenges for learning machining techniques through internet, is how to present spatial information to students to promote student practice ability? In this research, virtual reality (VR) techniques are adopted to describe various activities of machining in terms of translation, rotation, combination, and decomposition of geometric objects.

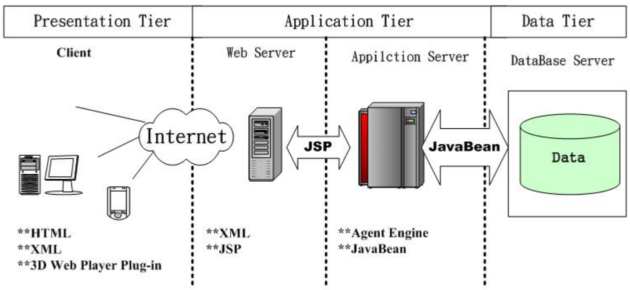

Figure 1. Architecture of manufacturing e-Learning system

The course model developed in this research is based on two methodologies: manufacturing feature and group technology. Manufacturing features are those which are meaningful to the manufacturing. Some manufacturing features are hole, groove, countersink, counter bore, pocket, hole tip, chamfer, fillet, etc. Figure 2 shows the manufacturing features of a turning process. The desired part is subtracted from the stock to obtain the finished part by removing volumes “a”, “b”, “c”, “d”, and “e”. The same method is applied to the milling process where the finished part is obtained by machining manufacturing features “a”, “b”, “c”, and “d”, as shown in Figure 3.

Usually, the geometry of desired parts is not as simple as depicted in Figure 2 & 3, which can be machined by turning or milling process only. Complex parts contain various manufacturing features. Therefore, a systematic way to identify manufacturing features from mechanical graphics is needed. In this system, group technology is used to develop a coding method for mechanical parts. The geometry of mechanical parts is represented by ten digit codes. Figure 4 gives an example of the coding process from a designed graphic. The machining method and manufacturing process can be generated according to the GT code. The approach of coding method employed in this research not only enables the learning contents of manufacturing to be standardized, but also lets students learn the machining method of manufacturing features and processes.

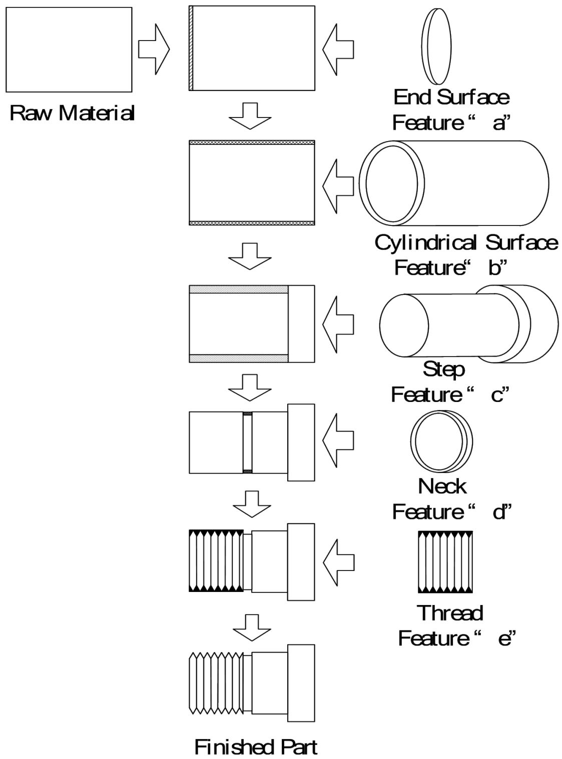

Figure 2. Manufacturing features of turning process

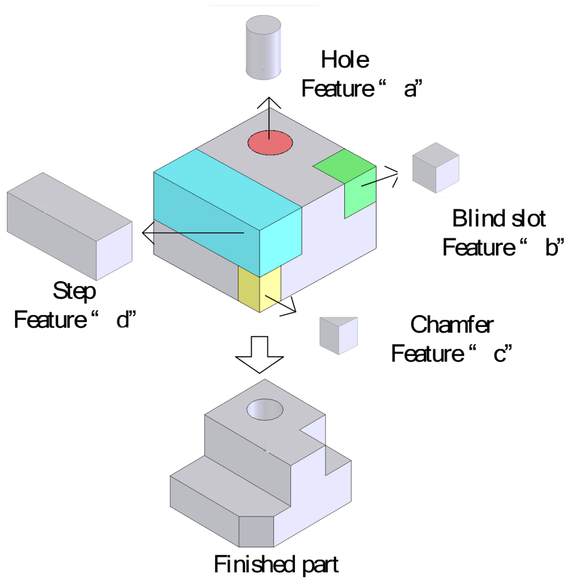

Figure 3. Manufacturing features of milling process

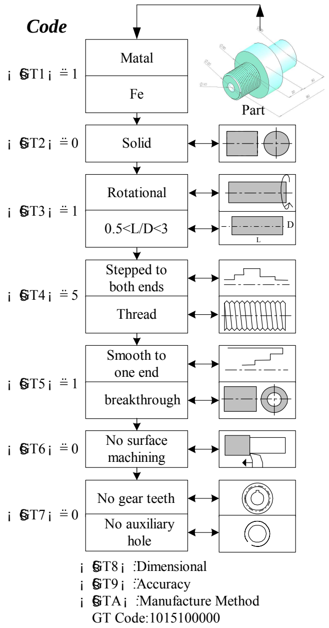

Figure 4. Coding process for a rotational part

III. IMPLEMENTATION AND RESULTS

This system provides students a systemic way to learn manufacturing technology, via the client-side graphical user interface. Students study the overall shape of the part, and specify geometric information of the desired parts, designed as 2D or 3D graphics. The system will automatically analyze the manufacturing features, and generate its GT code, according to the geometric information specified by students. The learning content of the manufacturing processes will be extracted from the database based on the generated GT code.

In order to let students learn the machining methods for basic manufacturing features, a module called □Basic Machining Skill□was developed. This module provides course material that allows students to study the basic skills (Turning, Milling, and Drilling) of machining basic manufacturing features. Students can learn the machining method for basic manufacturing features from this system. A student can select features of turning process in dialogue, as shown in Figure 5. For example: thread feature is chouse. The learning content of turning thread, including graphics and text, is displayed for the student to learn, as shown in Figure 6. Also, a video is cast to illustrate the real turning process for a thread feature. The selection of process parameters, such as cutting tools, cutting speed, feed rate …etc., is one of the key issues in machining processes. Therefore, a mechanism is designed in this system to assist students in learning the process parameters. Once the student inputs incorrect values of process parameters, it will be triggered automatically, and reference information is given to guide the student to input the correct values (Figure 7).

A virtual machining laboratory was developed to bring the machining practical training to web-based learning system. This will allow students to familiarize machining skills before real practice in the laboratory. The virtual laboratory of turning, drilling, and milling is built (Figure 8) to simulate, as real as possible, the skill of machining. In order to facilitate the effectiveness of education by the developed e-learning system, multi-media and virtual laboratory are integrated to demonstrate the machining skill.

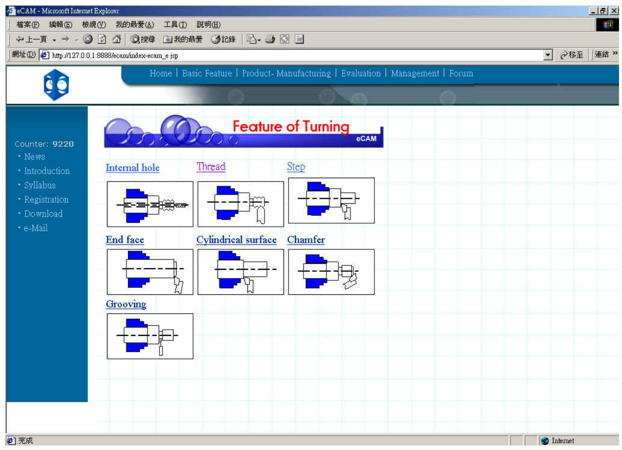

Figure 5. Machining basic manufacturing features

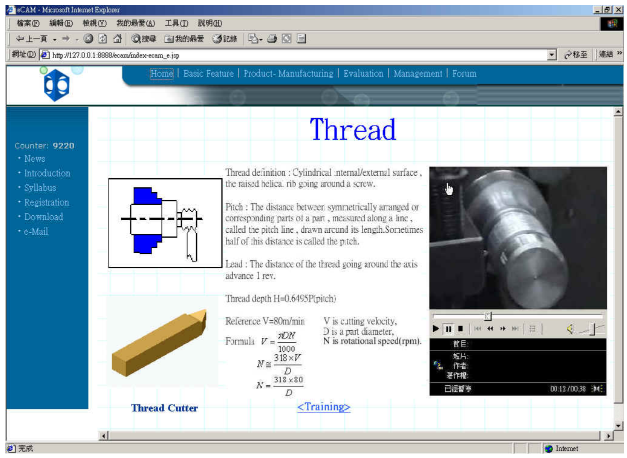

Figure 6. Learning Content of Thread Turning

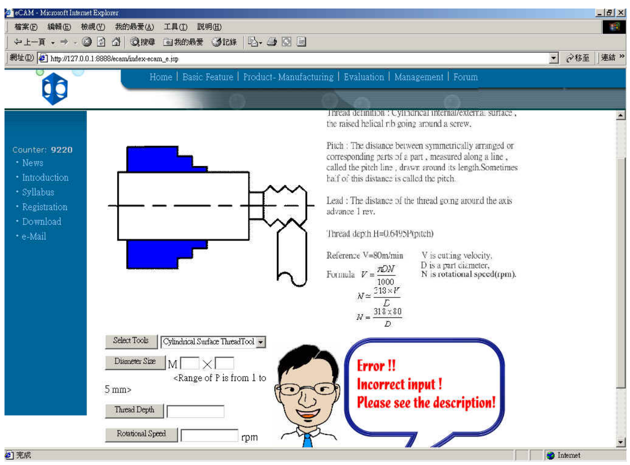

Figure 7. Guidelines for learning machining parameters

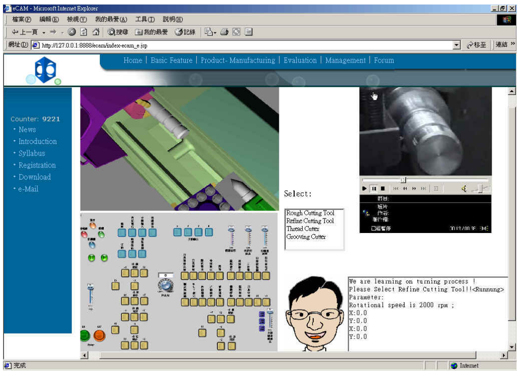

Figure 8. Virtual laboratory of turning process

Students can go further to learn machining process planning, once they have the capability of machining basic manufacturing features. In this step, the geometric information has to be read and specified (Figure 9) for a complex part. This system will create a GT code based on the geometric information specified, and generate the manufacturing features required to fabricate the desired part, as shown in Figure 10. The possible machining procedures are displayed to students in Figure 11. The system will indicate the appropriate procedure and give the reasons for decision making. In this phase, one objective is to give the student the ability to extract the manufacturing features for a complex part, from a mechanical drawing in either 2D or 3D. The concept of manufacturing process planning can also be brought to students.

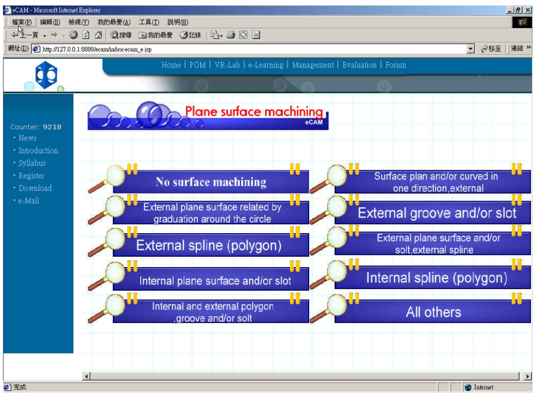

Figure 9. Specification of part geometry

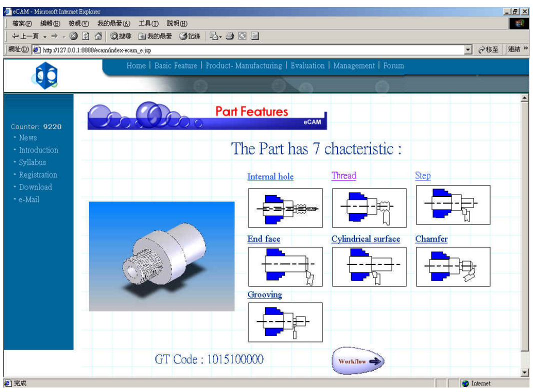

Figure 10. Manufacturing features for a complex part

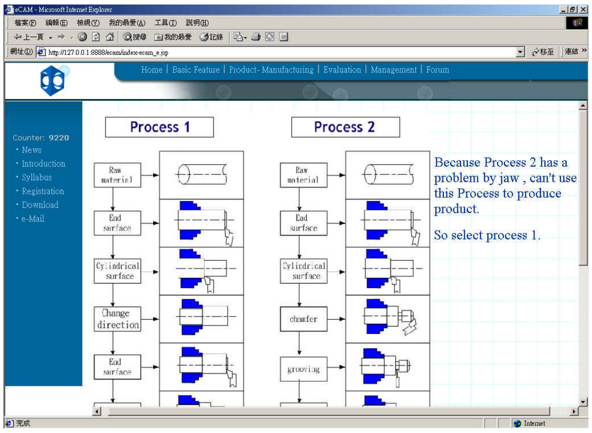

Figure 11. Machining procedures for a complex part

The computerized machines are continuously increasing in use. The development of educating engineers on computerized machines becomes much more important than ever. Therefore, learning contents of CNC coding method was established in this system. In addition to, simulation of CNC cutting path is delivered to students using multi media (Figure 12). In order to provide media contents for multi-users, eliminate the delay of casting processes, and increase cast quality, the SureStream is employed to manipulate stream files for casting. The stream media contents are controlled and cast by the Pear-to-Pear casting method to meet the multi-cast purpose.

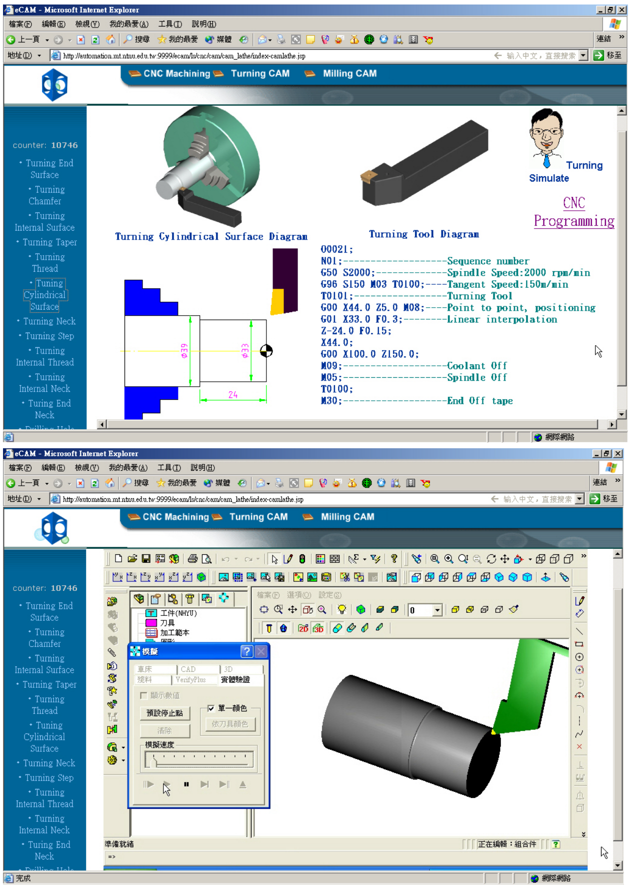

Figure 12. CNC programming and simulation

Online test can be scheduled as the convenience of students. Another major benefit of online testing is the scoring immediately and then provides students immediate feedback. However, creating review questions online becomes the major challenge for teacher. It involves text editing, video casting, graphics, 2D & 3D CAD model … and so on. Therefore, this study develops an interactive test administration module for teachers to create review questions online to measure student's performance with secured access. Besides text, videos, graphics, 2D & 3D CAD model can be imported into multiple-choice questions and pre-viewed from this interface as shown in Figure 13.

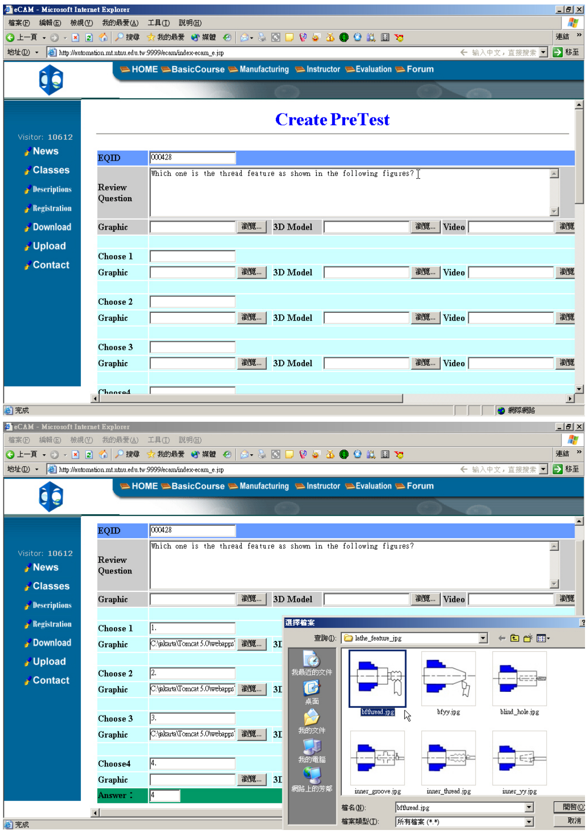

Figure 13. Creating review questions

IV. CONCLUSIONS

In this paper, a system of e-learning for manufacturing has been proposed and developed. It demonstrates the methodology of combining XML and Java to implement virtual reality, and Sure Stream media contents. Furthermore, it employs group technology to facilitate effectiveness and standardization of course material, and create sharable course content.

Compared with traditional methods, e-learning of manufacturing has certain advantages. The learning activities are free from time and location. The expensive learning resource of machining techniques can be circulated through the web for the purpose of sharing resources and the diffusion of education. The developed learning method and the virtual laboratory will help the student to improve practice ability.

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