Technology Enabled Curriculum for a First-Year Engineering Program


South Dakota School of Mines & Technology, Larry.Stetler@sdsmt.edu

Abstract - For the past three years, all first year engineering students at the South Dakota School of Mines & Technology have enrolled in a common introduction to engineering course. The course features a common curriculum contained on a course CD, utilization of technology tools, an engineering design project, and introduction to technical writing. All sections of the course are taught in a single classroom that is set up with tables and equipped with wireless notebook PCs. Technology tools are focused on collection, manipulation, and presentation of data using electronic portfolios, a permanent digital archive, spreadsheet tools, and data loggers. The use of spreadsheets for solving engineering problems is illustrated through example problems and several tutorial exercises that are both contained on the curricular CD. Portable data loggers are utilized in lab projects for collecting data that is then manipulated and analyzed on a spreadsheet. The design project requires students teams to function within specified design parameters, construct a simple device that is then used to collect data, analyze the data, and present the results both in an oral presentation and a formal technical document. In this paper, examples of technology uses in the curricular materials, engineering problems, and design projects used will be illustrated and discussed.

Index Terms - learning style, multi-media, technology

INTRODUCTION

As a response to changing practices in industry, the SDSM&T faculty initiated a revised curriculum for first year engineering students. Aspects of the curriculum have been taken and or modified from the EPICS program at Colorado School of Mines, the Foundation Coalition, and the SUCCEED Coalition, (see, for example [1, 2, 4-7, 15, 17]). Currently, the curriculum incorporates elements from project-based learning [5, 9, 17], cooperative learning [8, 15] and technology enabled learning [12,13].

Within three years, the program was expanded from a pilot of 25 students to a required course for all first year engineering majors. Currently, curricular materials include career exploration, team development through a semester-long project, and technology through applied problem solving and experimentation. Throughout, technical communication skills have been emphasized as well as data analysis and interpretation.

Course sections are limited to 25 students that are subsequently divided into five 5 member teams. All sections are taught in a common classroom that is equipped with tables and chairs (each team has a dedicated table), wireless notebook PCs, and an overhead computer projection system. There is also a sixth table that is used as a common work space. The course is 2 credit hours and is taught as a 1 hour lecture and a 2 hour laboratory session each week. In addition, several common 1 hour meetings are held each semester where all students come together for a required program activity. During a typical academic year, the program sees approximately 370 students.

FIGURE 1
GENERAL ENGINEERING PROGRAM CONCEPT MAP

INTEGRATION

An effective way to demonstrate interrelationships among different disciplines is through the integration of two or more courses. Such a concept is not altogether new and is currently being practiced in a number of engineering schools (see for example [1, 2, 4-7]). In the First Year curriculum, topics in general engineering were integrated with topics in math, English, and general sciences (i.e. Chemistry and Physics). In addition, relevant history associated with notable people in
engineering and science were incorporated through linkages with English. It was found that a multi-disciplinary approach was much easier to implement in the initial 25 student pilot of the program [9] than when the number of students increased to 370. Increased integration of numerous courses remains one of the goals of the program. A curriculum map outlining areas of study and linkages between those areas is shown below in Figure 1.

GOALS AND OBJECTIVES

The general engineering First Year curriculum attempts to address cognitive development within the context of engineering and science education. The model utilizes student teams and a problem based learning approach to solve simplified versions of realistic problems posed in engineering and science. Learning objectives and course outcomes are shown in Tables 1 and 2 below.

**TABLE 1**

**LEARNING OBJECTIVES FOR FIRST YEAR ENGINEERING**

To make the most of this course, it is recommended that students adopt the following five learning objectives to guide their priorities and actions during this term.

1. Be able to use technology tools (World Wide Web, Excel, PowerPoint, analysis software) to analyze, solve, and present solutions to engineering problems.
2. Become an effective team member.
3. Develop the communication skills necessary to package acquired technical and professional abilities that are required to succeed in engineering practice.
4. Understand the engineering profession enough to commit to a major and create an education/career plan.
5. Develop motivation for self responsibility, life long learning, and self development of a person of good character.

**TABLE 2**

**COURSE OUTCOMES FOR GE 115**

Upon completion of the course, students will be able to

1. Document a rationale for selection in their chosen major.
2. Author a web page and post to the Internet.
3. Incorporate the rules of significant digits when solving problems and check for dimensional consistency.
4. Incorporate the 7 step approach to solving engineering problems using engineering ethical standards.
5. Utilize spreadsheet tools to solve fundamental problems in engineering.
6. Use a data acquisition system to collect experimental data.
7. Utilize spreadsheet tools to analyze data and conduct a trend analysis on experimental data.
8. Utilize the fundamental principles of engineering design and team problem solving to design a rudimentary engineering system.
9. Utilize fundamental principles of technical writing to prepare a technical report, resume, and technical memorandum.

**TECHNOLOGY ENABLED LEARNING**

The first objective in Table 1 is centered around the concept of technology enabled learning. This objective in turn is supported by course outcomes 2, 5, 6, and 7 (see Table 2). For GE 115, technology enabled learning occurs in a variety of forms:

1. All course materials, supporting documentation, and supplementary tutorials are available on a course CD.
2. Assignments, course notices, and common reference material are posted to a course web site.
3. Curriculum incorporates an online literature search, web page development, and the use of spreadsheet tools to solve practical problems in engineering.
4. Students are required to maintain an electronic portfolio as well as post required documents to a digital archival system.
5. Individual sections may maintain a separate course management system specifically geared towards that particular section.

The remainder of this paper is devoted to a discussion of these elements as well as some assessment results of the technology and E portfolio elements.

**COURSE CD**

In the initial stages, curriculum development for the First Year engineering program centered around modules developed by the Foundation Coalition. It quickly became apparent that faculty buy in from all of the engineering departments necessitated a prolonged discussion of essential learning objectives and subsequent course topics. While useful, this final list also precluded the wholesale adoption of any curriculum. Indeed initial efforts required the use of several different texts that were then shrink wrapped as a combined text. Unfortunately, this was not very satisfactory for students who felt they were paying for several texts when only a portion of each was used.

Ultimately, curriculum development led to a text specific to the course content implemented at the South Dakota School of Mines & Technology (SDSM&T). Further, those instructional units are now available on the course CD. The course CD has several advantages in that curriculum can now be more effectively modified and adapted to the specific problems used in the First Year curriculum. In addition, instructional units can be directly integrated with and linked to supplementary tutorials and to online reference materials.
Figure 2 below shows a sample unit on the course CD with supporting reference material specific to that instructional unit.

In addition to the basic instructional units, additional tutorials are available for students requiring additional review or who simply want to explore more advanced topics in a particular area. There are a total of eleven tutorials covering topics in Excel for problem solving, charting and data analysis, Excel macros, and MathCAD. Each tutorial includes basic instruction over a particular topic, an activity designed to reinforce the instruction and a quiz exercise. A sample tutorial for charting and data analysis is shown below in Figure 3.

### COURSE MANAGEMENT

In addition to the course CD, the First Year program coordinator maintains a set of web pages for both students and faculty. The GE 115 course page contains assignments, notices, and supplementary material for students. In addition, it contains reference material for the semester project. The faculty web page, which is password protected, contains resource material and problem solutions for faculty.

In addition to online reference materials, many of the section instructors maintain a course management web site. All course management in the South Dakota Higher Education system utilizes WebCT. Course management sites allow faculty to post service links and other items of interest to students. The most common usage of a course management site (see Figure 4 below) is to provide a mechanism for increasing student-faculty and student-student interaction through the course messaging system. In addition to facilitating student interaction, the course management system is also useful for providing prompt feedback through the online grading module.

### STUDENT PORTFOLIOS

Each student is required to author and maintain an electronic portfolio. Students are required to post common spreadsheet assignments related to problem solving and data analysis to
this portfolio. The technical project and laboratory experiment report are also required to be posted. While the portfolio requirement was initially used as a mechanism for assessing student work, it is now used primarily for developmental purposes [12, 13]. A sample student portfolio page is shown in Figure 5 below.

In addition to having students maintain a portfolio for professional development reasons, the portfolio was also initially used for program assessment. However, as students progressed through the curriculum, elements of the portfolio would eventually be replaced by alternative assignments. Accordingly, longitudinal assessment of student growth became impossible under a student controlled portfolio. Consequently, in addition to required postings to their portfolio page, students are also required to post some elements to a digital archive system for assessment purposes (see Figure 6). Postings required for both the portfolio page and the digital archive are listed in Table 3 below.

TABLE 3
REQUIRED POSTINGS OF TECHNOLOGY ELEMENTS

<table>
<thead>
<tr>
<th>Web Page</th>
<th>Discipline Memo</th>
<th>Code of Cooperation</th>
<th>Resume</th>
<th>Problem Solving Exercise using spreadsheet tools *</th>
<th>Data Analysis using spreadsheet tools</th>
<th>Experimental Report</th>
<th>Technical Project Report</th>
<th>First Year Summary *</th>
</tr>
</thead>
</table>

The digital archive system was developed internally as a means of promoting portfolio assessment. The digital archive eliminated the need for cataloging mountains of student work and ensures that work accomplished in the freshman year is available in later years for longitudinal assessment regardless of any changes in a student’s major.

ASSESSMENT AND EVALUATION

Assessment is accomplished by selecting 25 students at random from all sections. Student work is then pulled from the digital archive and compared by a team of GE faculty members using rubrics adapted from rubrics developed at the Colorado School of Mines [16]. Rubrics are posted to the student web page [20]

Analysis of the spreadsheet assignments include two content areas: solving engineering problems and performing engineering data analysis including fitting and interpreting trend lines using spreadsheets. Assessment results for the spreadsheet assignments are shown in Figure 7 below. Assessment of technical writing was performed through analysis of a final project report that focused on the four areas shown in Figure 8 below.
While it appears from Figures 7 and 8 that student progression in problem solving and technical communications is satisfactory there is substantial room for improvement in the area of data analysis.

Although student self-assessment of course outcomes is not generally considered very reliable, it was utilized in GE 115 as a means of assessing student perceptions of growth in use of the technology tools used in the course. The radar chart on the left in Figure 9 shows student perceptions at the start of the semester and the radar chart on the right shows student perceptions at the end of the semester.

![Figure 9: Student Perceived Gains in Use of Technology Tools](image)

**Course Improvements**

In general, assessments indicate substantial learning gains in engineering production tools; e.g., spreadsheets tools, presentation software, data acquisition, etc. Students also seem to enjoy the multi-disciplinary approach and the exposure to a variety of engineering disciplines. However, students also continue to express concerns over perceived discrepancies in instructional support and content coverage between sections. Faculty concerns include increased flexibility for students to advance in skill areas already mastered and a strengthening of the units on problem solving and data analysis. Current improvements include a strengthening or problem solving exercises, a reorganization of the data analysis unit, and a reorganization of the experimental and data acquisition unit. In addition to the existing assessment tools, a reintroduction of student focus groups is under development for the coming year. Assessments for team development through the projects are currently under evaluation.

**Future Directions**

Future directions for the First Year Engineering curriculum involve inclusion of many of the components from the initial pilot program that have been lost upon expansion. Specifically, curricular content in English and GE 115 will be more closely integrated between linked sections. Similar linkages are anticipated in coming semesters with Freshman Math, Chemistry and Physics. Plans are also being developed to incorporate mentoring within the GE 115 curriculum. Finally, the GE 115 faculty are working closely with Student Affairs and other campus entities to develop a learning community and a more comprehensive First Year experience.

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**References**


**BIOGRAPHY**

**Larry Stetler, Ph.D.**, Dr. Stetler is an Associate Professor of Geological Engineering and 1st-year engineering program coordinator. He oversees all aspects of the program and performs assessment of the 1st-year engineering program with other key faculty. Dr. Stetler has authored 16 technical papers appearing in journals and archival publications. His research interests include landscape evolution, engineering geology, and mechanics of particle transport. Dr. Stetler is a member of the Geological Society of America, Association of Engineering Geologists, and the American Society for Engineering Education.

**Stuart Kellogg, Ph.D.**, Dr. Kellogg is Professor of Industrial Engineering at the South Dakota School of Mines & Technology where he currently serves as coordinator of the Industrial Engineering and Technology Management programs. In addition to pedagogical issues related to engineering education, his research interests include applied and numerical probability models in the industrial environment. He has published works *Mathematics and Computers in Simulation, Proceedings of IIE Research Conference, Quality Engineering*, and *Proceedings of the Joint Statistical Meetings*. Dr. Kellogg is a member of the Institute of Industrial Engineers and the American Society for Engineering Education.

**Jon Kellar, Ph.D.**, Dr. Kellar is an Associate Professor of Materials and Metallurgical Engineering at the South Dakota School of Mines & Technology. In addition to pedagogical issues related to engineering education, his research interests include surface chemistry and micromechanical testing of composite materials. He has published works in *Langmuir, Composite Interfaces and the Journal of Colloid and Interface Science*. Dr. Kellar is a member of the Society for Mining, Metallurgical and Exploration and in 1994 was selected as a National Science Foundation Presidential Faculty Fellow.