THE CREATION OF ELEARNING MATERIALS BASED ON REAL WORLD CONTENT

Muhammed Sohail Ahmed[1], Nancy L. Baskin [2], Gregory L. Tonkay[3], Andrea G. Wittchen[4], and Emory W. Zimmers, Jr.[5]

Abstract *¾ This paper describes the design and development of eLearning materials to teach engineering concepts within a real world manufacturing context. Introducing experiential learning into the educational methodology addresses the limitation of traditional classroom engineering education that results in engineers who lack the ability to translate their classroom learning into effective manufacturing practice. Two types of eLearning materials are presented. The first is a multimedia learning activity focused on direct time study, developed as part of the Greenfield Coalition's curriculum design sponsored by the National Science Foundation. The second is a manufacturing case study drawn from funded project work done as part of the Enterprise Systems Center at Lehigh University's industry/university collaboration. This case study is a larger and more complex presentation of a manufacturing challenge within a real world business. Both types of eLearning materials are dependent upon the successful combination of real world content, technology and an experienced educator.*

Index Terms ¾ course development, eLearning, manufacturing engineering, real world content, technology.

INTRODUCTION

Traditional engineering education methods often produce engineers who have difficulty integrating theory with practice. As a result, these engineers lack the ability to translate their classroom learning into effective manufacturing practice. These competency gaps have been identified in the Society of Manufacturing Engineers' Manufacturing Education Plan: 1999 Critical Competency Gaps[1]. The Plan documents a depressing lack of applicative knowledge on the part of newly graduated engineers, as well as a correlative deficiency in communication skills.

Introducing experiential learning into the educational methodology addresses these competency gaps by providing engineering students with exposure to real world environments. In these environments, they are challenged to apply their theoretical knowledge to solve operational problems for real companies. Involvement in the funded industry/university projects that provide the context for these eLearning materials improves not only the student's engineering skills but also his/her communications and leadership skills.

COMPONENTS OF EFFECTIVE ELEARNING MATERIAL DEVELOPMENT

Experience gained at the Enterprise Systems Center (ESC) at Lehigh University, Bethlehem, PA and Greenfield Coalition in Detroit, MI points to the need for three critical components in the development of effective eLearning materials. Effective materials are the result of the marriage of real world content, technology, and educators.

The real world content provides the critical link between the engineering student and his/her ability to use theoretical knowledge to solve concrete problems. At Lehigh University this real world content comes from projects that are completed through funded industry/university collaborative programs at the Enterprise Systems Center. These projects are not simulated to provide an educational experience but rather are, first and foremost, contracts with specified deliverables for regional companies that are dependent on the usefulness of the deliverable to run the company. Project work covers areas such as implementation of cellular and lean manufacturing systems, constraint analysis, supply chain management, workflow analysis and improvement, enterprise resource integration, and product development and enhancement.

In order to produce a solid deliverable in real time for the partner company, the student must quickly connect to the factory floor workers to understand the problem and its relationship to the larger company picture. This process moves the student beyond the superficial "plant tour"-type of education into a hands-on, problem-solving experience. At the same time, it develops the student's communication skills as he/she works with employees at all levels of the partner company.

Technology provides the next link in the process of eLearning material creation. The availability of increasingly more sophisticated image capture equipment at comparatively low prices has made it easier and more attractive to include multimedia elements in educational material. Easy-to-use equipment has also made the image capture process less intrusive to work on the factory floor.

[1] Muhammed Sohail Ahmed, Wayne State University, Industrial and Manufacturing Engineering Department, Detroit, MI, sohail@mie.eng.wayne.edu
[2] Nancy L. Baskin, Wayne State University, Greenfield Coalition, Detroit, MI, baskinn@focushope.edu
[3] Gregory L. Tonkay, Lehigh University, Department of Industrial and Systems Engineering, Bethlehem, PA, glt0@lehigh.edu
[4] Andrea G. Wittchen, Enterprise Systems Partners, Inc., Bethlehem, PA, awittchen@att.net
[5] Emory W. Zimmers, Jr., Lehigh University, Enterprise Systems Center, Bethlehem, PA, ewz0@lehigh.edu

More companies are therefore willing to allow such activities within their facilities. Improvement in the ease of manipulation of the captured images also permits the timely updating of eLearning materials. Media objects can be deleted and replaced with new media objects as technologies and techniques change and evolve.

The third critical element, the knowledgeable educator, then takes this mass of raw material and shapes it into a useful educational tool. The educator must identify the behavioral objective of the eLearning material, determine what delivery method most accurately and effectively communicates the information to the learners, and construct the problem-solving framework that the learners will use. The educator brings to the problem his/her expertise of key elements that are necessary for learning to occur.

MULTIMEDIA LEARNING ACTIVITY

The first example of eLearning material derived from real world project work is an eLearning activity developed as part of the Greenfield Coalition's innovative curriculum design, sponsored by the National Science Foundation. The Coalition's learning system integrates engineering education and practice on the assumption that engineers will more effectively learn how to become problem solvers if they actively participate in their learning.[2] This unique system is represented by the learning hierarchy shown below.

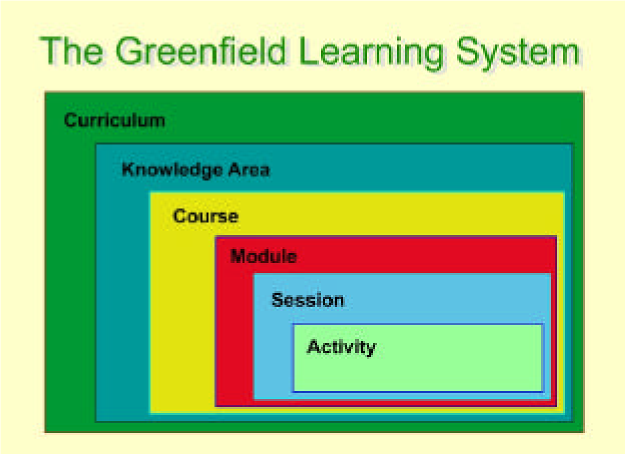

FIGURE 1.
GREENFIELD COALITION LEARNING HIERARCHY[3]

These experience-based learning activities are a basic building block of the curriculum and teach a specific theory, process, or technique within a factory environment. Additional information on the development of the learning activity within the Greenfield Coalition Learning Hierarchy is available in Web-Based Learning Activities In Manufacturing Systems [4].

STRUCTURE FOR LEARNING ACTIVITY

The session to which a learning activity belongs is organized around a general outline. Background material is provided through a number of means, depending on what is most appropriate for the subject matter. These can include reading material, a web-based environment, or a faculty-facilitated classroom discussion. This introductory material is accompanied by questions to simulate student thinking about the subject matter to be emphasized and its relationship to the engineering environment. The exercise to be completed is then defined.

The learner then completes the activity, solving the problems posed and answering questions pertinent to the outcome and submits the work product as directed. The activity is recapped followed by a review of how the activity fits into the broader subject of the session.

It is important at each step in the development process to consider what multimedia objects from real-world environments are available to support and enhance the learner's understanding of the activity. These objects might be video clips, software screen shots, audio interviews or other examples of real-time interactions with factory personnel. The goal is to make the concept taught in the learning activity relevant to the learner and place it in a real-world context.

DIRECT TIME STUDY LEARNING ACTIVITY

The direct time study learning activity is part of a session on human factors in the Manufacturing Systems 1 Course Structure at Focus:HOPE's Center for Advanced Technologies. This learning activity was the result of a joint development effort between ESC and Greenfield Coalition personnel. The information that follows describing the learning activity was first presented in Web-Based Learning Activities In Manufacturing Systems [4].

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 2). 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 2.
BROACHING OPERATION AT FOCUS:HOPE'S CENTER FOR ADVANCED TECHNOLOGIES

The learning activity also includes an Excel spreadsheet necessary 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.[4]

DEVELOPING A MANUFACTURING CASE STUDY

The second type of eLearning material is the case study. This is a larger and more complex presentation of a manufacturing challenge within a real world business. These cases are drawn from funded project work done as part of the ESC's industry/university collaboration. The case study may be composed of multiple learning activities, such as lectures, faculty-facilitated discussions, student exercises, team activities, or role playing.

The structure for the eLearning case study is modeled on the Harvard Business School outline for case study development[5]. A standardized outline was developed to be used in each case study. However, as the example case study shows, the resulting framework often must be adjusted based upon the uniqueness of the people and situations involved in the original interactions. The case study development process is not meant to be overly proscriptive. It purposely must include variation as it adjusts to the nature of each case, the constraints of the technology, and an understanding of what a learner can absorb. It is in making choices about these variations that the contribution of the experienced educator to the final compilation process is most crucial.

One important difference in the manufacturing case study is the use of video clips. Video clips can illustrate shop floor processes, present interviews with plant personnel, or provide additional instructional material and deliver learning in an alternative mode to traditional lecture and reading. The ability to observe a particular manufacturing process directly from the shop floor, for example, puts the engineering student in contact with the realities of the manufacturing environment.

The template is created in Microsoft PowerPoint because it is a commonly available program and relatively easy to use. In addition, it can accommodate the insertion of video clips. Image capture from the factory flow is accomplished with consumer-grade digital camcorders. The resulting footage is edited with Sony DVGate, basic editing software, on consumer-grade editing equipment. The process involves transforming mini-DV tape into .avi computer files that are then compressed into .mpeg files to enhance their compatibility with PowerPoint and improve their ease of manipulation.

Content Components

Following is a list of the content components of a manufacturing case study:

- Title Page
- Company Background
- Context
- Company Issues
- Targeted Problems and Goals
- Sample Exercise Problems and Solutions
- Summary
- Connection and Transfer
- Footnotes/Bibliography

The Company Background section provides a brief overview of the partner company's story, including its history and current situation.

The Context section addresses both the learning context for the case and the company context for the case. This includes the case objectives as well as any prior knowledge the learner needs. This section also includes perspective on the company context, information such as company mission and challenges, market pressures, and other environmental constraints.

Company Issues includes the kinds of factors that an industrial engineer will encounter in attempting to solve problems for companies, such as company culture, budget, timeline, equipment, and regulations. These issues can be viewed as the "As Is" situation in which the engineer must work to bring about change.

The Targeted Problems section identifies the specific problems that the ESC project team addressed at the partner company.

Sample Exercise Problems and Solutions replicate the problems and solutions that were part of the original project.

The Summary section ties the case back to its objectives. The Connection and Transfer section relates the specific knowledge learned to the engineering theory on which it is based.

MASS CUSTOMIZATION CASE STUDY

This manufacturing case study focused on the need to change from mass production to mass customization at a company that manufactured time management solutions. The case was in two parts: one focused on how to perform an as-is analysis, the other focused on simulation of the proposed system.

Following a review of the company background, identification of the case objectives, and a definition of the business problem to be addressed, the manufacturing process flow is described, accompanied by video clips of the various machines used at different steps in the process (see Figure 3).

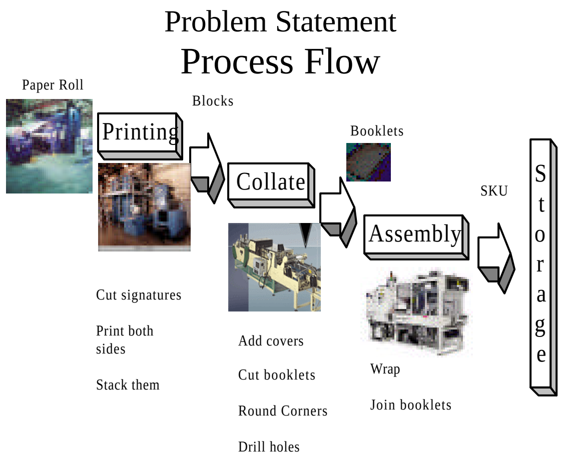

FIGURE 3.
PROCESS FLOW FOR CASE STUDY COMPANY

Each part of the case then identifies the target problem to be solved. In Part I – As Is Analysis, the learner studies the manufacturing process as well as the production planning and control elements in place at the partner company. Within the case study, these elements are represented by video clips of equipment as well as screen shots of actual production planning software in use at the partner company. The learner is then required to respond to system analysis questions such as those used in the original company project. The in-class assignment at the end of this portion of the case study requires the learner to estimate nominal throughput on three of the work centers and then prepare a presentation of the analysis for the company.

In Part II – Simulation, the learner is provided with information on the development process for arriving at the configuration of the simulation model that is to be tested. The learner is then presented with the simulation model as well as the description of the type of output that will be provided (see Figure 4). The learner then specifies the maintenance schedule to be modeled and runs the simulation.

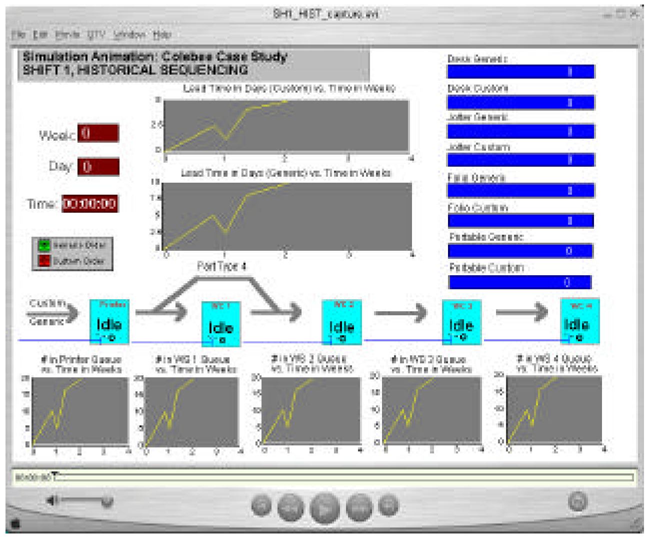

FIGURE 4.
SAMPLE SIMULATION OUTPUT FROM CASE STUDY COMPANY

Following completion of the simulation, the results along with the learner's analysis of the results are submitted to the professor. Concluding slides connect the as-is analysis and the simulation exercise with the broader issues of moving a company from mass production to mass customization.

The creation of this case study highlighted the importance of the contribution of the educator to the process. It was not feasible to embed the entire simulation program in the case study to exactly reproduce the conditions of the project at the company. However, for educational purposes, the inclusion of the entire program in the case study is not necessary for the learner to learn the value and applications of simulation for problem-solving in this context. A representative sampling of possible simulation results sufficed to provide the necessary integration of simulation theory with real world practice.

SUMMARY

These two eLearning activities represent two approaches to providing engineering students with alternative learning methods that connect classroom theory with real world environments. eLearning can be delivered as tightly focused learning activities, such as the direct time study learning activity, or broader manufacturing case studies, such as the mass customization case study. In either instance, it is the ability to set the educational material within a real world context that improves the engineering student's problem-solving capabilities. This improved competency better prepares the engineering student for the realities of life as an engineer in a manufacturing environment.

The creation of effective eLearning activities is dependent on the successful interaction of three components – real world industry content, technology, and the experienced educator. These components work together to produce eLearning materials that can be updated to remain current and relevant to the world of the practicing engineer.

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