INTERDISCIPLINARY TEAM TEACHING IMPROVEMENTS

James R. Rowland[1]

Abstract *- Interdisciplinary team teaching improvements are described for a sophomore mathematics course on differential equations and linear algebra offered at the University of Kansas every semester in a team environment by mathematics and engineering professors. The five-hour course is required for engineering, computer science, and atmospheric science majors. Significant improvements are described beyond the team teaching experiences reported at FIE 1996.*

In response to a recent ABET visit, a coordinating committee composed of engineering and mathematics professors who had been involved with the course mandated several changes to be initiated in Fall 2002. The implementation and success of these course changes are described from the viewpoints of the engineering professor (the author), mathematics professor, teaching assistants, and sophomore students in the course. The author had team-taught the course twice previously, served on the coordinating committee, and teamed up with one of the mathematics professors to teach during the initial semester under a new format.

This paper describes recent improvements in the interdisciplinary team-taught course, discusses the strategy of using and coaching teaching assistants for weekly recitations, and describes a process for continuous improvement in compliance with EC 2000.

Key Words: Interdisciplinary, Team teaching, TA training, Accreditation

INTRODUCTION

Successful team teaching equires focus, compromise, and cooperation. Even at its best when team members are highly compatible, team teaching can be both uplifting and frustrating at the same time. It appears that key parameters are the team members' home departments, their technical backgrounds, their tendencies for cooperation, and the course level and expectations. Easier matches may occur when the team faculty are from the same department, have the same general technical specialty, and are team teaching in a graduate course. In such cases, the strengths of each member are easily brought together to enhance the course in a collegial spirit of easy-going class discussions and encouragement. On the other hand, lower-level courses having professors with different backgrounds, from different departments, and with somewhat differing ideas on class procedures can be more difficult for team teaching and require careful planning and compromise.

The successful teaming experience described in this paper is based on an interdisciplinary team for a sophomore mathematics course on differential equations and linear algebra at the University of Kansas during Fall 2002. The five-hour course is required for engineering, computer science, and atmospheric science majors. Nearly 300 sophomores enroll in the course every academic year. A coordinating committee, chaired by the Associate Dean of Engineering and composed of several engineering and mathematics professors who had taught the course, met twice the previous spring and indicated specific course improvements in response to recommendations from a recent ABET visit. The committee approved a plan for the materials to be covered in the course, made a textbook change that more nearly reflects the desired course content in a preferred chapter order, added a third teaching assistant, revised the late-afternoon discussion format, and decided which engineering professors would be assigned to the course during the next three years.

The author is a member of the coordinating committee and the engineering professor assigned for Fall 2002 and Fall 2003. The mathematics professor for both of these semesters is a friend and colleague with whom the author enjoyed teaching the course previously in Fall 1995 [1].

TRADITIONAL FORMAT

Since the early 1970s, the five-hour course had been team-taught by an engineering professor and a math professor with two graders. Professors had alternated daily lectures during 50-minute periods in blocks of 3 to 5 days each with the non-lecturing professor always in attendance as a spectator. Moreover, for many years the same math professor had co-taught during fall semesters with different mathematics professors in spring semesters. It was this fall-semester math professor who had taken the primary lead in developing and maintaining the course, including any changes. The six engineering departments had rotated the course assignment annually. During fall semesters, voluntary discussions, conducted by the math professor, had been held weekly on late Tuesday afternoons, and computer assignments featuring simple Euler integration had been made.

[1]James R. Rowland, Prof, Dept of Electrical Engineering and Computer Science, University of Kansas, 1460 Jayhawk Boulevard, 415 Snow Hall, Lawrence, KS, 66045 jrowland@eecs.ku.edu

The course had been regarded as challenging by students, and their retention of concepts to be used in later courses had often been weaker than desired. The coordinating committee was convinced that changes were needed to achieve stronger outcomes-based performance by students in their following junior and senior courses.

IMPROVED FORMAT

The Fall 2002 teaching team met twice weekly late in the previous spring and continued with several meetings each week during the summer. Although both professors had co-taught the course before, once with each other as noted above, further compromise became necessary to meet the new objectives while focusing on the special strengths of each professor. One professor wanted daily topics and homework assignments to be announced the first day of classes; the other favored a sequential approach for homework problems during the semester. Other issues also had to be negotiated. For example, agreements had to be reached on a suitable format for recitation sessions and how the teaching assistants would be instructed to enable them to manage these 15 weekly recitation sessions consistently. Despite differing views on some issues, there was a highly cooperative spirit and eventually complete agreement on how the course changes should be made. Enthusiasm for the upcoming Fall 2002 semester was extremely high as three teaching assistants were added to the team. The mathematics TA was a graduate student, and the two engineering students were electrical engineering seniors who had naval leadership training.

It had become a stronger team-teaching foundation that featured two professors with three teaching assistants as a five-person team. The team met Tuesday afternoons apart from the class lectures for TA training sessions, in some sense replacing the Tuesday afternoon voluntary discussions from the previous format. Recitations met Wednesdays during class time in three breakout sessions across campus. These recitation sessions were aimed at having informal discussions when students could ask questions on recent homework and learn specific skills, such as operating with complex numbers as vectors and plotting exponentials and decaying sinusoids. These latter skills had been taught during lectures in the previous format but were moved to recitation sessions because only 60 of the original 75 lectures were retained during the semester.

Planning for the weekly recitation sessions was the responsibility of whichever professor had the most recent lecture block. A coaching sheet for the TAs included a list of topics to be covered, three to four examples to be worked, specific "points to make", and a brief short quiz, which was to commence 15 minutes before the end of the session. Genuine excitement reigned during these coaching preparations as the professors and TAs interacted with ideas on how best to handle the recitation sessions the following day.

In brief, as suggested by the coordinating committee, a new textbook was adopted for Fall 2002, the Tuesday afternoon voluntary sessions were replaced by required Wednesday recitation sessions conducted by the TAs, and the computer assignments on Euler integration were omitted. Reduced numbers of handouts used previously to support the textbook were posted on the web with some homework assignments referring to this website.

ASSESSMENTS FOR FALL 2002

It must be recognized initially any assessment based on student performance in senior classes will not be available for those sophomores until Fall 2004 and beyond. However, evaluations for Fall 2002 by the engineering professor (author), mathematics professor, TAs, and the students themselves can be reported now.

An evaluation from the engineering professor is that possibly too many different topics remain in the course, even though several are receiving less emphasis than in Fall 1995 when last co-taught by this professor. The general modeling concepts are good, except for perhaps too much emphasis on mixing tanks as examples. More coverage is needed on underdamped second-order systems, including an emphasis on skills for performing analysis of these systems. This professor also taught both Circuits I and Circuits II in Fall 2002, providing first-hand experience on how students from this course perform in the following courses. It appears there remains too much emphasis on website materials (previously handouts) instead of the textbook. Such materials are appropriate as supporting but not as replacements for the textbook. Overall, the course is difficult for students because of the concepts and the amount of work required. A learning emphasis in a course format having fewer concepts with stronger skills development is recommended.

The mathematics professor for Fall 2002 recommended more on electrical and mechanical models, including multiple loop and multiple node circuits. His other evaluations are that skills need to be improved in many areas including Laplace transfoms, quizzes perhaps should not be given in the recitation sessions, and an emphasis on checking to verify that solutions satisfy the differential equation needs to be made [2, 3].

Evaluations from the TAs expressed their view that the course is not actually difficult but somewhat tedious and requires a strong effort from the students. On Laplace transforms, more drill is definitely needed. On mixing tanks, the students appear to see the examples but forget the details within a few days. This topic might well be omitted as just one of the many which could be reduced in number. On Euler integration, students must realize that the computer is indeed used to solve much larger problems but uses more complicated integration formulas. Hence, their introduction to the computer in this context might be important but not for Euler integration itself. The TAs noted that many students seem to work within groups and submit correct homework but themselves do not understand concepts. They suggested that review materials only (no new concepts) should be presented in recitation sessions. Finally, as expected, they reported that both of the professors seemed to speak above the level of the students, validating the need for recitation sessions.

The sophomore students acclaimed that recitation sessions were great, not just to have closer contact with the TAs but mainly because no homework assignment is due on the day of recitation sessions, thereby reducing their number of homework assignments by 20%. While their understanding of mechanical models is good, they have a fear of electrical models and suggest reducing electrical circuit examples in the course. Students seem not to appreciate Laplace transforms and see this topic as one of memorizing the table. Overall, students view the course as difficult because of the workload required (daily homework) and the technical concepts.

STUDENT SURVEY

In response to reviewers' recommendations received in May 2003, a brief survey was distributed to a small sample of the 140 students from the class in Fall 2002. Only 19 students from the class could be located, and all agreed to participate in the "two-minute" survey. These were engineering students from several fields that were either studying for Spring 2003 final exams in the Engineering Library during evening hours or moving between final exams during 30-minute breaks during mid-morning hours. Both strong and weak students were included randomly in the survey.

For the questions shown in Table 1, students were asked to insert a number between 1 and 10 with a 6 to indicate barely understanding the concept, a 7 or 8 for some greater level of understanding, a 9 or 10 as very well understood, and any value between 1 and 5 as a measure of not really understanding the concept or procedure. The brackets following each question show the sample mean XBAR for that question, based on 19 responses. Sample variances calculated for each question and groups of questions, as noted below, were used in determining p-values in statistical tests.

TABLE 1
STUDENT QUESTIONNAIRE

Q1: Solve linear homogeneous differential equations having constant coefficients. [XBAR = 8.32]

Q2: Understand time constants and use them in reading exponential graphs. [XBAR = 7.11]

Q3: Find the determinant of a matrix, matrix inverse, and other matrix operations. [XBAR = 8.84]

Q4: Use the method of undetermined coefficients to find particular solutions. [XBAR = 7.84]

Q5: Use Gauss elimination to find the solution of a set of linear algebraic equations. [XBAR = 8.89]

Q6: Find Laplace transforms of time functions such as steps or exponentials. [XBAR = 7.47]

Q7: Use partial fraction expansion to convert Laplace transforms back to time functions. [XBAR = 7.68]

Q8: Use Euler's method (or Euler's formula) to perform numerical integration. [XBAR = 7.11]

Observe that Questions 3 and 5, which focus on matrices and linear algebra, have the largest sample mean among four groups that can be identified as key components of the course. The other groups, in order of decreasing sample means are Questions 1 and 4 on solving differential equations, Questions 6 and 7 on Laplace transforms, and Questions 2 and 8 on graphical and numerical procedures. Statistically, the mean of the combined Questions 3 and 5 is greater than the mean of the combined Questions 1 and 4 at the 10% level of significance ($p = 0.096$). Grouping even further into only two groups overall, the combined 76 responses to the first two groups, i.e., Questions 3, 5, 1, and 4, can be compared statistically ($p = 0.006$) to the combined 76 responses for the other two groups, i.e., Questions 6, 7, 2, and 8, to show that the students apparently learned more about matrices, linear algebra, and solving differential equations than they did about Laplace transforms and graphical and numerical procedures. Such survey results provide an indication of topics that may require a greater emphasis as part of the continuous improvement process, depending somewhat on their relative importance to the course.

CONTINUOUS IMPROVEMENTS

Plans for Fall 2003 with the same two professors as in Fall 2002 focus on new changes based on the experiences reported here. In responding to the assessments above, expanded recitation sessions (80 minutes each Wednesday instead of 50) will feature skill-enhancing exercises based on assigned homework and will omit any new materials. No recitation quizzes will be given but homework collected instead, notably contrary to what student preferred on required homework. An emphasis will be placed on learning outcomes by requiring students to check their solutions by substituting them back into the differential equations. In-class exercises will focus primarily on developing skills, understanding concepts, and checking solutions.

Changes initiated in Fall 2002 were carried forward to Spring 2003 with different professors and two new engineering TAs. The mathematics TA for Fall 2002 continued for Spring 2003. Recitation sessions held on Fridays focused again on helping students to understand course concepts. The TAs for Spring 2003 reported that students had several questions during the early recitation sessions but later sessions consisted mainly of working examples related to their recent homework assignments.

CONCLUSIONS

Interdisciplinary team teaching improvements and a plan for continuing improvements have been described for a required sophomore differential equations and linear algebra course at the University of Kansas. Changes mandated by a coordinating committee in response to a recent ABET visit were implemented in Fall 2002 and an initial assessment made. A key component has been the introduction of mid-week recitation sessions conducted by the teaching assistants. Further improvements in concurrence with those assessment results are planned for Fall 2003.

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