Learning Written and Oral Communication, Team Work and Engineering Competition in A Manufacturing Systems Class

Neda Saravanja-Fabris
Professor, Mechanical Engineering Department
California State University, Los Angeles

1. Introduction

The role of engineers has changed drastically in recent years, from being solitary thinkers, designers and trouble shooters to being team players, able to present and "sell" their products, process designs, ideas and accomplishments to bosses, peers and more and more often, to groups of internal and external "customers" with no or little engineering background. This present considerable difficulty to many engineering students who choose engineering careers because they were "good in math and science", but not in written and oral skills, or who were too "shy" to argue their point of view in front of others. Also, engineering in its international universal background was a "refuge" for new emigrants, or people with English as a second language giving them the opportunity to excel despite the hurdle of mastering a new language.

The new engineering paradigm and industry requirement to "hit the ground running" places special emphasis on engineering education to provide graduating engineers with the experience and practice in oral and written communication in their engineering classes. With this emphasis in mind, and to reflect the greater emphasis in manufacturing industry on new management techniques (Total Quality Management, Just in Time, Quadratic Loss Function) and use of statistical process control, several years ago I developed a senior level lecture course for mechanical engineering students entitled "Automation and Computer -Aided Manufacturing". This course, consistent with the modern industry practice of continuing improvement, changes almost every year.

This course is an elective, offered once a year, and is very well attended and received by students. The content of the course was very favorably reviewed (in his e-mail massage) by an external consultant, Dr. Myron Tribus, former US Assistant Secretary of Commerce, and former Director of the Center for Advanced Engineering Study at MIT. This paper briefly describes the material covered in the course with emphasis on different projects and activities students are involved in.

2. Scope of the Course

Since this was a new elective class, I had complete freedom in choosing material to be studied and in developing the activities and projects. As a basis for the class I choose the book, "Automation, Production Systems, and Computer-Integrated Manufacturing" by M.P. Groover[1]. Although this book is not up to date on several subjects, and several chapters in the book are devoted to material covered in other courses (Industrial Robots, and Control Systems, for example), still the variety of material covered, as well as number of homework problems, makes this book, in my opinion, the best one currently available. The topics that I cover are given in course outline in the Appendix of this paper. Some topics like production economics, I cover briefly to review material for undergraduate students who have already attended a class in engineering economics and more importantly to introduce this topics to many graduate students who did not have the chance to study this topic before. Other topics, for example, statistical process control, I expand and supplement from other textbooks and papers like the one given in the paper by McFadden[2]. In the process of developing this course I have acquired a quality control handbook given to employees of a major engineering firm, and I provide a copy of the text to my students (drawings and examples are omitted for confidentiality reasons).

Other material covered in the class is based on the following list of current industry practices.

- Principle of Total Quality Management, including a historical approach from F. Taylor to Deming
- Taguchi Method of Design of Experiments
- Pareto and Ishikawa Diagrams
- Robust Design
- Ergonomics Design

Since, these topics are not covered in one book, I distribute background material from different sources[3, 4] including examples of practical industrial applications.

Our school has purchased several SME Manufacturing Management videotapes that I show in class.

3. Assigned Projects with Emphasis on the Team Work

In this class two projects are assigned to students:

1. CAD-CAM project
2. Ergonomics design group project

The CAD-CAM project involves the *Dyna* numerically controlled milling machine and Master Cam CNC software. This project gives mechanical engineering students a hands-on opportunity to use our well-equipped automated manufacturing laboratory and learn about numerically controlled machines and Computer Aided Manufacturing. On this project two students work as a group, designing and manufacturing two matching parts of dies that have close fit tolerances. I explain in class very briefly the principles of CNC, then students learn the details of design and manufacturing on their own or with help of teaching assistants, who keep the lab open on Saturdays and Sundays (most of our students work during the week and take classes in the evening).

The handout for the project is given below.

PROJECT I (CAD-CAM)

PURPOSE:

1. *FAMILIARIZE YOURSELF WITH DYNA NUMERICALLY CONTROLLED MILLING MACHINE*
2. *LEARN HOW TO PROGRAM USING MASTER CAM CNC SOFTWARE*
3. *LEARN HOW TO "DOWN LOAD" MASTERCAM AND MANUFACTURE PARTS ON THE MILLING MACHINE USING CNC.*

4. LEARN CONSTRAINS INVOLVED IN MANUFACTURING CLOSE FIT MATCHING PARTS.

GOAL:

Each group of two students design and manufacture ***two close fit matching*** *parts on the given wax blocks (45 mm x 45 mm). Use in your design as many different elements as possible.*

PROCEDURE:

1. After learning about the possibilities MASTERCAM can offer, decide with your partner on a design. Draw your design to scale on a piece of graph paper and submit it to the teaching assistant for review.

2. Program the tool path on MASTERCAM and " down load " it to DYNA to be machined.

GRADING:

Project is worth 15% percent of your total grade. (From those 15 points, five are assigned for complexity of the project, five for fit and accuracy and five for documentation).

PROJECT II: ERGONOMIC DESIGN

Purpose of this project is to simulate real life competition between different manufacturers of the same product who want to persuade customers that their product is better than the one produced by the competition. Due to the large amount of work in this class, I choose a relatively simple project for this exercise. One year it was the crimping pliers, that caused carpal tunnel syndrome in industrial workers; another year it was a student's desk and chair, and yet another year it was a moving TV cart (that I push from class to class and it is certainly not ergonomically designed!).

For this project students are divided in two groups by randomly drawing the letters A or B from a plastic bag or hat. We have small classes (maximum 25 students) and this elective senior level class does not exceed 20 students. Most of the time groups consist of six to seven students. The random drawing precludes that the selection process based on friendship, or ethnicity. The purpose of this exercise is to provide students with realistic constrains when working in diverse teams. I grade the final drawings of the design, one copy per team and this represents only five points of the project grade. The rest of the team grade is provided by the group of "customers" that I recruit for that purpose (department secretaries, professors from other departments, School Dean,…) or industry representatives. They grade student presentations (every student has to participate in an oral presentation of the project) and overall design of the product indicating which one they prefer to "buy." All students on the winning team get a base grade of five points, while the losing team members receives three points. Each student earns up to five points for his or her presentation. This approach gives each student a different number of points on the project.

An example of Project II, given last year, is summarized below.

ERGONOMIC DESIGN AND DESIGN FOR ASSEMBLY PROJECT

Design a student's desk and chair. Use each other as experimental models to determine the best chair seat back height and tilt. That means, devise an experimental table and chair whose heights, inclinations and location of book and pencil holder, can be changed. Each member of the group should use the setup and determine the best combination for his or her personal use. In addition to overall suitability, your design will be graded on its ruggedness, appearance and economy of constructions as well as design for assembly.

Each member of the group will be involved in the design and discussion. In order to determine a suitable design you should consult literature on ergonomic design and design for assembly. Each *team should meet at least once a week to work on the project, preferable before or after the class. One member of the team should be designated as team leader in charge of logistics. One member should be in charge of keeping a journal of the meetings outlining discussions and the outcome. Also, attendance at the meeting should be recorded. At the first meeting tasks should be specified and assignments distributed.*

Your design should also include an estimated cost of the product based on materials used and labor involved for developing prototype as well as for mass producing of the project. For this purpose you should consult technicians and catalogs of similar products.

Technical drawings of the table and chair (preferably done using a CAD program) should be provided to the other group for review one week before the assigned presentation.

On the specified day, each group will have one half hour to present their design to a panel of prospective customers, comparing them to the design of the other group, i.e., their competitors. After both groups have completed the presentation, each group will have 10 minutes for rebuttal. The panel of "PROSPECTIVE CUSTOMERS" will decide on one product. The decision will be made based on the design, price, presentation and critique of the other design. This critique should be professional and polite.

4.Written and Oral Communication

In preparing and presenting the ergonomic design project, students practice teamwork and oral presentation SKILLS. In previous years, I have also assigned a research topic related to manufacturing or management for students to present in class. The topics ranged from group technology systems for electronics industry to differences in management techniques between Japan and the USA. However, with the expansion of the second the project, there was not enough time in class for those types of presentations. Instead, I am now assigning each student to review one “Manufacturing Insight” tape, and before the tape is shown in class they give a short critical presentation of the tape (five minutes maximum) including the rating of the tape on a scale from 1-10. Students also are asked to suggest which parts of the tapes could be fast-forwarded to shorten the presentation. If there are more students in class than tapes, I assign some students to summarize interesting papers and articles and present their findings in class. One example is the article “Automating the Worker” by Gies, published in Invention & Technology in 1991[5]. During class presentations of tapes, all students are required to take notes and write a one-page summary of the tape to be submitted for grading.

5. Grading of the Course

As can be seen from the outline, the evaluation of the class is quite time consuming and complex. In addition to projects, CAD-CAM and Ergonomics (15% each) minute essays and videos (10%), students are graded on homework (10%), a Midterm exam (20%) and Final exam (30%). Both exams have an open book part where problems are solved and a closed book part to test the students understanding of the concepts.

Although part of the grade is based on the team activity, most of the grade is based on the individual effort to ensure a fair grade. Most students in the class receive relatively high grades (average B), higher than in other classes. I attribute this to the variety of activities giving individual students the opportunity to excel in several of them. I also feel that students who have persisted in completing all of the requirements, and with so much work done outside regular class hours, they have learned enough to receive a good grade.

6. Evaluation of the Class

As it can be seen from the previous information, ME 428 is a very demanding class for the student. Sometimes I do not have time to cover all the topics in the outline. Oral presentation of the ergonomics project often takes up a whole class period. For viewing the tapes most of the times we stay after class, which can cause problems. I spend a lot of time on this class, especially since we do not have graders, and the funding for the teaching assistant comes from a special grant that I apply for every year. In order to reevaluate the class content, for the last two years, I have included a one page class evaluation be completed by students during the final exam. To preserve confidentiality, I ask students to hand in the evaluation separately with no name on it.

Students were asked to rank, on the scale of 1-10 (1 being worst, 10 being best), the following activities: 1. Ergonomic Design, 2. CAM Project, 3.Videos, 4. Material Covered in Class, 5. Exams and Assignments. The grades were given for: a) *How Much You Have Learned, b) How Much You Liked c) Importance of the Activity.*

I was pleasantly surprised that students found all activities meaningful. The favorite is the hands-on CAD-CAM project. Students indicated they liked this project, mainly because they had to execute the whole process from conception to finished product. Students in the class, seniors and graduates in mechanical engineering, already have knowledge of several CAD packages and they found learning Mastercam easy and interesting. Choosing the right tolerances so that two parts are neither too snug or too loose was not easy, Many of them had to machine several parts before they found a right fit. In their evaluation, they often commented that: ”It was fun.”

Students rated the teamwork in ergonomic design as very useful. One student commented that he did not realize how fast he was talking until students pointed out that to him. Other, mainly foreign graduate students, commented how much they liked interacting with the other students. They also found useful having to go to stores to look for prices of different items. Several students commented that some students did more work on the projects than others (what else is new!), and also that the project required much more work than the number of points assigned to it (15%). Some suggested that more structural design should be required, since the project did not require stress calculations of the elements. I have purposely omitted dimensioning of the elements to shorten the project. Mechanical engineering students already spend one whole year on a much more comprehensive Senior Design Project.

The videos shown in class and oral review were also evaluated as being useful, although for some students more than others (more experienced students found them redundant).
Students’ comments on exams were that exams are important and the closed book exam is especially important indication of how much students understand the material. However, on the question how much they liked tests, one student wrote: ”Who likes exams and homework?” I always tell them: ” I do not like them either” (i.e. making and grading them).

In general most students gave the class an overall rating, of 8, 9 or 10 (best). More important, several students who graduated told me that they got job thanks to this class (impressing recruiters by knowing the difference between statistical process and product control, for example). Several, who now work in local industry, came back to tell me that they now have a better understanding of the material that they studied in this class.

7. Conclusion

In this paper I have described in detail the different projects and activities that I conduct for the ME 428, Automated Manufacturing class. To better follow industry trends and requirements, this course is constantly changing. For example, several years ago, I placed much more emphasis on Total Quality Management and success of management techniques in Japan and West Europe. Now I am placing more importance on the design of experiments and statistics. During my sabbatical next year I hope to spend more time on preparing, and organizing material for this class.

Although this class requires a lot of effort, the response to the class by students and industry has convinced me that this is worthwhile effort. Consultant Myron Tribus wrote to me, after one educational meeting and after reviewing my course file for this course: “I was impressed by the things you said at the meeting, end even more so, when I took time to read the outline of your course ME 428. How fortunate your students are. As you can see from my papers on education I am proposing to employ various quality tools in the design of the educational experience. You teach most of them.”

I hope this paper will entice some of my colleagues to implement some of above described idea in their classes, as well as discussion about this paper will help me to improve my class.

Bibliography

1. Groover, M.P, Automation, *Production Systems, and Computer-Integrated Manufacturing*. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 1987
2. McFadden F.R., *“Six-Sigma Quality Program”* Quality Progress, June 1993
3. Boothroyd G., Dewhurst P., Knight W., *”Product Design for Manufacture and Assembly”* Marcel Dekker, Inc. New York, 1994
4. Singh N. *“Systems Approach to Computer-Integrated Design and Manufacturing”*,
5. Gies J. *“Automating the Worker”* Invention & Technology, Winter 1991

NEDA SARAVANJA-FABRIS
Neda Saravanja-Fabris received M.S. in Mechanical Engineering, manufacturing option, from University of Sarajevo in 1965, M.S. and Ph.D. in 1972 and 1976 from the Department of Mechanical Engineering, Illinois Institute of Technology. Dr. Fabris has taught and conducted research in three counties including one year at Institute for Machine Tools, in Aachen, Germany and three years at Bell Telephone Laboratory in Napperville, Illinois. Her research in manufacturing is in tool wear and self excited chatter in metal cutting. Dr. Fabris is also active in the recruitment of women in engineering, organizing and conducting “Mother-Daughter” workshops. Dr. Fabris joined California State University in 1979 and served as a Chair of Mechanical Engineering Department 1989-1993. She is recipient of Manufacturing Educator Award from SME Region 12 in 1998.