The Foundation Coalition Freshman Year: Lessons Learned

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Abstract

Three years ago, mathematics, science, and engineering faculty at the University of Alabama (UA) designed a new set of freshmen courses which integrate science and engineering topics, promote active learning, and incorporate computer tools. The new courses have now gone through two cycles (1994-95 and 1995-96 academic years). The original goals of the new courses are presented followed by discussions of some of the advantages and disadvantages of the approaches.

FC Educational Goals

Development of the new courses was supported by the NSF Foundation Coalition (FC) which is made up of seven schools (Arizona State, Maricopa Community College, Rose-Hulman Institute of Technology, Texas A&M, Texas A&M - Kingsville, Texas Women's College and UA). Faculty at the other FC schools are involved with related curriculum development efforts and the UA faculty drew on their ideas and experiences to develop and implement the new courses.

Freshmen students undergo a major life-change upon entering a university and are particularly impressionable during this period, especially in the first semester. The FC faculty work hard to build good academic habits and to instill an enthusiasm for learning in the freshmen students during this window of opportunity. The intention is for the freshman year to provide an environment in which students can build a strong foundation to support a quality university education. The Foundation Coalition strives to provide an enhanced learning environment via three thrust areas.

Curriculum Integration All students in the FC curriculum enroll in a Math, Physics, Chemistry, and an Engineering course each semester. Arranging the topics in these courses so that students learn related topics simultaneously promotes a broad-based level of understanding rather than a more narrow discipline specific understanding.

Active Learning Decreasing the amount of lecture and increasing the opportunities for students to interact during class periods stimulates students and enhances understanding by letting students manipulate concepts verbally as well as manually.

Technology Enabled Education Incorporating modern computer software throughout the curriculum frees students from many monotonous tasks such as plotting data and integrating long equations and allows them to concentrate on "higher order" tasks such as detecting trends in data and understanding mathematical and physical relationships.

While the Math, Physics and Chemistry courses had the traditional charge of teaching a significant body of knowledge to the students, the Engineering courses had two less traditional objectives. The first objective was to give the students a "taste" of Engineering early through a series of design projects. Each design project was built around a current topic in either Physics or Chemistry. The goals were to increase students' interest in Engineering and to encourage and motivate their efforts. Occasionally the opposite occurred, however, and good students transferred out of Engineering because "nothing sparked." Either way, students made a more informed decision at a stage when it was expedient to change majors.

The second objective of the Engineering courses was to develop good problem solving skills in the students. The students had particular problems using units consistently and in setting up problems. Word problems using current topics from Math and Physics were used to illustrate correct problem solving techniques and were assigned as homework. Also, students had to grapple with under-specified problems in the design projects. Follow-on FC courses will continue to provide under- and over-specified problems to develop practical problem solving skills (as opposed to text book problem solving skills).

Curriculum Integration

The most integration of topics was achieved between the Math and Physics courses [1]. In both courses, topics were rearranged from the normal order of presentation so that students would learn about related topics simultaneously. Chemistry and Physics attained a modest level of integration, which improved during the second year as the professors became more familiar with each other's topics [2]. Math and Chemistry had little integration since freshman Chemistry uses little Calculus.

The engineering course drew topics for design projects primarily from Physics but also from Chemistry. Several homework assignments used word problems from Math which involved differentiation and integration. An effort was made to use a topic after it had been introduced in another class but before students were examined on it. Successful engineering projects are briefly described below. These projects are described more fully on the FC web site -http://foundation.ua.edu

1 Golf-ball launcher (adapted from Arizona State). Students used trajectory equations from Physics to predict the flight of a golf ball from an adjustable launcher. After calibrating their launchers using video capture equipment, students had one chance to set their launcher and hit a target at a specified range and height.

2 Stream pollution model (Dr. Gary April, Chemical Engineering). Students modeled the dilution and degradation of phenol from commercial discharges into a creek upstream of a municipal water treatment plant. Based on data from a consulting case, students assumed roles as engineers representing the commercial plants or the environmental agency. Students devised remediation plans and defended the plans before a "judge" at a mock public hearing.

3 Polymer design and marketing (Dr. Dave Nikles, Chemistry). A joint project with the Chemistry course, students created their own polymer in the Chemistry lab, tested mechanical properties of the polymer, contrived a commercial product for the polymer (using information from the Internet), and developed a marketing plan. The students pitched their product development plans to the corporation's "board of directors" during imaginative and lively oral presentations.

Two years of experience has revealed some positive and negative aspects with curriculum integration., which are listed in Table 1 below. Advantages which outweigh the corresponding disadvantages are shown in italics, and vice versa.

The most serious disadvantage to curriculum integration was the heavy work load for students in their first semester at the university. To provide a more gradual transition between a typical high school work load and the university work load, in the future the UA FC team will delay Physics one semester. This will disrupt the integration between Physics and Chemistry but will enhance somewhat the integration between Physics and Math, allowing Math more time to concepts needed for Physics.

Active Learning

In the context of the FC at UA, active learning consists of several related teaching strategies, which includes (but is not limited to!) teaming and cooperative learning. It often means simply that the professor stops lecturing and asks the students to discuss or work a problem with their teammates. After anywhere from 1 to 20 minutes, the professor begins to lecture again. Other

Table 1. Advantages and Disadvantages of Curriculum (and Course) Integration

Advantages	**Disadvantages**
Students have the same classmates and teammates for four classes which helps them find study partners quickly (typically by the second week of class).	Students miss the variety of having different classmates with each class, part of the "college experience."
The interwoven nature of the FC courses requires students to take all four courses simultaneously. Also, students must pass all four FC classes to progress to the next semester's FC courses.	*Students with poor high school preparation and students on scholarship, for example, cannot drop one class to ease the workload.*
Students learn topics common to two or more courses simultaneously which helps them to generalize the concepts beyond the boundaries of one course. Teaching efficiency is also somewhat enhanced.	None. (Some may argue that it's good for students to see some topics over and over again. Unfortunately, most professors are unaware of the nomenclature and equations used in the students' previous courses, which effectively places the typical student back at square one.)
Faculty learn what and how other faculty teach.	Learning what goes on in other classes and cooperating with other faculty is time consuming and may not be recognized for promotion and merit evaluations.

classroom activities, such as working on the computer, building a physical model or performing a short experiment are included as "active learning" for the purposes of this paper.

The FC invited recognized leaders in active and collaborative learning to lead workshops for science and engineering faculty at UA (Karl Smith from the University of Minnesota and Rich Felder from North Carolina State University). Also, faculty discussed classroom successes and failures at weekly "Freshman Teaching Faculty" meetings. Like any skill, learning to use active learning effectively takes time and practice. Finally, although active learning can enhance student learning in all courses, the amount of active learning for most effective learning depends on the course, the professor, and the student.

FC professors were asked to complete a short "Class Activity Report" at the end of each class. Professors estimated the number of minutes spent in class activities such as lecturing, individual or team problem solving and using the classroom computers (two students per computer). The Class Activity Reports were intended to measure and document the FC faculty's progress toward the FC goal of a more dynamic and participatory classroom environment. The forms may also have gently encouraged FC faculty to try new "active learning style" classroom activities.

The Engineering courses made the most extensive use of teaming, largely because the emphasis was on teaching skills in the Engineering courses rather than on teaching a large body of knowledge. The advantages and disadvantages of active and collaborative learning in the FC at UA are summarized in Table 2. As in Table 1, advantages which outweigh the corresponding disadvantages are shown in italics.

The most important disadvantage to cooperative learning is the lack of individual accountability when students are graded on work submitted by a team of students. Weak students may over-rely on help from other students and be misled when they receive high grades for homework. Also, weak students may be "pushed away" from project work by stronger, more aggressive students. Lazy students quickly learn that they can "coast", let others do the work, and still receive good grades.

Several possible solutions exist to the problems with active learning at UA. Students can be taught techniques for more effective student-to-student learning. Students can be asked to indicate which work is collaborative work and which work is their own. The importance of truth-in-authorship can be stressed with a lesson about professional ethics. Students can learn cooperatively but be evaluated individually via tests, reports, and presentations.

Finally, the trade-off between spending class time to cover more material vs. spending class time to let students manipulate technical concepts is a controversial issue. In a world where technological accomplishments are expanding geometrically, future engineers will need to learn new technology on their own. Necessary tools for "life-long learning" will be a firm grounding in the basics and the ability to learn on one's own. Active learning promotes a deeper understanding of technical concepts in students by encouraging them to manipulate those concepts physically, verbally and on the computer.

The Role of Computers

Beginning with the first class, Freshmen FC students are immersed in the use of computers at UA. One of the most visible differences between FC and non-FC students at the end of the Freshmen year is that FC students are much more comfortable using computers. In fact, it is becoming increasingly apparent that students need to be taught some restraint when using computers. The abilities to add and multiply numbers in one's head, to estimate the magnitude of answers, and to compose several meaningful sentences and then deliver them orally are all abilities which must be performed without a computer.

The computer tools which have been used most successfully in the FC are the applications which simplify

Table 2. Advantages and Disadvantages of Active and Cooperative Learning

Advantages	Disadvantages
The students are awake.	The classroom is noisy and feels out of control.
Students teach and learn from other students.	Students copy mistakes and bad habits of other students.
Students learn to strive for team goals.	*Weak or lazy students coast and do not learn.*
The professor has less class-performance effort.	*The professor has large preparation effort.*
Students manipulate technical concepts verbally and assimilate material better.	Less material is covered.

the more mundane tasks: word processors, e-mail, spreadsheets, and presentation managers. Students quickly learn to use these applications and these tools make an immediate impact on their day-to-day activities.

Computer tools for more specialized tasks such as drafting and computer programming have been less successfully implemented in the FC. The two FC engineering courses replaced traditional freshman engineering graphics and computer programming (FORTRAN) courses. Computer-aided drafting (CAD) and computer programming are useful production tools for industry's large-scale, repetitive tasks, but are less well suited for the small example problems typically used to teach students engineering. Several engineering departments at UA no longer require CAD and the FC will not teach it next year. Students in departments requiring CAD will enroll in a new separate course. One of the objectives of this new course is to develop specific exercises which use the three-dimensional capabilities of CAD to improve students' ability to visualize three-dimensional objects.

The question of whether students need to learn computer programming is more controversial than the question of whether they need to learn CAD. Advocates of teaching all engineering students computer programming say that writing computer programs develops students abilities to think logically and to construct algorithms for solving generalized problems. Opponents counter that students can get practice in logic and algorithm development using computer tools which require much less overhead (spreadsheets, for example). The FC will teach computer programming next year but may try a different approach. Problem solving and algorithm development will be first taught using electronic spreadsheets. Later, problems requiring iteration, arrays, and file input and output, (problems for which a programming language is better suited), will be introduced to help motivate students. For many students, especially students with no computer programming experience, learning to program is a difficult hurdle which demands 100% effort for success.

The FC Math courses use a computer tool for the primary purpose of enhancing student learning. Maple has been used in the FC Math courses for the last two year with mixed results. The plan was to use Maple to free students from tedious tasks such as integrating long expressions, allowing students more time to concentrate on understanding mathematical relationships.

A fair amount of time must be devoted to teaching students how to use Maple. Test results indicate FC students are grasping math concepts better and Maple's graphing capabilities have proven especially useful. Students can use Maple's plotting capabilities to visually compare functions and to quickly see the effects of changing a function's parameters.

The students may be over-relying on Maple, however, for such basic tasks as algebraic manipulation. The Math professors have implemented exams on "basic skills". Students must satisfactorily complete the basic skills exams in order to pass the course.

As the math professors gain more experience teaching calculus using Maple, it will be used more effectively as an instructional tool. Also, if and when other courses which use calculus (such as engineering science courses) adopt Maple, the time students spend learning Maple in the freshmen year will pay dividends.

The FC Physics courses used a computer tool last year which is exclusively an instructional aid. Interactive Physics allows students to graphically build models of physical systems and then simulate their behavior. Last year's experience with this tool was very positive. Plans are to use Interactive Physics more extensively, including applications in the engineering courses.

In summary, computer tools which simplify the more common, mundane tasks are the most useful. These programs, which include word processors, electronic spreadsheets, presentation managers and e-mail, are also very easy to learn. Computer tools which have been developed primarily to increase production in industry are less useful and may eventually be phased out of the curriculum. In their place will be computer tools developed exclusively as instructional aids.

Conclusions

A review of the first two freshman years of the Foundation Coalition program at the University of Alabama has been presented. Several advantages and disadvantages of the three thrust areas, curriculum integration, active learning, and technology utilization, have been presented. One measure of success for the program is that some engineering departments are already seriously considering adopting the FC program for all of their entering freshmen. With the lessons learned from these two year’s experiences, we are looking forward to an even larger and (hopefully) improved program in the future.

References

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