"Nine Years of Engineering Educators: The Foundation Sequence in Civil Engineering at the University of Memphis".

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Abstract

This presentation is a summary of the continuing evolution of the Foundation Sequence courses in the Civil Engineering program at the University of Memphis. The Foundation Sequence was originally a three-course sequence in the freshman/sophomore year that was developed with the goal of integrating design skills, communication skills, and computation skills. The current iteration is a four-course sequence that has expanded to incorporate graphics. During these nine years, our faculty members have been continually challenged to meet the changing demands of the students, the Civil Engineering faculty, the changing technology of the information age, and of the profession in general. In particular, the focus of this paper is how this changing technology has resulted in curricular changes.

Introduction/Background

This paper presents a retrospective view of the continuing evolution of the Foundation Sequence courses in the Civil Engineering program at the University of Memphis. In 1994, The Foundation Sequence was originally a three-course sequence in the freshman/sophomore year developed with the goal of integrating design skills, communication skills, and computation skills. In 2003, The Foundation Sequence is composed of four courses with the original goals at more complex and analytical levels, and with the integration of graphical skills.

In summary, the current iteration is a four-course sequence that replaced a more traditional sequence of courses over a nine-year period. Originally, three of the courses were offered in the Civil Engineering department and one in the Mechanical Engineering department. More specifically, these changes have occurred as a result two concurrent processes: (1) continual feedback from our program constituents: our students, our alumni, their employers, our advisory board committee; (2) continual awareness of the changing technology of the information age, and of the profession in general. Each of these factors involves the distribution and transfer of information, and our paper presents three discrete areas of change:

(1) Content Information: How the engineering-specific content engineering students required for successful practice as professional engineers has changed over the past decade, and how our classes have changed in response to those demands.

(2) Psychosocial Information: How the integration and application of communication skills, presentation skills, and problem solving strategies have been influenced by evolving technology and the attempts we have made to incorporate critical skills required in use of the information age technology.

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(3) Professional Information: How examples and models of the information integration in the examination of contemporary engineering issues, engineering ethics, and professional responsibilities required of design professionals in the information age has been incorporated in our courses.

We have used a system of continual assessment as a systematic approach to meeting these goals, to measuring our progress, and to incorporating feedback into the future of our program. Hopefully, our experiences and this nine year retrospective report will provide examples, templates, and educational research models, and encouragement to engineering educators across the country.

Background Information

With the beginning of the 1993-1994 academic year, the Civil Engineering department offered three courses at the freshman/sophomore level and one course at the sophomore level taught by the Mechanical Engineering department. The three courses offered by Civil Engineering were courses that had their roots in departmental changes of the late 1980s. One course was an introduction to surveying and was shared with an architectural technology program. It was devoted to traditional methods of surveying with the introduction of some recent technology through the use of electronic data measurement. Topical content had not changed substantially from the early 1970s with the exception of some utilization of the college's mini-computer. The second course was a course in the utilization of microcomputers and included fundamentals of use of the operating system, word processing, and spreadsheet fundamentals. The third course was a traditional FORTRAN programming course, taught on the campus mainframe computer. The final course was a graphics course that emphasized the utilization of AutoCAD for the development of engineering drawings.

None of the courses were prerequisites for any other courses in the engineering sequence. The courses had been unchanged by curricular changes and were not well integrated into the departmental goals. Also, the courses were often relegated to be taught by graduate students, new faculty, or faculty members with small enrollment levels in upper-division courses. No faculty member was assigned to these courses on a regular or consistent basis, and there was no connectivity between the three classes. Unsurprisingly, the level of both student and instructor interest was usually low. Students would put off taking these classes until they "fit in the schedule" and consider them as just hurdles with no real meaning in their academic plans.

In addition to these concerns, members of the Departmental Advisory Board expressed concerns about the communication ability of our graduates through department surveys and interviews with our department chair. While most member of the committee believed that our graduates were technically proficient, they were much less satisfied with their ability to write or to deliver an oral presentation. At the time, there were two classes in our undergraduate civil engineering program that required oral presentations, and both of these classes were offered in the final year of the student's work. Writing was limited to formal lab reports and to a class offered by the English department in technical writing.

In response to constituent feedback, two of the Civil Engineering faculty members, Dr. Charles Camp and Dr. Paul Palazolo, offered to revamp the three Civil Engineering courses to try and integrate communication into the course work. Retrospectively, our department was not alone in facing issues such as these. Newberry and Farison (2003) discuss the changes taking place within departments that offer "general engineering" programs, and they predict that unless these programs adapt to local constituency needs, they will be extinct. Newberry and Farison further separate these programs into three discrete types: instrumental programs, flexible programs, and philosophical programs with the prediction that only the flexible engineering programs are likely to succeed in the long term. While we used different terms, our strategies mirrored those of the flexible engineering programs described by Newberry and Farison. We began with a micro-level analysis of methods to integrate communications into our existing courses, and found ourselves adopting more of a macro-level perspective on the courses themselves as they fit into the rest of the curriculum.

Evolutionary Curricular Changes

During the summer of 1994, a complete revamping of the courses was undertaken. It was decided to integrate the computer use class into the surveying class and add much more emphasis to design and communications through projects which would require both of these skills along with the technical skills of surveying and computer usage. A fundamental set of surveying skills was identified and considered as a critical component, but a number of skills that had been part of the classes previously were abandoned. Replacing the surveying skills were new skills in materials, through a concrete design problem, and environmental ideas, through a water treatment design problem. Three problems were posed each semester, one in land development, one in concrete beam design, and one in water treatment. Each problem had a design component as well as both a formal written report and oral presentation.

Similar problems were proposed for the second semester with additional constraints and parameters added to the design problems. The FORTRAN course remained relatively unchanged at this point. As with any change, there was resistance from faculty members with the charge that necessary skills were being lost and replaced with skills that were either more appropriate in the upper-division (design) or in other departments (oral and written communication). In addition, the available lab equipment was not well suited to these types of exercises. Fortunately, our department chairman was willing to invest in the ideas and made funds available for equipment and supplies.

The course projects evolved over time, and the next major change came in 1997 when the first two courses were made prerequisites to any course in Civil Engineering at the sophomore level or higher. While this posed new difficulties for transfer students, our other faculty members were supported on the basis that they were beginning to see increased competencies of the students in their upper-division courses.

The next major change came in 1998 when greater emphasis was placed on the FORTRAN class to bring it into line with the first two classes. A decision was made to shift the programming language to Visual Basic within EXCEL and to develop more projects that required programming competency to complete. In addition, the same emphasis that had been placed on communication in the first two courses was to be carried into the third class. This change was met with mixed success.

In 1999, a technical writing instructor, Ms. Anna Phillips-Lambert, was added to the teaching team. Prior to her joining the team, Camp and Palazolo had attempted to teach both the communication and technical/design aspects of the courses. With the addition of Phillips-Lambert, a more rounded and balanced communication component was achieved. Also, in 1999, the programming class was shifted from Visual Basic within EXCEL to Visual Basic alone because we believed that without the necessity of using the EXCEL object model, learning to program would become less difficult.

The most recent change came in the 2002 when the fourth class was transferred from Mechanical Engineering into Civil Engineering. The Mechanical Engineering department moved to a program more suited to their needs, and the teaching of graphics was given to Civil Engineering. It was decided that programming and graphics would be combined in the two courses so that both topics would have a whole year of exposure. This year, 2003, is the second year that the program, now termed the Foundation Sequence, has extended over four complete semesters.

Content Changes:

In the nine-year-time-period, there has been a substantial shift in the amount of engineering-specific content required to operate successfully as a professional engineer. New information must be combined with existing information and new methods/techniques must be presented in conjunction with an awareness of the previous methods/techniques in order to produce engineering students with solid, substantive engineering backgrounds, so our content has shifted to meet these expectations. As an example, Table 1 presents the evolution of major topic areas in our Foundation Sequence Courses.

Table 1: Example Evolution of Course Topics

	1993	1998	2003
Surveying	Full course; distance measurement, leveling, boundary surveys, isolated problems	Part of two courses: topographic survey leading to cut and fill design problem	Part of four courses: topographic and boundary surveys, land development problems, drainage problems, construction estimation
Computer Usage	Complete class: Formal instruction in DOS, Word, and EXCEL	Class segments in how to develop technical documents, information gathering from on-line sources, use of EXCEL for computational analysis	Topic specific focus on utilization of computer tools to support the design process
Programming	Complete Class: FORTRAN	Complete Class: Visual Basic	Development of programming skills in support of project analysis, development of macro-programs in EXCEL
Graphics	Complete Class	Complete Class	Integration of visualization as a design skill, topic specific skills development in AutoCAD
Design	None	Six design project over the first two classes	Twelve design projects over two years
Written Communication	None	Eight formal design reports over the first three classes	Twelve formal design reports and four poster presentations over two years
Oral Communication	None	Seven oral presentations over the first three classes	Ten oral presentations over two years

Implementation changes:

Our department has taken a rather unusual approach to addressing the problem of teaching/evaluating technical communications skills by hiring a faculty member outside the engineering discipline with specific expertise. This faculty member works in collaboration with the other Foundation Sequence faculty members by team-teaching the freshman-level courses in the sequence and by providing editing and evaluation assistance to the sophomore-level courses in the sequence. Students are taught how to integrate their existing word processing and writing skills with their recently acquired Excel skills, and each project culminates in a formal technical report with a PowerPoint presentation. The technical communications faculty member is in charge of introducing the criteria associated with the technical communication aspects of the course, and she handles the evaluation of the technical communications portion of the course. Student groups are given significant feedback on their performance through working sessions on their writing to de-briefing sessions where their oral presentations are critiqued from video tape and from peer review information.

Problem solving skills/technology issues

Before the introduction of the current courses, the emphasis on the courses was on development of technical skills related to the current topic. For example, in the introduction to microcomputers course, word processing exercises would be given that only had as a learning goal the development of word processing skills with no connection to the content involved. While the exercise might be topically related to civil engineering there was not linkage between the utilization of the skill and the process of doing engineering. With the introduction of the new course work, skills were presented as “just in time” in order to complete some facet of an engineering design.

Design itself was introduced in the new sequence. A heuristic for solving design type problems was introduced and reinforced during the entire Foundation Sequence. A text was selected to support this effort and close integration between the design projects and the methodology being modeled was emphasized. Students were expected to utilize the technical skills being developed in support of engineering design. Computations and graphs were expected to be developed in EXCEL, written documents in WORD, and visual support of oral presentations in POWERPOINT. Initially, a significant fraction of the class time was devoted to this integration but as the students entering the program become more sophisticated in the use of these common tools, the focus was able to shift to more emphasis on the content rather than on the tools.

Critical thinking skills/technology issues

Prior to 1994, our program faculty did not introduce the concept of design comparison/design analysis into the four courses. With the introduction of the new courses in 1994, it was decided to utilize formal instruction in the design process in the courses and to have the students participate in design projects with ill-defined, real-world problems. While this required that the students accept some technical material without the usual supporting coursework, all of that supporting coursework was still available in the upper-division courses. Students were given limited information and guidance on what would be a “good” design and were allowed to design experiments that would explore the design space either through modeling or physical testing.

Prior to the introduction of the new courses, little emphasis was given to the generation of alternatives and to the selection of a problem solution based on goals and constraints. With the exception of the surveying class, little field data was used in the classes. With the shift in emphasis of the new classes, more and more data was collected by the students. The addition of equipment to aid in this process accelerated the shift from instructor-provided data to student-collected data. In a number of design projects, the students actually select what types of data they wish to collect and how it is collected under instructor supervision.

The burden of analyzing information critical to the design process has shifted to the students. While general goals as modeled from industry are presented, the students are often only given limited information on the constraints and have to make their decisions on what constraints are applicable. During the nine years, some students have moved far beyond what the instructors expected. An example is in the design of a concrete beam where the students did such a good job of design that it exceeded the limits of the testing apparatus that was in place (it has since been replaced). Samples of the projects are available at www.ce.memphis.edu/1101 and www.ce.memphis.edu/1112.

Professional Information:

The original second course was the direct descendant of an introduction to Civil Engineering course which presented the sub-disciplines of Civil Engineering in lecture format with the possibility of a guest speaker detailing just what a specific type of Civil Engineer encountered in their professional practice. While the students heard just what each type of engineer did, there was no hands-on work in the same area. The Foundation sequence draws problems from all areas of Civil Engineering and allows the students to do lab work and design work which is typical of each type of area. One area which had been lacking was water resources but with the addition of a tilting flume, this area should expand in the next academic year.

Contemporary issues

As a result of feedback obtained from student surveys and input from our professional Advisory Boards, we are implementing more contemporary issues into the courses. Projects are including a regional component by posing the problems based on communities in the area and attempting to make linkages to items which have been in the public view over the last few years. This is still in development but plans are underway to use a Sooner City model to more closely link the projects to the community. Examples of projects from the Sooner City model are available at www.soonercity.ou.edu.

Engineering ethics

In the 2002-2003 academic year, the issue of incorporating a stronger ethics component into the sequence was proposed by upper-division faculty in the department. While this has always been considered as part of the sequence, no specific exercises were included in any of the classes. As of this semester, ethical problems are being presented as part of the design process and communication exercises are used to focus the student's attention on the ethical responsibilities inherent in Civil Engineering.

Professional responsibilities

One of the most interesting components of the process was the integration from the start of teams to work on design projects. While it was originally made to model how engineering teams work, it had a number of significant learning outcomes, which were not foreseen in the original plan.

Students began to understand that unless everyone becomes involved, the team is rarely successful. Over the nine years, a number of groups of students who have had members with a record of academic success have not been successful. The work requirements of a typical project are such that a full team effort is usually necessary for success. A sense of professional responsibility develops in the successful teams and each member provides for a critical component.

Discussion/Recommendations

It is well known that an essential component of any evolutionary change is assessing the product that results from the change and in our ongoing project, that theory is applied to both product and process. As constituent needs have fluctuated, teaching methods have had to be adapted to meet the new needs. One important pedagogical adaptation is a shift away from the content-centered paradigm toward a more learning-centered paradigm (Fink 56). Basically, this means that faculty members teaching in our Foundation Sequence have had to educate themselves about learning processes and paradigms, and in doing so, most have adopted a sort of hybrid paradigm that mixes the solid engineering content needed by freshman/sophomore engineering students with the learner-centered methods that promote multi-dimensional thinking and encourage multiple solutions to the same problem. These pedagogical shifts have worked well with the changes described above. In turn, these pedagogical shifts have filtered upward and had an impact on all the courses taught in the department.

From an initial apprehension of the changes being made, the faculty has now become very supportive of the work. Students exiting the Foundation sequence have served as wonderful advertisement for the program to both the upper division faculty and to advisory boards for the department and the college. As a result of the performance of these students in their other classes, both the Mechanical and Electrical Engineering departments have revamped their introductory courses to follow the models used for the Foundation sequence.

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