Foundation Coalition First Year Integrated Engineering Curriculum at Texas A&M University-Kingsville: Development, Implementation and Assessment

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Abstract

This paper presents a first year integrated engineering curriculum that was implemented at Texas A&M University-Kingsville in the 1995-96 academic year. The curriculum is the result of the efforts by the Foundation Coalition, a National Science Foundation sponsored engineering coalition of 7 institutions around the United States. The goal of the Colaition is to implement curriculum reform in engineering education. In line with the goals of the Foundation Coalition, this curriculum was designed to incorporate changes in four major thrust areas: curriculum integration, technology enabled learning, human interface development, and assessment, evaluation and dissemination. Traditional first year courses in Science, Engineering, Math, and English, have been modified such that topics are delivered based on a predefined sequence which emphasizes basic skills and thematic concepts rather than discipline boundaries, and problem solving strategies, and design. Active learning, or collaborative learning, is also being used in the classroom.

Introduction

The current first year integrated engineering curriculum at Texas A&M University-Kingsville (TAMUK) was developed from a commitment made by TAMUK, together with six other Foundation Coalition (FC) partner institutions, to provide a foundation that will ensure student development and life-long learning in engineering education [1]. The FC is an engineering coalition funded, in the Fall of 1993 by the National Science Foundation (NSF). Coalition partners are: Arizona State University, Maricopa Community College District, Rose-Hulman Institute of Technology, Texas A&M University, Texas Women's University, and The University of Alabama-Tuscaloosa and TAMUK. The FC is also committed to offering both freshmen and sophomore curricula, as well as introducing changes to junior and senior years.

The changes the FC is introducing in engineering education are not isolated since several institutions in the United States and around the world, and revising and changing engineering curricula in rather innovative ways [2,3]. Many of these changes are driven by today's global multidisciplinary industrial environments, where in addition to technical knowledge in their fields, engineers are required to understand and apply several disciplines in the solution of complex problems. In addition, they need to be flexible and adaptable to new technology and changing situations, combine ideas to synthesize creative solutions, work effectively in teams, have excellent written and oral communications skills, and be highly productive [2].

In line with the goals of the FC, TAMU-K's first year curriculum has been developed to incorporate changes to the traditional curriculum in four major thrust areas: (1) curriculum integration to de-emphasize discipline boundaries, (2) technology enabled learning, (3) human interface development to foster improved student-student, student-faculty, and faculty-faculty interactions, and (4) assessment, evaluation, and dissemination for continuous improvement [1].

Curriculum Integration

An effective way to show students the inter-relationships among different disciplines and topics within them, is the integration of two or more courses [4,5]. One of the most highly integrated first year engineering curriculums is the one developed at Rose-Hulman Institute of Technology. In this curriculum a whole set of traditional first year courses totaling 37 quarter credit hours completely replace three 12 credit hour integrated courses [5]. Topics are given to the students without explicitly identifying discipline boundaries, and arranged such that links between topics in different disciplines are constructed. At TAMU-K, it was decided that the best way to integrate courses, for this prototype was as follows. First, take traditional courses taken by most engineering majors during each semester in the first year, and schedule them back-to-back in 2-3 hr. blocks of time. Second, review, revise, and reorganize course content based on fundamental areas students need to master by the end of the first year; and third, strive for enrollment in these courses by a group of students from several engineering disciplines.

Table 1 illustrates the courses selected for integration. The computer based graphics design courses deal with CAD, solid modeling, and C programming. The University Success class is a university wide course which has been designed to increase the likelihood of student success, by assisting the student in developing personal, academic and life skills necessary to formulate and achieve educational and career goals.

Table 1. Integrated First Year Courses

Fall Semester	Hr.
Chemistry I w/Lab	4
Analytical Geometry	3
Computer Based Graphics Design I w/Lab	3
English I	3
University Success	2
Total	15

Spring Semester	Hr.
Chemistry II w/Lab	4
Calculus I	3
Computer Based Graphics Design II w/Lab	3
Physics I w/Lab	4
English II	3
Total	17

Integration of course material started with a review of topics being covered in each class. Then, following the approach used at Rose-Hulman Institute of Technology to develop their first year integrated curriculum [5], course contents were reorganize and revised based on three fundamental areas students need to master by the end of the first year. These areas are basic skills, thematic concepts, and problem solving strategies and design. Basic skills being emphasize include units, constants, variables, parameters, concept of functions, vectors and scalars, two-dimensional and three-dimensional visualization, teaming, active learning, and writing across the curriculum. Most of these skills were delivered via the courses in the Fall semester. Thematic concepts being targeted include rate of change, accumulation, equilibrium, conservation principles, and statistical phenomena. Emphasis in these thematic concepts minimizes discipline boundaries and provides a way of integrating topics. Finally, problem solving strategies and design emphasize problem definition with emphasis on conceptual, methodology/ structure aspects, formulation, solution interpretation, alternate solutions and design, and use of technological tools to solve problems.

After revising the courses, a weekly tentative integrated syllabus was developed for the Fall Semester, and the backbone of the Spring semester defined. Since the beginning of the Fall 95 semester, faculty met weekly to further revise and change the integrated weekly syllabus as needed. Since the integrated syllabus was revised once classes began, the syllabus for the Spring semester was only generated the three weeks at a time only. During the weekly meetings, each instructor explained or gave a briefing on how his/her class was going that week. These meetings proved to be very valuable and important for instructors to become aware of their courses, and the courses of other faculty and to further plan ways of achieving the desired integration (i.e., integrated assignments, homework, and integrated tests, which were given every 3 weeks on Friday). Students were also given the integrated syllabus each week. Instructors also tried to visit each other's classes to further enhance their awareness as to the level of integration being used.

Three design projects in the Fall, and two in the Spring semester were given to incoporate design into the curriculum. Most of these design projects were developed in the Summer of 1995 by an interdisciplinary team of engineering faculty. These projects were assigned in the University Success course, the computer based graphics design courses, and the physics course. Particularly significant has been the integration of English with the reports required from the students for each design project. A standard format for writing technical reports was adopted and used in the curriculum. In addition, students wrote a technical research paper in the Spring semester dealing with a topic in their major, as part of the English class. The introduction of design in the integrated curriculum also comes in response to ABET Criteria 2000, that the Accreditation Board of Engineering and Technology will use in the future to accrediting engineering programs in the United States. [6].

While grades were primarily determined by each instructor in his/her class, part of the grade in each class came from integrated assignments and tests. This practice emphasizes to the students the importance of every discipline in the curriculum. Standard textbooks were used and it was up to the instructors to link the material. An exception was the English class where instead of traditional English text, books like Flying Buttresses, Entropy, and O-Rings: The World of an Engineer by James. A. Adams, The Culture of Science by J. Hatton and Paul B. Plouffe, eds., and Researching and Writing in the Sciences and Technology by Christine A. Hult, were used.

Technology Enabled Learning

The incorporation of technology in the curriculum was greatly facilitated by the design and renovation of a high tech classroom located in the Physics building on campus. The design of the classroom was done using input from faculty teaching in the curriculum, as well as computer hardware and software experts. The classroom has twelve multimedia 486 based computers place around the periphery of the room for student use, one faculty computer at the front with an LCD panel display, a laserjet printer, and a Pentium based computer that controls the network. The classroom is designed for up to 24 students (2 student per computer). More details of this classroom can be obtained from reference #7. Software available for the curriculum included MAPLE, a mathematics software, Microsoft Office (w/ WORD, EXCEL, and POWERPOINT); CADKEY, a computer aided engineering drafting software; a C language compiler; ENCARTA, an electronic encyclopedia; and TELNET, for access to E-mail and Internet. Students used these software packages throughout all classes. Faculty and students were strongly encouraged to use E-mail as a communication protocol. Early in the Spring semester, it was decided to also use MATHEMATICA as a math software, since it can be easily integrated with C programming. Solid modeling was taught using I-DEAS, an integrated design engineering analysis software. However, this program is available only in the Mechanical and Industrial Engineering Computer Lab which is equipped with SUN workstations needed for this application.

This high tech classroom readily allowed for the integration of technology into the curriculum which students used to solve problems, write reports, make presentations, communicate electronically, and explore the vast information network available. The skills they are developing are a necessity for survival and in today's highly technological workplace.

Human Interface Development

One of the primary roles human interface development plays in the FC is to foster improved student-student, student-faculty, and faculty-faculty interactions. For this purpose, collaborative learning and teaming is an active component of this curriculum. Collaborative learning in the classroom involves the use of carefully structured groups such that students are cognitively, physically, emotionally, and psychologically actively involved in constructing their own knowledge. It is a way to change the passive often impersonal character of many college classrooms [8]. As such, it provides an active learning environment, and carefully used, promotes high levels of student-student, and student-faculty interactions.

In order to facilitate this aspect of the curriculum, three areas have been addressed. The first one deals with the incorporation of an environment conducive to the use of active/collaborative learning and teaming in the high tech classroom described previously. For this purpose, the classroom has six 4 feet diameter tables with padded chairs and rollers that allow students to work collaborative in class. The tables are placed in the middle of the room surrounded by the computers so students have easy access to the tables or computers as needed. In general, the collaborative learning model being used is the one described by Johnson et. al [8]. Second, a collaborative learning/team training workshops have been organized for students and faculty. In addition, collaborative learning training was planned at the beginning of the Fall semester as part of the University Success course. Third, activities that improve faculty-faculty and student-faculty interactions have been supported. For example, students have been asked to organize outdoor social events that include FC faculty members. Also, at the beginning of the Fall semester, students were placed on base groups where they could provide peer support for each other. As described by Johnson et. al [8], base groups should allow students to provide support, encouragement, and assistance to keep up with school, and hold each other accountable for striving to make academic progress. Finally, high levels of faculty-faculty interactions are being achieved since the only way to successfully implement this integrated curriculum is if faculty communicate with each other and develop a sense of a community and cooperation among themselves.

Evaluation and Assessment

The last major component in the design of this first year curriculum is the establishment of a continuous improvement process via evaluation, assessment, and dissemination. The FC nationwide has chosen several standardized tests that can be used in a pre and post test fashion to evaluate and assess its efforts to modify engineering curricula. At TAMU-K, the California Critical Thinking [9], and Myers -Briggs [10] tests are administered to FC students during the Fall semesters. The rationale for using pre and post testing is to see if students show improvements as they progress in their education and complete the FC curriculum. With these tests, changes in their critical thinking abilities and personal attitudes and types are being measured. With respect to technical knowledge, Hestenes' Force Concept Inventory & Mechanics Baseline tests have been selected. The Inventory test is given to determine student preconceptions about mechanics while the Baseline is used to test actual knowledge of mechanics. Therefore, the Inventory is the pre-test, while the Baseline is used the post-test. These tests have been shown to be useful in determining how well students learn mechanics, and the effectiveness of methods used to teach this subject (i.e., passive vs. active learning) [11,12]. Traditional engineering students are also being tested to compared them with FC students. The FC is currently working on additional testing tools to assess student overall performance once they graduate. Testing will be done in the junior and senior years as well.

Several other tools are being used continuously to assess the curriculum. These include student and faculty surveys, focus group interviews, plus/delta feedback, and student journals. Student surveys have been designed to assess student attitudes towards collaborative and team learning, to monitor individual skills needed to work in teams, and to evaluate the effectiveness of teams in accomplishing tasks. Faculty surveys across the FC are being planned to document faculty attitudes, problems, and changes as a result of participation in the program. Focus group interviews with students during the semester have proved to be an excellent way to provide student feedback to faculty teaching the integrated courses, identify and resolve various issues/problems and/or conflicts, and change the curriculum when needed. FC students are helping fine tune the curriculum. Plus/delta sessions for student and faculty provide a way of highlighting the strengths of the program (plusses), and suggesting possible solutions to problems (deltas). Finally, as part of the English class, FC students are required to keep a personal journal (2-3 entries/week) during the Fall semester. The purpose of the journal is to motivate writing, provide a tool to see individual progress in academics, and a mechanism for student reflection on the curriculum.

Student Cohort for Integrated Curriculum

A cohort of 24 students were invited to participate in the integrated curriculum for the 1995-96 school year. Participation was on a voluntary basis, but subject to the following requirements: ACT greater than 19 or SAT greater than 900 (with some exceptions), and freshmen status with a declared major in mechanical engineering, industrial engineering, chemical engineering, and civil engineering. These departments agreed to allow their students to participate in the FC curriculum. At the beginning of the Fall semester, the student profile was: 25 % White males, 12.5 % White female, 37.5 % Hispanic males, 20.8 % Hispanic female, and 4.2 Asian male. Hispanic minority representation in the integrated curriculum was similar to the overall student profile in the College of Engineering at TAMU-K. However, the percent of women students in the FC was higher than the current enrollment of women in the College.

During the fifth week of class in the Fall semester, 3 female students withdrew from the FC and the University. Reasons cited for this withdrawals included dissatisfaction with grades, FC was not what was expected, personal (family related) and health reasons, and working 15-20 hr/week. At the beginning of the Spring semester, 13 students decided to continue participation in the program and 2 new students joined the program. Out of 21 students that completed the Fall semester, 8 dropped out of the program. Some of the reasons for not participating in the Spring semester included: change of major, moving out-of-state, low GPA, and decision not to commute. Another problem with the curriculum was poor performance in Chemistry, which students attribute to their pwn weak Chemistry background. However, this is not unique to the FC curriculum, but also a major problem at TAMUK.

The student profile in the Spring semester was 33.3 % White male, 46.7 % Hispanic male, 13.3 Hispanic female, and 6.7 % Asian male. Of the 15 students that started the Spring semester, 10 students will joined the second year engineering curriculum being planned for the Fall semester 1996. While all 15 students expressed their desire to remain the FC, 5 students can not continue because of low GPA.

Currently, more evaluation and assessment is being conducted to detail the deficiencies associated with the curriculum, so that corrective actions can be taken for the next offering of the first year integrated curriculum in the Fall of 1996. For example, due to the low performance in Chemistry, a 2 week Chemistry bridge program has been established for August 1996, and supplemental instruction sessions with extensive problem solving using collaborative learning have been planned for both the Fall and Spring semesters. Also, data is being collected and analysed to compare FC students performance in each class, compared to other engineering students and non-engineering students. While these results were not ready at the time this manuscript was due for printing, they will be presented at the conference in November of this year. Finally, the national FC has appointed a team to study the high droppout rate of women throughout the coalition.

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