Innovative Approaches for Teaching Calculus to Engineering Students

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Abstract

A successful engineering program requires proficient and dynamic mathematics classes to enhance the teaching and learning of complex subject matter. Without a sufficient amount of problem solving and engineering applications, students are left with rather vague concepts regardless of the instructor's effectiveness. Improving student performance in mathematics classes requires inventive approaches to both subject matter and content delivery. Introduction of new technology, in-class problem solving, and discussion sessions are important factors in the enhancement of students' deep understanding of mathematics. At the University of Central Florida the College of Engineering and the Department of Mathematics are "team teaching" calculus for engineering majors in a "high tech" classroom. The instructional delivery involves group work combined with the use of computer technology to analyze the relationship between the physical problems and the mathematical models

I. Introduction

A strong foundation in the knowledge and application of calculus provides a distinct advantage in the learning of all engineering concepts. Learning and retaining complex subject matter in engineering greatly depends on students' mathematical proficiency established earlier on. Effectively teaching calculus establishes a strong base of knowledge from which all future learning of these concepts is supported. The University of Central Florida has embarked upon an innovative and collaborative approach for the effective teaching of mathematics. Several dynamic techniques have been initiated to deliver a result-centered learning environment. These techniques include team-teaching, a technology rich classroom environment, and a unique classroom layout. The syllabus was developed by a team of engineers, physicists, and mathematicians and correlates the Calculus I class with the beginning physics course. Vectors are introduced early and vector calculus is emphasized from the very beginning.

II. Team Teaching

An unprecedented format, including two professors from different disciplines (mathematics and engineering) collaboratively provides students with a rich and diverse approach to the learning and application of calculus. The two professors meet every week to plan the class activities and they share the responsibility for each class. The mathematics professor provides the students with an introduction to the topic and discusses the mathematical techniques while the engineering professor provides application through real world engineering problem solving. The two professors work together during the class to achieve a symbiosis between the mathematics and the engineering. This multi-disciplinary perspective gives the students a holistic learning experience in the area of engineering mathematics.

III. Technology in The Classroom

The classroom was designed after the model of "studio" classrooms developed at Renssalear Polytechnic Institute. The students are seated in groups of four at "tee" shaped tables. Each table has two computers providing the students at that table with Internet access and a variety of mathematical and word processing software. Various Internet sites are used to provide examples and applications of the course material that is being discussed. The primary software package used in the course is MathCad. This arrangement allows students to simultaneously solve problems while the professors provide instruction. This dynamic method of teaching helps the students learn how to use the software along with enhancing their understanding of the engineering concepts. The instructor's station at the front of the room has full multi-media capability to project a computer screen and to work under a document camera. Anything at the instructor's station can be sent to every computer screen in the room. In addition, the student work on any computer in the room can be imported to the instructor's station and either projected or sent to the other student computers. On many occasions the work of some particular student was imported to the instructor station and projected for all the students to use as a model.

IV. Physical Layout of Classroom

Our experience indicates that it is very important for the instructor in one of these "high-tech" classes to be able to see every computer screen in the room from the instructor's station. The tables at which the students are seated have the computer screens facing the front with a direct line of site to the instructor's workstation. Maintaining control of how the technology is used during the lecture requires constant vigilance. Otherwise the students will begin to experiment with the technology and will loose their focus on the course.

V. Syllabus

A team of engineers, physicists, and mathematicians developed the course syllabus. The first objective was to correlate the Calculus I class with the beginning physics course. As a result vectors are introduced at the very beginning and vector calculus is emphasized throughout the course. Some

topics that have traditionally been included in a beginning calculus class are either omitted or are de-emphasized. For example, "curve sketching" is virtually eliminated since the availability of graphing technology makes this topic less important for engineering students than other applications of the derivative. WebCT is used as a course organizer. The syllabus is maintained "on-line" and all of the assignments are available at the Internet site. Well beyond the scope of a standard syllabus, the students are provided with a full detailing of each course session, including homework assignments and in-class activities, throughout the semester.

VI. Homework Assignments

Homework problems emphasize applications in real world problem solving. The students are encouraged to use MathCad to complete homework assignments. Unsupported solutions, however, are not acceptable. The students are required to provide an explanation of how the answer was obtained. The homework is collected and graded. The totality of the homework counts the same in the computation of the grade as one examination.

VII. Examinations

Throughout the course, careful planning was done in order to give emphasis to learning through application. In no other area is this given greater weight than in the design of the course examinations. The tests are constructed and graded jointly by the professors from engineering and mathematics. On some of the exams the students were allowed the full use of the technology. They could use the computer or any graphing calculator with which they were familiar. On these tests the problems were not routine, but were designed to emphasize the interaction between the students' knowledge of how to solve the problem and their understanding of how to use the technology. On every problem there would be a point at which the student would have to know how to use the technology and what to expect the answer to be, or they would not be able to continue. In this way emphasis was given to critical thought rather than mere regurgitation of facts and formulas.

VIII. Conclusion

The teaching initiative carried out at the University of Central Florida proved effective in the learning and retention of core calculus concepts for most of the students. Students with average or above average competencies excelled, while students with below average competencies found this learning environment challenging. It is our belief that the students who succeeded in this course are much better prepared than successful students from the standard introductory calculus course. Interestingly, some of students found working with the technology difficult and cumbersome despite their above average grasp of the content matter. Overall, the learning experience for both students and professors was positive and provided valuable insights and feedback for future course development.

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