Web-Based Learning Activities in Manufacturing Systems

Muhammad Sohail Ahmed, Nancy L. Baskin, Gregory L. Tonkay, Andrea G. Wittchen, Emory W. Zimmers, Jr.
Wayne State University/Greenfield Coalition/Lehigh University/ Lehigh University/Lehigh University

Abstract *– This paper will focus on the design and development of multimedia sessions which are web-based learning activities designed to teach engineering concepts within a real-world manufacturing context. Traditional engineering education methods often result in competency gaps between the theoretical and the practical. As a result, traditionally educated engineers may have difficulty translating their classroom learning into effective manufacturing practice. These competency gaps can be addressed by introducing experiential learning into the educational methodology.*

This paper describes how the learning session is created using a set of digital objects that fulfill a single educational objective. A session uses these multimedia objects to teach a specific theory, process, or technique with a factory context. For example, to teach direct time study, video images captured from the factory floor can become multimedia objects to be used in a session. The resulting session requires the learner to analyze the environment and conduct time studies by viewing real factory personnel in work settings.

In the approach described in this paper, joint university/industry projects serve as a source of data and experiences that can be used to support computer-based learning activities. Real-time interactions with factory personnel that are accomplished through Web-cam technology and interactive meeting software are often used to capture key objects needed to create a session. As specific examples of our approach, this paper discusses the development of two multimedia learning sessions – one on direct time study and one on the use of simulation. It includes the educational plan development, techniques used for creating multimedia objects, and concludes with a description of the resulting learning sessions.

One of the challenges in engineering education is producing engineers capable of integrating theory with practice. The Manufacturing Education Plan: 1999 Critical Competency Gaps[1] documents the competency gaps that exist when such integration capabilities are not present in manufacturing engineers. These competency gaps can be addressed by introducing experiential learning into the educational methodology, offering engineering students opportunities to translate their classroom learning into effective manufacturing practice.

One approach to addressing this integration has been the educational model developed by the Greenfield Coalition at Focus:HOPE. The Greenfield Coalition learning system is predicated on the belief that students will learn faster and will become more effective problem solvers if engineering education and practice are integrated, and students actively participate in their learning[2]. To implement these concepts, the Coalition developed a unique approach to the definition of a curriculum. The following figure describes the components (see Figure 1).

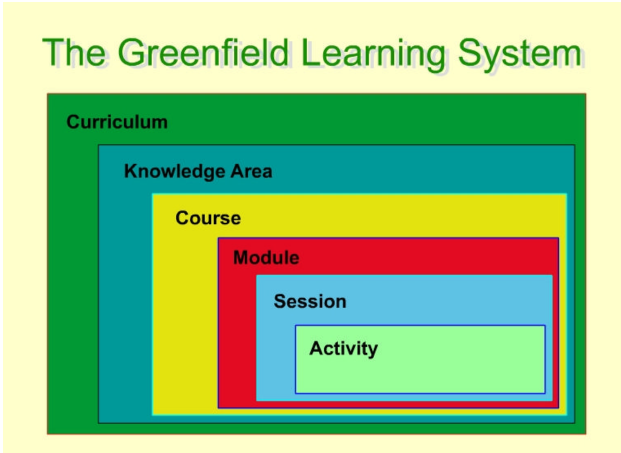

FIGURE 1. Greenfield Coalition Learning Hierarchy[3]

The learning activity is the smallest component of the curriculum and the location for experience-based learning to take place. Multiple learning activities, some web-based and some faculty-led, are combined to create a concept-focused session. Sessions aggregate to modules. Modules are combined to create one-credit courses that are, in turn, components of meta-objects called knowledge areas. Collections of knowledge areas form the curriculum.

Manufacturing Systems I

The web-based activities presented here are from the course Manufacturing Systems I, which is being designed by Greenfield Coalition in partnership with Ford Motor Company, Lehigh University, and Wayne State University. In placing Manufacturing Systems I into the hierarchy of The Greenfield Learning System (see Figure 1), it is within the curricula for the following degrees: Associate of Science in Manufacturing Engineering and Technology, Bachelor of Manufacturing Engineering, and Bachelor of Science in Manufacturing Engineering Technology. The knowledge area is Manufacturing Process, and the following table details the modules and sessions for this course (see Figure 2).

Module 1: Introduction to Manufacturing Systems

- Session 1: Types of Manufacturing Systems
- Session 2: Designing Manufacturing Systems
- Session 3: Manufacturing Support Systems
- Session 4: Automation/Computer Integrated Manufacturing

Module 2: Analysis Tools (Graphical & Computer-Based)

- Session 1: Graphical Tools
- Session 2: Quality Tools
- Session 3: Use of Computer Simulation

Module 3: Human Factors

- Session 1: Work Environment
- Session 2: Applied Anthropometry
- Session 3: Work Measurement

Module 4: Data Communications and Networks

- Session 1: Migration to Automation
- Session 2: Distributed Systems
- Session 3: Local and Wide Area Networks
- Session 4: Machine (M/C) and Robot Programming
- Session 5: Ladder Logic and DeviceNet

FIGURE 2. Manufacturing Systems I Course Structure

Design & Development Process

As shown in the figure below, the first step in designing a course is to identify behavioral objectives that can be measured (see Figure 3). The objectives will guide the rest of the course design. Once the objectives are identified, the team is ready to brainstorm a list of activities to support them. After the team agrees upon the activities, the selection of delivery methods begins. The team needs to explore what methods are best suited for the activities. There are activities where a classroom setting cannot do them justice, and a web-based environment is the best choice. Throughout the process of selecting, designing, and developing the activities, there is collaboration with the media/programming team to ensure that technology supports the plan.

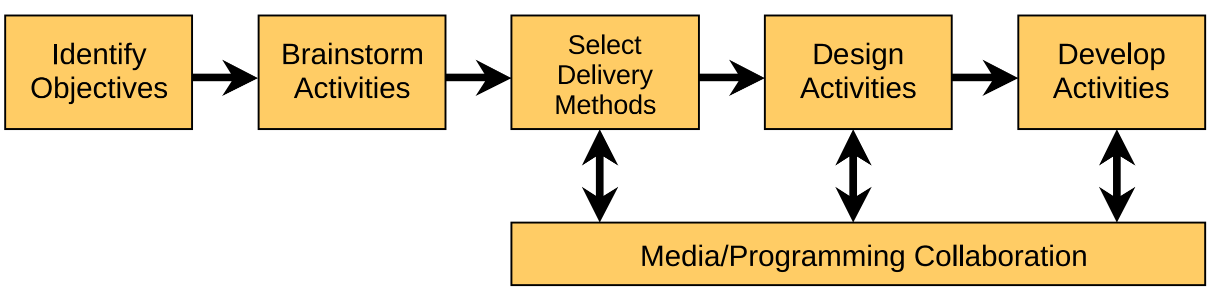

FIGURE 3. Design & Development Process

Learning Activity Characteristics

The two learning activities of focus are direct time study (located in Module 3: Human Factors, Session 3: Work Measurement) and computer simulation (located in Module 2: Analysis Tools, Session 3: Use of Simulation). Consistent with Greenfield Coalition's belief that technology can provide new capabilities to support learning, these particular activities have been designed as web-based to provide a learner controlled environment and are supported by classroom discussion. A student can access a web-based activity at a time of convenience. The learner also can learn at his/her own pace, reviewing and replaying sections as necessary. Once the learner understands the concepts, there are questions for him/her to answer which are captured online. The instructor is able to review the learners' responses before the next class period and focus the discussion based upon them.

Another important feature of the learning activity is that technology permits image capture from the factory floor, placing the activity in the context of a real-world environment. The resources for these real-world environments are the industries that partner with Lehigh University's Enterprise Systems Center (ESC) and the manufacturing facility at the Center for Advanced Technologies (CAT), a component of the Focus:HOPE program. These functioning manufacturing enterprises are used to record machines, personnel, and day-to-day operations for use as multimedia elements in the construction of the learning activity. Multimedia enhances the activities by providing a real-world context and helps the learner to make connections from a theoretical problem or process to a practical solution or application.

Learning Session Structure

Depending upon the complexity of the material presented, the sessions follow a general learning structure. An introduction to the session content occurs in one of the following ways: reading material, a web-based environment, or a classroom discussion. The online activities are framed by an introduction to the specific concept, the actual activity, and a recap of the most important takeaways from the material. The activities are focused on solving situations faced within engineering environments, and the questions are pertinent to the outcome. Directions are supplied for proper submission of the student's work product (generally electronical). The activity is summarized through a discussion of how the concept fits into the broader subject of the session and is transferred into authentic engineering situations.

At each point in the design of the session, consideration is given to what elements are available from real-world environments to enhance the learner's understanding of the concept. These elements may be video or audio clips taken from real-time interactions with industry personnel or video of specific shop-floor equipment and its operation. The purpose is to make the concept tangible—to give it life and dimension and to make it more easily understood by the learner.

Direct Time Study Learning Activity

To learn about directed time study, learners participate in an interactive web-based activity, where they watch a video of a hub broaching process and conduct a time and motion study. These video clips come from the broaching operation at Focus:HOPE's Center for Advanced

Technologies (see Figure 4). Through viewing one cycle of the broaching process, the candidates first identify the individual elements involved. After the elements have been identified, the candidates view each isolated element for a further understanding of the breakdown of the entire task. Upon completion, the candidates view five cycles of the entire broaching process while conducting a time and motion study.

FIGURE 4. Broaching Operation at Focus: HOPE's Center for Advanced Technologies

The learning activity also includes the Excel spreadsheet necessary (see Figure 5) for recording element times and calculating standard times for each element of the cycle as well as the cycle as a whole. Based upon the learner responses from the web component, a classroom discussion is facilitated to further transfer the content into real-world situations.

Element # and Description																														
Cycle	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT	OT	R	NT
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														

Summary

Total NT										
No. Observations										
Average NT										
% Allowance										
Standard Time										

Total Standard Time (sum standard time of all elements):

FIGURE 5. Excel Spreadsheet for Direct Time Study Documentation

Computer Simulation Learning Activity

The session on the use of computer simulation, still under development, follows a similar learning structure. After an introduction to the topic is provided, a problem is presented for the learners to solve in a web-based environment. They are given a scenario concerning a manufacturing plant's need for operational improvements for the production of daily calendars. They have a series of resources to view, which detail the product flow. The learners manipulate the data within a computer simulation (see Figure 6) and observe the results of their selected specifications. After viewing a series of outcomes, they are capable of drawing conclusions on which parameters optimized the manufacturing plant's operations. The computer simulation exercise is followed by a discussion of the use of simulation in the broader context of analysis tools and engineering environments.

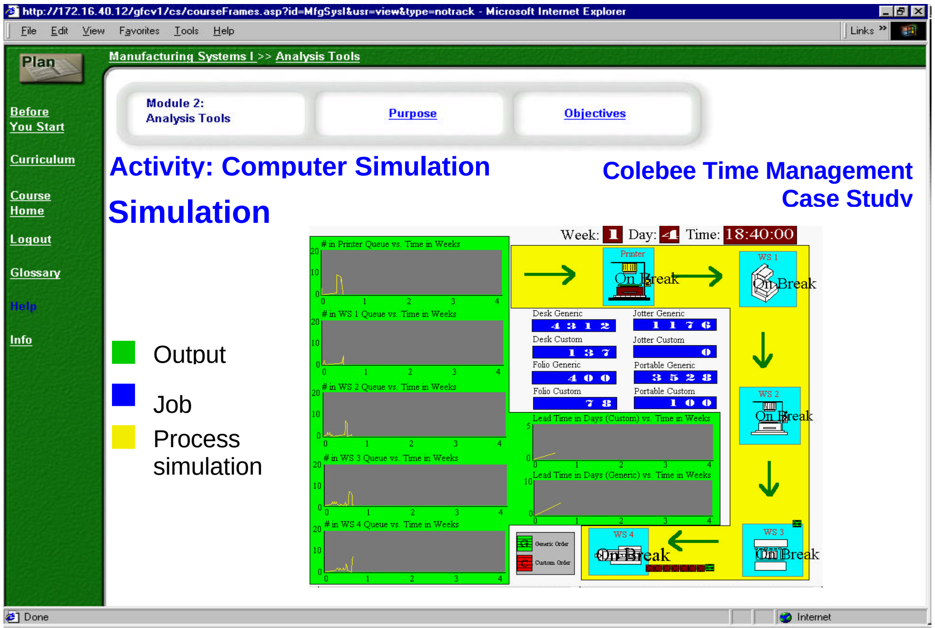

FIGURE 6. Data Manipulation

Summary

These two learning activities are examples of the type of individual learning components that can be created to enhance the quality of instruction provided to engineering students. These learning activities utilize visual images, both still and motion, from real-world manufacturing environments to assist the engineering student to make the correlation between the theoretical and the practical. Rather than words on a page or an instructor lecture, these learning activities put the learner closer to the action of the manufacturing environment and let them visualize the application of engineering theory to real-world processes through the use of multimedia.

The success of these activities as educational vehicles is based on the commitment in the development stage to emphasize the "active" in learning activities[4], in order to engage the learner more directly in the learning process, and in the availability of industry and university partnerships that permit access to real-world learning environments for use as content. In addition, their availability as self-contained components that can be folded into a broader curriculum permits dissemination of this type of student-involved, real-world education. This enhanced form of engineering education addresses the competency gaps of today's graduates and produces better-prepared and better-equipped engineers. By placing educational experiences in an authentic context, a person is better able to transfer knowledge and skills to the workplace.

Acknowledgement

The Greenfield Coalition is partially supported by a Grant EEC-9630951 under the Engineering Education Coalitions Program at the National Science Foundation. Focus:HOPE, our industry and academic partners have contributed valuable resources to support the development of Greenfield.

Bibliography

[1]Rogers, Jr., D., Stratton, M., King, R., *Manufacturing Education Plan: 1999 Critical Competency Gaps.* Society of Manufacturing Engineers, Dearborn, MI, 1999.
[2]Falkenburg, D., "The Greenfield Coalition: Partnership for Change in Manufacturing Engineering and Technology Education," *Proceedings of the International Conference on Engineering Education*, Oslo, Norway, August 6-10, 2001.
[3]Falkenburg.
[4]Falkenburg.

Biography

MUAMMAD SOHAIL AHMED, Ph.D. is an employee of Industrial & Manufacturing Engineering Department, College of Engineering, Wayne State University. He is a knowledge expert for the courses Manufacturing Systems I and II. Ahmed has been working with the Greenfield Coalition since 1999. He has worked on two NIST ATP grants on variation reduction and is currently involved in Knowledge Management and eManufacturing Research.

NANCY L. BASKIN, M.Ed. is an employee of Greenfield Coalition, College of Engineering, Wayne State University. She is the project lead and instructional designer for the course series Manufacturing Systems I and II. Baskin has worked in the education field for over thirteen years. She will begin her doctoral studies in the spring.

GREGORY L. TONKAY, Ph.D. is an associate professor and associate chairperson of the Industrial and Systems Engineering Department at Lehigh University. He is also the director of the Electronics Manufacturing Laboratory. Tonkay has been actively involved with Greenfield Coalition course and curriculum development since 1994.

ANDREA G. WITTCHEN, M.B.A. works with the Enterprise Systems Center's program office, contributing to the Center's industry and government programs and identifying new opportunities for Center-sponsored university-industry collaborations. Wittchen's area of expertise is strategic planning and program development.

EMORY W. ZIMMERS, JR, Ph.D. is Professor of Industrial and Manufacturing Systems Engineering and Director of the Enterprise Systems Center at Lehigh University. In his thirty-two years at Lehigh, Zimmers has been responsible for more than 200 funded research and technology transfer projects with over 115 industry partners. These projects have been used as the vehicle to couple experience-based learning with industry value creation.