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Student Written Engineering Cases*

C. O. SMITH
Engineering Consultant, Terre Haute, 1920 *College Avenue, IN, U.S.A.*

A prime objective of teaching is to provide a medium through which learning (analysing, reasoning, decision-making, etc.) can take place. With engineering students, this involves becoming proficient in applying basic knowledge to solve engineering problems. A secondary objective is to develop communication skills. Involvement in design projects and using engineering cases are very useful ways of moving toward these objectives. Writing engineering cases is an additional option. This paper is an account of two courses which included studying a number of published cases and writing cases by the students. Comments are made on the conduct of the courses. A summary of evaluation indicates that students and instructor viewed these as educationally successful.

INTRODUCTION

THE TASK of the engineering teacher is to manage the learning situation for students so they can start to acquire skills and expertise in order to become practising professionals. A secondary task is to develop communication skills. Lectures and problems in engineering sciences are necessary for students to learn much of the information needed to function as engineers. They must also have practice in applying this. Laboratory exercises and design projects help greatly in developing practical application, while using engineering cases (Refs [1–10]) can also help. Studying cases serves as a complement to projects to provide an additional, useful, powerful, teaching technique in practical application.

An engineering case is a written account of an engineering activity as it actually took place. It tells the story of a real engineering experience, often from the viewpoint of at least one participant. A well-written case includes some detailed background information such as: sketches, drawings, photographs, memoranda, calculations, test data, catalog data, scheduling data, production processes, field reports, budget information, and other pertinent information which helps the reader follow actions taken. *The Focus is on obtaining results rather than demonstrating validity of a solution.* Consequently, unsuccessful efforts attempted before successful solution are often documented.

Engineering cases are of immense value in the education of engineers, both in and out of the classroom. When they are written for classroom use, they become unique supplements to the more traditional classroom tools of lectures, projects, problem-solving sessions, etc. In using cases, there is an opportunity for both writers and users to profit from them. It is recognized, however, that the potential profit is substantially greater for the writer than for the user.

This paper discusses the content and conduct of a semester course (15 weeks) with two different sets of graduate (primarily Master's level) students. This course required students to study and discuss a number of published cases, and write a case involving an industrial project.

COURSE OUTLINE

Fifteen weeks were available with class sessions scheduled twice each week, with two hours per session. The first class meeting was devoted to a discussion of the concept, objectives, and mechanics of the course. The objectives were to:

(1) become acquainted with the case method;
(2) gain insight into design and engineering practices;
(3) assess the decision-making process as it functioned in the cases studied;
(4) write a case.

During the first five weeks, the class studied, prepared written discussions of, and then verbally discussed ten engineering cases. Five were from the American Society of Engineering Education Engineering Case Library and five were student-written cases generated at the University of California at Berkeley under the direction of Dr R. F. Steidel.

During the second five weeks, students in teams of two or three met with a project engineer in an industrial organization. This project engineer served as a 'clinical professor'. During this period, each team was required to review a project conducted by the project engineer and learn how it had been accomplished. The team visited the engineer, listened to his exposition, and asked questions (recording the discussion on tape). Between interviews, the team went through the results of the

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interviews and any file documents and drawings loaned them. The team was expected to review the design from concept to completion (including field performance if possible) with particular attention to chronology, key decisions and factors involved in reaching them, wrong directions taken as well as successful directions, and a critical review of technical aspects. During this period, the class did not meet together, but the instructor was available for consultation. The instructor accompanied each team on its first visit with the project engineer at his place of work but not on subsequent visits. Thus each team had to function independently under non-academic circumstances.

At the end of the tenth week, representatives from each team met together for the purpose of exchanging drafts so that every student in the class had a draft of each of the student-written cases. Each student was required to critically review the work of the other teams. After allowing one week for this review, the next three class sessions were devoted to oral presentations by each team with critical questions being asked by the rest of the class and the instructor.

A further period of ten days was allowed for the team to confer again with the project engineer, fill in any gaps, and develop a final draft. The last two class sessions were devoted to public oral presentation of the cases. Members of the Faculty, project engineers, and other students were welcome at these presentations.

CONDUCT OF THE COURSE

During the first five weeks, there were a number of very good discussion sessions with nearly everyone in the class participating. Diverse ideas were presented on each case and defended against opposing views. Even though there was a definite and spirited difference of opinion on many occasions, this was done in a professional manner with full respect for the integrity of all concerned. This was a valuable experience for the students.

The first time the course was conducted, there were seven teams. Six of these reviewed the development of the project as both the project engineer and his team had gone through it, as indicated above. In the seventh one, however, the project engineer was very insistent that the students work out a solution before he would disclose his solution. The team was unhappy with this since it felt this would require a tremendous amount of effort in a very limited time. The instructor concurred. A compromise was reached, with the team working through a conceptual solution under the guidance of the project engineer who then presented his solution at the last meeting with the team. When this team had completed its final draft, the team (part-time graduate students who were full-time industrial employees) made the point that this approach was an especially fruitful one. The team strongly recommended that this approach be used in the future if more time could be made available, but not at the expense of the preliminary period of discussion of various engineering cases.

The second time the course was offered, there was some shift in emphasis. The team met again with the project engineer and discussed the background of the problem and arrived at a problem definition. The team was then expected to try to develop a conceptual solution. On each successive meeting with the project engineer, the work of the team was reviewed by the project engineer. Additional information was presented to the team and it proceeded further with its conceptual solution, or it was substantially altered, as appropriate. At the end of the series of visits, the project engineer told the team how the problem had actually been solved.

INSTRUCTOR EFFORT

The instructor must search out in advance, and carefully select, a set of suitable projects and project engineers. This requires much visiting and discussion after establishing initial contacts. The written discussions submitted by the students during the first five weeks obviously need prompt attention so they can be returned, with comments, at the next class session. During the period while the teams are working with their project engineers, relatively little is required of the instructor. When the drafts are submitted, much effort is needed to make sure they are in good technical, organizational, and editorial order. Some additional editorial effort is required if the cases are to be made available to other academic institutions (as produced by the University of California at Berkeley). Ten student written cases were produced from these two courses and were made available for use in other institutions. The cases and the sponsoring organizations are listed in Appendix 1.

STUDENT REACTION

Each student was asked to respond to a brief questionnaire whose results are given in Table 1. In addition, the students also made a number of comments for improvement to the course. Perusal of Table 1 indicates that the students felt the course was quite successful. This is gratifying when one recognizes that each team produced a document of perhaps 50 to 80 pages relating to a design project in an area in which they may have had classroom background, but little, if any, practical experience. It was also gratifying to realize that all the part-time students, employed full-time in local industry, believed the experience had been broadening, valuable and worth the effort.

SUMMARY

Discussion with the project engineers after completion of the course clearly indicated that they

Table 1. Summary of student reaction

	YES	NO	NOT SURE
Was the overall course concept good?	18		
Do you now have a better concept of various ways in which design projects may be handled?	18		
Do you now have a better concept of how various industrial organizations operate?	15	2	1
Is the idea of working with a project engineer worthwhile?	18		
Was your contact with your project engineer a valuable part of the learning process?	18		
Do you believe that the writing of the case was a valuable learning experience?	17		1
Do you believe that the oral presentation of the case was a valuable learning experience?	16	1	1
Do you feel you were greatly overworked for the three semester hours credit?	1	16	1
Would you advise other students to take this course if it were offered again?	18		

also believed the experience had been valuable for them and the students. It was agreed that the students gained a greater insight into real product development with its interplay of analysis, design, testing, and decision-making, than would have been possible through only academic study. In at least one situation, the student team proposed a conceptual solution which the project engineer admitted had not occurred to the industrial team, but which appeared superior to the one which had been developed.

As the instructor, I was convinced the course was clearly successful in terms of the stated objectives. I am further convinced that working with the project engineers, working as a team, writing and presenting their cases, and interacting with their peers in class discussion was a very valuable experience for the students. Although these two courses were offered at the graduate level, I believe a group of seniors (fourth-year students) would equally profit from the same experience.

I strongly urge others to try this approach.

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APPENDIX I
Student-Written Engineering Cases

FAST—A New Friction and Wear Test for Brake Linings, Ford Motor Company, Dearborn, Michigan

Development of an All-Paper Asphalt Container, Owens-Illinois, Toledo, Ohio

Development of Military Industrial Standard Engines with Specific Consideration of the Governor, Teledyne Continental Motors, Warren, Michigan.

Design and Development of a Brush Burning Plant, City of Detroit, Detroit, Michigan.

First Harmonic Analyzer, Uniroyal, Detroit, Michigan

Automatic Cam Brake Adjuster, Eaton, Yale & Towne, Southfield, Michigan

Transformer Load Management Research Program, Detroit Edison, Detroit, Michigan

Design of the Pocket Select Gate for the Burroughs B9134-1 Reader Sorter, Burroughs Corporation, Detroit, Michigan

Evaluation of Passenger Car Eyellipse for Visibility Requirements, Ford Motor Company, Dearborn, Michigan

A New Air Flight Control Power System, Sperry Vickers, Troy, Michigan.

C. O. Smith has a BS in Mech. Eng. from Worc. Poly. Inst., an SM in Mech. Eng. and an ScD in Metallurgy from MIT. He spent 3 years in the U.S. Navy, 14 years in industry, and 29 years in academia. He has written 4 books and 200 engineering cases and papers on design, materials, and engineering education. He was the first recipient of the Fred Merryfield Award of the ASEE for *excellence in teaching engineering design*. He was the second recipient of the Triodyne Safety Award of the ASME for *outstanding contributions to teaching or research in safety aspects of mechanical design*. Retired from academia, he teaches short courses for the ASME and SAE and serves as an expert witness in product liability litigation.