

A Corrosion Module for Computer Based Instruction of Materials Science: Initial Student Feedback and Analysis

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Abstract

The National Science Foundation (NSF) is sponsoring the Greenfield Coalition for New Manufacturing Education, which was formed in order to initiate a new curriculum in **manufacturing** engineering and technology for students wishing to obtain associate and bachelors degrees in manufacturing engineering technology and bachelor of science degrees in manufacturing engineering. The new curriculum is not based on traditional classroom experiences, but on computer based instruction combined with experiential learning. Together with the six coalition universities, the Center for Advanced Technologies (C.A.T.) at Focus: HOPE in Detroit provides a state-of-the art manufacturing facility for student-candidates to gain engineering knowledge within the context of an industrial environment. The C.A.T. provides both case studies and projects for the candidates to investigate during the course of their education. The curriculum for these degrees was divided into several broad knowledge areas, one of which was the engineering materials knowledge area. The engineering materials knowledge area was subsequently divided into twelve modules, most of which used the dissemination method of computer based instruction. This presentation and paper describe the educational methodology used to develop the corrosion module, as well as the initial feedback from the candidates who went through the module. The corrosion module was designed to use case studies from the C.A.T., as well as common materials the candidates have experienced in their everyday lives. The module teaches basic principles of corrosion science and engineering, as well as corrosion prevention by **careful** materials selection and part design. The structure and content of the module are developed on the "Authorware" software program which enables interactive techniques and multimedia instruction to enhance learning.

Introduction

Engineering materials is a required course in the **curriculum** for ABET accredited undergraduate engineering and engineering technology institutions. For this reason, the engineering materials knowledge area was one of six original knowledge areas selected for curriculum development by the six universities (Lawrence Technological University, University of Detroit-Mercy, Wayne State University, University of Michigan - Ann Arbor, Lehigh University, Central State University) in the NSF sponsored **Greenfield** Coalition for New Manufacturing Education. The Greenfield Coalition was established in order to develop a new curriculum for manufacturing engineering and technology education using non-traditional methods of instruction. These methods include computer based instruction, case studies and projects, portfolios and experiential learning. The unique element of the Greenfield Coalition is its partnership with the Center for Advanced Technologies (C.A.T.) at Focus: HOPE in Detroit, Michigan, which is a national project including a futuristic 220,000 square foot manufacturing/learning facility opened in 1993. The C.A.T. provides both students, called candidates at



Focus: HOPE, and a working laboratory of engineering case studies. The candidates work full time in the C.A.T. They leave the shop floor at specified class times, as well as on their own time, to use the electronic library and attend classes.

Objectives

The objectives of this work were as follows:

- 1) Define and establish an innovative corrosion education module for the engineering materials knowledge area.
- 2) Establish the instructional process, the prerequisites and the test for competency of the corrosion module.
- 3) Incorporate the candidates' experiences in the C.A.T. in the corrosion module case studies.
- 4) Develop computer aided instructional material and testing methods for the corrosion module.
- 5) Collaborate with coalition partners to establish academic credit and degree requirements for the engineering materials knowledge area.
- 6) Incorporate initial candidate feedback from the corrosion module into its redesign for offering to subsequent candidates.

Results

Organization

The engineering materials knowledge area was divided into twelve modules:

- EM 1. Structure Of Materials
- EM 2. Metals
- EM 3. Ceramics
- EM 4. Polymers
- EM 5. Composites
- EM 6. Inspection and Testing
- EM 7. Heat Treatment
- EM 8. Adhesives and Coatings
- EM 9. Corrosion
- EM 10. Failure Analysis
- EM 11. Selection of Materials
- EM 12. Materials for Manufacturing

Different combinations of modules were required for the three degree programs. Figure 1 illustrates these combinations. An Associate of Engineering Technology degree requires the six core modules in the center (EM 2, EM 3, EM 4, EM 5, EM 11, EM 12). The Bachelor of Engineering Technology degree requires the additional three modules shown on the left (EM 6, EM 7, EM 8). The Bachelor of Science in Engineering degree requires the three modules shown on the right (EM 1, EM 9, EM 10) in addition to the Associate degree requirements.



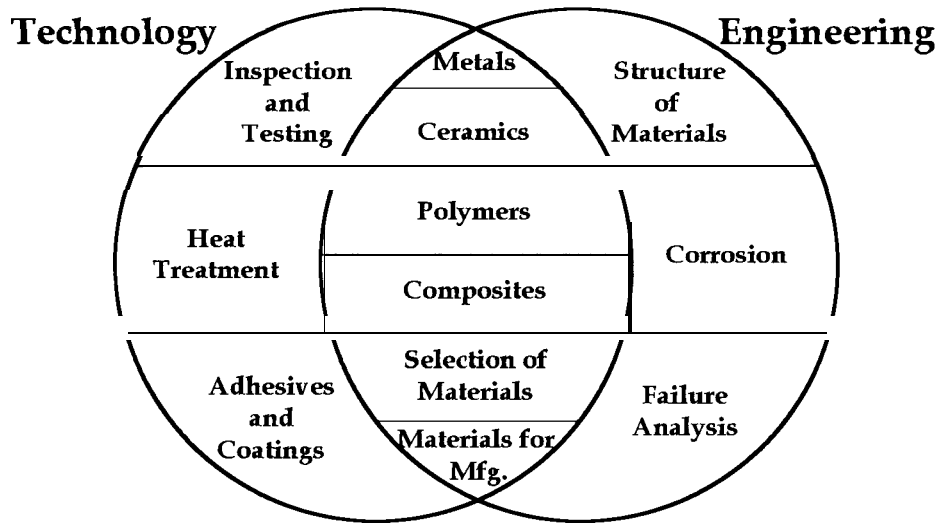


Figure 1

These groups of modules were designed to be equivalent to courses offered by Lawrence Technological University. Equivalent courses will be determined by the other coalition universities. High school chemistry was a prerequisite for the first modules offered; later modules built on knowledge gained from the previous modules. EM 1 (Structure of Materials) and EM 2 (Metals) were prerequisites for the corrosion module.

Delivery

The modules used different combinations of instructional delivery methods; however, the corrosion module was developed for computer based instruction and testing. A number of available software packages were evaluated by the coalition, and “Authorware” was chosen. This software was distributed to the curriculum developers and a week-long course was offered as an introduction to its use.

The development of an interactive, engaging computer based curriculum is a very time consuming process which requires both computational skill and artistic talent. Traditional teachers may only do a cursory computer development; a dedicated authoring department is necessary in order to assemble the personnel and equipment required for a true multimedia curriculum. In order to achieve consistency in the resulting curriculum, the authoring department should also be responsible for providing “templates” and directions for the course developers. The success of the instruction is certainly tied to the degree of interactivity provided by the multimedia presentation, and non-traditional students may need more interactivity than traditional students.

Content

The objective of the corrosion module, EM 9, was defined as follows:

“The candidate will understand the basic nature of corrosion, its forms, and measuring techniques. This will enable the candidate to establish guidelines for reducing and controlling corrosion problems. ”

In organizing the corrosion module, a number of case studies were interspersed throughout the sections of the computer module. These case studies used the candidates’ background knowledge and provided

motivation for learning the more difficult aspects of corrosion. These case studies came from the candidates' everyday experiences, as well as from their experiences in the C.A.T. Introductory materials science textbooks¹⁻³ were used to divide the subject of corrosion into the following nine areas. Case studies are shown in parentheses.

- I. Galvanic corrosion (galvanized steel parts)
 - A. **Oxidation-reduction reactions**
 - B. **Standard electrode half-cell potentials for metals**
 - C. **Galvanic cells**
- II. Uniform corrosion (**automobile body panels**)
 - A. Coatings
 - i. Paint (painted steel automobile body panels)
 - ii. Tin (tin cans)
 - iii. Plastic (polyethylene coated underground gas lines)
 - B. Inhibitors (used on machined parts and in cooling systems in the C. A. T.)
 - C. Cathodic protection (used for underground gas lines and **ship** hulls and propeller shafts)
 - D. Uniform corrosion rates
 - i. Measurements
 - ii. Faraday's equation
 - E. Passivity
- III. Pitting (aluminum automobile radiators)
- IV. Crevice corrosion (poorly gasketed bolts)
- V. Special types of corrosion
 - A. Hydrogen embrittlement (plating environments)
 - B. Sensitization (welding of stainless steels)
 - C. Dealloying
 - i. Dezincification
 - ii. Graphitization (cast iron water mains)
- VI. Stress corrosion cracking
- VII. Corrosive wear
 - A. Erosion (pumps)
 - B. Cavitation (propellers)
 - C. Fretting (bearings)
- VIII. Oxidation
 - A. Mechanisms of oxidation
 - B. Protective oxide films
 - C. Oxidation rates
- IX. Testing and designing for corrosion control
 - A. Material selection
 - B. Environmental control
 - C. Laboratory corrosion tests
 - D. Designing for corrosion control

The material presented in the module is equivalent to the amount of material presented in 1 1/2 to 2 weeks of traditional classroom lecture. It is less than the content of one chapter in an introductory materials science textbook. However, it is probably more than a typical instructor would present in an introductory materials course.

Assessment

Self-check questions were scattered within each section after key information had been disseminated. These questions enabled the learner to apprise themselves of his/her understanding. A graded test for final evaluation was provided at the end of the module. The test consisted of 20 multiple choice questions.

Candidate Feedback / Conclusions

The corrosion module was designed for self-paced, computer based instruction. Most of the candidates did not have any contact with the course instructors until the Failure Analysis module (EM 10) was offered. (EM 10 is a project-based module.) An instructor was available one afternoon each week to answer questions about all the computer based engineering materials modules; however, few students used this opportunity to ask questions. Major concerns of the student candidates were as follows:

1. Many of the candidates chosen for the initial offering of this course did not have the necessary prerequisites (high school chemistry). Since the candidates at Focus: HOPE are nontraditional students, their academic backgrounds are varied and there are no systematic placement procedures. Some of the students placed in the Engineering Materials course were frustrated by their lack of proper background.
2. Overwhelmingly, candidates who were working 40-50 hours per week found that sitting at a computer for several hours in order to complete the corrosion module was tedious. Higher levels of interactivity would alleviate some of their boredom; however, the development time and cost for higher levels of interactivity are also higher. Most of the course developers at the six coalition universities probably do not have the time, the artistic talent, or the computational skills to create a highly interactive multimedia course. A dedicated authoring department, either at Focus: HOPE or at each coalition university, is needed.
3. There were not enough computers for each candidate to have his or her own computer at all the times they wished to work on the Engineering Materials modules. This was especially troublesome because the candidates in the class did not have their own computers during the time the instructors were there to answer questions. Some candidates logged onto a computer in the morning and then came and went, locking other candidates out of the course. Also, the computer lab at Focus: HOPE was not open on weekends. A university using predominately computer based instruction needs a computer for each student, preferably a laptop that the student can take home. A related issue is that Authorware does not have a "PRINT PAGE" option; any notes the student took had to be taken by hand, and they had no course text.
4. Although the course was outlined on the computer, students did not understand the requirements (e.g. how many modules, the sequential nature of the modules, time requirements to complete each module and the course). Requests for outlines and handouts were common. Students craved personal contact with an instructor, although most did not actively seek it out.
5. Logistical problems were rampant. Courses and rooms were frequently double booked. Three hours a week were scheduled for students to work on the engineering materials modules while an instructor was present.



However, candidates were often pulled from class to work on the shop floor. In theory, education at Focus: HOPE takes preference over production. In practice, this did not occur.

6. Due to the experimental nature of their course development work, all of the instructors tended to cover their subjects in much greater detail than they might have in a traditional classroom setting. In addition, each course had more than one instructor (Engineering Materials had four). Hence, the candidates were presented with more information than traditional students. To quote one candidate: "We're trying to satisfy too many people!" All the candidates work full time and most have families, so they have less time than traditional students to filter our important concepts and study.

Acknowledgments

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