EXPERIENCING TEAM RESPONSIBILITY IN CLASS*

R. RUSSELL RHINEHART
Texas Tech University
Lubbock, TX 79409-3121

THE ABILITY TO effectively manage a project within a team of peers is one signature of a professional—one which is often ignored in engineering education. However, such an experience *can* be successfully woven into the curriculum to the enhancement of technical fundamentals.

Even as an entry-level engineer, a person must plan, schedule, and then coordinate the work of operators and technicians in adjacent groups. Soon thereafter, one plans, influences priorities, and coordinates peers' activities across organizational boundaries. In any case, that one person is solely responsible for timely results; but he or she must rely on the contribution of others, must accommodate the priorities of others, must foster effective interpersonal relations, and has input into the performance rating of others. Key skills of a practicing engineer include planning, communicating, interaction management, accommodating, and listening. Key perspectives include project ownership and accountability. Such professional attributes, however, are not usually descriptive of an engineer's formal education.

It is likely that at least 50% of an engineer's effectiveness will depend on human team interaction skills. However, the academic experience is largely individualistic, and even the scant group exercises in lab and design are often without assigned leadership responsibility and authority. In practice, a design engineer must cooperate with others; for instance, he must rely on an R&D engineer to generate design data for his project. But we teach and test for *indi-*

TABLE 1
Rules

The project descriptions I have written are suggestions based on my experience, but may be changed. As you progress you will find many other aspects of your topic and you will want to pursue those that interest you. If you want to change the project scope, however, be sure to coordinate that action with me. In any event, you need to meet with me to ensure that your plans meet my expectations.

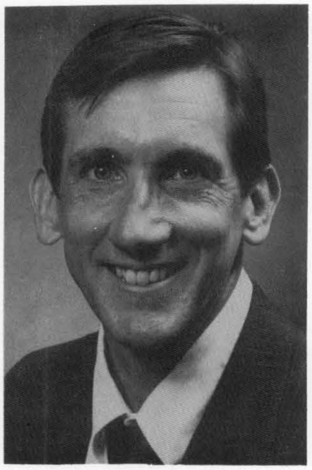
I will grade the written report. It should be neat, organized, and presented so that it teaches a technology or demonstrates an application. Make it something which can be useful to you five years from now. The grade will be weighted 50/50 on technical accuracy and completeness and on communication effectiveness (logical presentation, writing clarity, organization).

The written reports should be 15 to 25 handwritten, single-spaced, or typed, double-spaced pages, including examples, figures, derivations, and computer code. Don't go for broke...this is just a one-month project. But do present some meaningful and useful work.

On the due date the leader will present a ten-minute oral report for the class. The oral report will not be graded.

Take care of your group members. Plan ahead so they can plan their own work schedule. Assign portions of the project that interest them so that they do their best work for you. Use your group members. Delegate, or else you will overwork yourself trying to meet my expectations.

Use me as a consultant for personnel problems as well as technical methodology.



R. Russell Rhinehart is an assistant professor of chemical engineering at Texas Tech University. He received his PhD from North Carolina State University after a 13-year industrial career as an engineer and group leader which included development of reaction systems, process control, solvent recovery, and process safety and reliability. His interest in the special aspects of industrial process modeling, optimization, and control techniques led to his pursuit of an academic career.

*Presented at the 1987 annual AIChE meeting November 17, 1987, in New York, NY

© *Copyright ChE Division ASEE 1989*

vidual performance. A process engineer must get the cooperation of a production staff to run trials, and he must rely on lab services to analyze the results. Yet, throughout his education, we have encouraged, rewarded, and prepared the graduate for individual performance. Consequently, a student's perspective on the practice of engineering is usually misdirected.

If education means developing life skills in preparation for social responsibility (as opposed to merely developing a technical facility), then it is our responsibility as professors to move beyond a technical/academic focus and to incorporate life-relevant experiences into the classroom. Success at human management is a requirement for successful technology implementation. As faculty who are concerned with individual technical performance, we are sometimes unaware that we have omitted the development of the interpersonal skills required for effective engineering.

The objectives of the in-class team responsibility project are:

- **To integrate some of these professional perspectives into the classroom**
- **To coach students toward improved project and people management effectiveness**
- **To support the traditional educational objectives**
- **To enjoy the experience.**

As faculty who are concerned with individual technical performance, we are sometimes unaware that we have omitted the development of the interpersonal skills required for effective engineering.

ASSIGNMENT STRUCTURE AND RULES

Each student in the class becomes a project team leader once and chooses a project topic from a prepared list. The project will take about a month to complete and will demonstrate relevant engineering skills. Projects have included writing computer simulators, technology reviews, a mini chapter for a text, and conducting personnel surveys. The assignment statement is shown in Table 1, and Table 2 lists the project titles given to the students in a junior heat transport course. (While the topics in the third section of Table 2 are non-technical, I think that they are important to engineering sucess and, therefore, relevant to the education of an engineer.)

Three other classmates are assigned to the project leader as team members. Each student is a team leader once and participates in a total of four projects. The team leader has sole responsibility for the project scope, its planning, work distribution, daily coordination, and for both the written and oral presentations. (The oral is required but not graded.) The leader

TABLE 2
List of Projects for a Junior Heat Transport Course

Write a computer simulator and run "trials" of
- A binary boiler
- A condenser
- A red-hot quench
- The transient conduction in a rod
- The steady state temperature profile in a slab of non-constant thermal conductivity
- The steady state performance of a shell-and-tube liquid/liquid heat exchanger
- The steady state temperature distribution in a fin of non-constant cross sectional area
- A steam traced pipeline
- The transient response of a temperature detector in a thermowell with external conduction

Write a technology report, a mini-chapter in a text, presenting an overview of the topic, design equations, and original examples of
- Natural convection
- Heat pipes
- Coiled heat exchangers
- Alternate boiling/condensing heat transfer fluids
- Engineering/business economics
- Heat transfer in two-phase flowing fluid
- Human perception of hot and cold
- Mechanical design criteria for baffles
- Dehumidifiers and after-coolers
- Thermosiphon and calendria reboilers
- Insulation
- Developing and validating correlations
- Steam tracing
- Evaporators/cooling towers
- Temperature measurement device technology and calibration

Write a mini-chapter to introduce the relevance and the engineering skills associated with
- Systematic diagnosis of process faults
- The transition from student to engineer
- Critical thinking to recognize and demythify technical folklore
- Personality development and inappropriate adult behavior
- Decision analysis
- Creativity
- Social structure within human institutions
- Perception of performance
- Industrial performance reward systems
- Temptations and attitudes that lead to less than desirable engineering quality
- The balance of power: marketing, finance, or engineering?

The nature of such an assignment is quite different from the highly structured, individual, deterministic, short-term, private type assignment for which the student has been programmed during his previous fifteen years of school. It is important that the students are comfortable with the change.

meets with me to learn what my expectations of an appropriate project scope are, but then makes the final decisions himself. The project grade is assigned exclusively to the team leader; however, the leader grades his team members. My grade of the project contributes 15% to the leader's course grade, and each of the three grades he receives as a team member counts 5%. The combined four-project grade is 30% of the course grade.

Projects are assigned near the beginning of the semester but are due about one month after the fundamentals of a topic are covered in class lecture. The projects require sustained effort during the last two-thirds of the semester, and I reduce the extent of weekly homework assignments as a result. Topics from the last three weeks' lectures are not assigned as projects. Students select their own project choices from a list of topics that I have prepared. Students can suggest other topics, but rarely do they have that foresight in an unfamiliar technology. Not all of the topics are specific to the course technology, but I judge all to be relevant to the practice of engineering (*e.g.*, engineering economics, human perception of hot and cold, systematic trouble diagnosis, debunking of technical folklore). I match project leaders to one of their first project choices and then assign other team members in order to distribute their project due-dates throughout the semester. I then assign other members so that each student works on at least one project of each type (computer simulator or report) and finally, to shuffle personnel as much as possible.

PREPARATION FOR SELF AND CLASS: A REQUIREMENT

The nature of such an assignment is quite different from the highly structured, individual, deterministic, short-term, private type assignment for which the student has been programmed during his previous fifteen years of school. It is important that the students are comfortable with the change. As adults they can choose to put their personal energy where they perceive it to benefit them the most, and it is important that they "buy into" the objectives of this new type of assignment. So, distributed over several early lectures, I spend about one-half of a class previewing the assignment, discussing the engineering work environment, discussing the experiences I want them to be prepared for, presenting the objectives of the particular assignment, and offering assurances of my availability as both a personnel and a technical consultant. As projects are in progress, I spend five minutes here and five minutes there discussing group assignment plans, coordination, flexibility, ways to handle intractable "employees" and other skills that I perceive are relevant. I also reinforce the workplace/classroom differences to periodically justify the project strangeness in order to keep the adults "on board."

Problems occasionally arise: a failing student decides to put his energy into other courses and fails to contribute his share to the leader's project; a leader plans too late and then unreasonably expects group members to perform at a high level regardless of their other commitments; one project turns out to be much more difficult than the others. It requires a self-confident professor to calm the slighted student's panic, to be flexible, and to assure students that, in spite of individual situations, subjective grading can be fair. The professor must be willing and able to manage such common personnel situations as when a student feels that events beyond his control will affect the reward of his personal performance. These are common workplace problems which a practicing engineer must handle and that a student can preview in his education. Success at human management is a requirement for successful technology implementation.

RESULTS

Comments from the semester-end student course evaluations are one source of results. Verbatim they include:

- **The independent research is a *great* learning experience—*keep it!***
- **Leading a team is *super,* have to deal w/ people not willing to do their part and taking all the input & putting it into 1 report.**
- **Learned TONS! I think it will be very helpful later on.**
- **The [independent] research is a good change from number crunching.**
- **I learned that I need work on my organizational skills.**
- **It is hard grading fellow classmates— *but* good experience.**
- **Also learned a few more things on my own.**
- **I enjoyed working as a team, it helped bring us closer together, and we learn more through research [independent study].**

- **. . . has given us a big opportunity to learn to work together and to be a responsible person in every aspect.**
- **Heat transfer concepts as well as fundamental human interactions were taught.**
- **Required and inspired creative thinking in solving practical engineering problems.**
- **I'm glad projects were assigned. They brought a special type of learning into the course.**
- **Keep it.**
- **Do it again next year.**

Overall, the positive evaluations (70%) outnumber the negative evaluations (8%) by 9 to 1. The negative comments concern either the unfairness in student grading or the variable difficulty of the computer versus the independent study type of projects. I will address these complaints later. The ambivalent responses, such as "grading of the projects was fair," or "give more time to complete the projects," comprised 22% of the evaluation. The students felt that the exercise achieved the desired results. So did I.

Along with my personal perception that the exercise met its objectives, there has been one outstanding tangible result. One student chose to investigate the on-the-job transition one must make in the student-to-engineer metamorphosis. Her group augmented their literature review with personal interviews and a mail survey to our graduates with two to five years' work experience. The questionnaire was developed after their initial investigations and focused on the sufficiency and relevance of engineering education to the skills necessary for life and the practice of engineering. The project report was excellent. It was accepted for publication in the Texas Tech engineering student journal [1].

DISCUSSION

I think that such an exercise is appropriate to the maturity level and stability of juniors, seniors, and graduates. I would anticipate that the mid-term drop-out rate and marginal commitment of many freshmen and sophomores would create severe personnel problems if such an assignment was included at their level.

The 15% and 5% grading schedule provides sufficient incentives. The leader wants a quality report and must rely on substantial team member contributions to meet my expectations. Additionally, the appearance of the half-letter grade control that the leader has provides sufficient incentive to the member for quality participation. In actuality, however, members receive contribution grades from A to D—at worst a sixth of a course letter grade per project. In effect, as professor I really give up very little course grade assignment authority.

With the 15% and three 5% project grades and with homework counted as 20%, non-test grades count 50% of the course grade. Tests count as the remaining 50%. I have no problem with that weighting; however, students occasionally suggest that tests should count more.

Initial assignment descriptions are very brief, *i.e.*, "Write a chapter on heat pipes for a heat transfer text. Describe the phenomena, uses, operating conditions, and fluids. Give design equations and create examples." On that particular project, with initial research the student finds that liquid-wicking phenomena for zero-gravity applications, multicomponent VLE behavior, rarified vapor fluid dynamics, variable surface area control, and internal fins are each of application's importance. The student chooses the specific technology that he finds interesting and relevant and, together with me, works out a project scope that meets my expectations and my realization of the limits of a month-long project that counts 15% of one course in one semester.

. . . there has been one outstanding tangible result. One student chose to investigate the on-the-job transition one must make in the student-to-engineer metamorphosis.

I have not yet graded the oral presentations. To some it is an intimidating event, and I wanted to create a pressureless environment for the verbal class presentation. Additionally, I did not want the students to compete for fancy visual aids. However, the oral presentations were often ill-prepared and of no use to the other class members. In the course evaluations, a few students suggested grading the oral presentation as a portion of the project grade and I plan to try it next time.

A recurring student suggestion is that more time should be allowed for completion of the projects. I suspect, however, that some students shoot for substantial results and completeness, enjoy the independence, and would write a book if allowed. I also suspect that others get started late and would never have enough time. Considering the planning and delegation experiences I want to create, and the justifiable time demand of the project portion of one course, I think that the one-month duration is appropriate. Before students err, however, it is necessary to preview these time constraint aspects. The students must be made aware of the need to limit project scope, to delegate, and to start early.

The reports submitted at the end of the semester benefit from the grading, comments, and in-class discussions on the earlier reports. In spite of my previews, the initial projects are at a grading disadvantage. The students also come to recognize this, and to be fair, I add a letter grade to projects due early in the semester. The students seem satisfied. I have reserved this option and keep it unannounced until I grade the second set of projects, but I have felt that it is appropriate each semester.

Students have a tendency to do most of their own project work. Perhaps it is educational inertia. Leaders' estimates of their personal effort ranged from 50% to 90% of the total group effort. Delegation and coordination are important job functions and, in discussions with leaders, I have encouraged them to delegate. Although I am satisfied with the average leader contribution of 75%, I would prefer to push that to 60% and in subsequent classes will help leaders identify project portions that can be delegated.

As mentioned in the results section, there were two student criticisms of the assignment. One of the two negative evaluations concerned the assignment of grades by the student leaders, and was characteristically stated as, "People give good grades to their friends, without considering their actual work." The objection is not to the student-grading-student aspect of the exercise, but that student grading is not as objective as one would like. Although project leaders did assign D's, A's were assigned to 70% of the members' contributions, and B's to about 25% of the contributions. However, we all recognized that the inflated grades are not indicative of a member's performance and that friends may grade friends too leniently. I've discussed optional grading policies, such as pass/fail and S+/S/U with the classes. However pass/fail lacks discrimination, and the S+/S/U is too similar to A/B/C and may also be subject to grade inflation. I am now trying an alternate approach. Leaders do not grade, but fill out a "Group Member Evaluation Form" (see Table 3) for each group member. The form originated as an industrial performance review but has been

TABLE 3
Group Member Evaluation Form

NAME ______________ **Experiment No.** _____

INSTRUCTIONS:
Place an "X" mark on each rating scale, over the descriptive phrase which most nearly describes the person being rated. *Evaluate each quality separately.* Avoid the common tendency to rate nearly everyone as "average" on every trait instead of being more critical in judgement. Also avoid another common tendency to rate the same person "excellent" on every trait or "poor" on every trait based on the *overall* picture one has of the person being rated.

ACCURACY is the correctness of work duties performed.

Made many errors	Somewhat careless	Avg. number of mistakes	Accurate most of the time	Exceptionally accurate

ALERTNESS refers to the ability to grasp instructions, to learn from research and to solve problems.

Slow to catch on	Needed more than average instruction	Grasped instructions with average ability	Quick to understand and learn	Exceptionally keen and alert

FRIENDLINESS refers basically to the ability to get along with team members.

Distant & aloof	Friendly once known by others	Warm, friendly, and sociable	Very sociable & outgoing	Excellent

PARTICIPATION is being available for and participating in group activities.

Often absent or unavailable	Lax in availability and participation	Usually available and participating	Very prompt & regular	Outstanding, did more than share

DEPENDABILITY is the ability to do assignments well with minimum supervision.

Quite unreliable	Sometimes required prompting	Usually did assignments on time	Very reliable	Outstanding in reliability

JOB KNOWLEDGE is the information each individual had to know or learn in order to do his/her part in all phases of the experiment

Poorly informed	Lacked knowledge of some phases	Moderately informed	Understood all phases	Had mastery of all phases

QUANTITY OF WORK is the amount of work done by the individual throughout the planning, conduction and documentation phases of the experiment.

Unacceptable	Did just enough to get by	Average volume of work	Did more than was required	Superior work production

OVERALL EVALUATION in comparison with other group members.

Definitely unsatisfactory	Below average but made an effort	Did an average job	Definitely above average	Outstanding

COMMENTS:

Group Leader ______________________ Date _______
Group No. __________

modified and used by laboratories in Mechanical and Chemical Engineering and Engineering Technology at Texas Tech. It contains a descriptive five-item scale on each of eight team and technology performance attributes. It also has a section for other comments. I will compile the evaluation data, use that to assign a team member grade, and share the compiled results with the team member. There are several advantages to such an approach. Student leaders can check off attributes without the bias that grading carries and, consequently, may produce a more accurate measure of their team member's performance. Additionally, discussion of the compiled data with each individual may aid coaching for improved performance. Initial feedback is positive.

The second negative evaluation concerned the variable difficulty of the projects, and a typical comment was, "How do you grade a hard program compared to an easy project?" ". . . all projects should be either programs or reports." "Don't compare apples and oranges." Students perceive that the computer projects are more difficult than the technology reports. Considering the level of computer programming expertise of our juniors, I must agree. Perhaps two-thirds of the class have forgotten both the programming language and the systematic approach to programming learned in their freshman course. They tend to write the entire program at once (without having performed hand calculations for familiarity with the procedure), then become extremely frustrated as they debug simultaneous and interconnected syntax and logic erors. Although I preview this, it remains a problem, and I plan to reducing my expectations on the computer assignment scope and strengthening my message to the computer simulator project leaders.

SUMMARY

In an attempt to integrate project management and interpersonal skills development into a junior level transport course, student project exercises were structured with one accountable leader who plans, coordinates, and grades the work of three team members. The exercise structure achieves its objectives and is received well by the students. The course professor must be prepared for the degree of subjectivity introduced and be able to manage personnel problems. Student-to-student evaluations may improve with a non-grade rating form.

REFERENCES

1. Everett, Gayle L., "The Transition From Student To Engineer," *TECHnology MAGAZINE*, (a student engineering publication of Texas Tech University, PO Box 4200, Lubbock, TX, 79409), 1986/87, pp. 10-12. □

REVIEW: Advances in Drying

Continued from page 37.

the viewpoint of the soil scientist, the equations of change for mass and energy transport, formulation of the relevant mass fluxes, consideration of the transport properties, and choice of boundary conditions are covered. Experimental measurement of the transport properties also is considered and the drying of soils by buried heat sources is discussed. A mathematical model for convective drying with the incorporation of sorption isotherms is presented in Chapter 5. This chapter is not a review but rather a research paper concerned with the drying of a porous capillary body and accompanied by a very limited bibliography. Chapter 6 is primarily a descriptive review of the solar drying of crops. After a brief discussion of drying principles, the status of solar drying technology together with equipment description is presented. This is followed by a discussion of the design features and typical performance characteristics of solar heaters for air. A very brief consideration of the relevant economics concludes the review. Certain principles of operation and design considerations for spouted-bed drying are presented in Chapter 7. Emphasis is placed on the selection of a spouted-bed system and its fluid-mechanical characteristics. Three previously published models for describing the performance of this type of dryer are summarized and compared. Chapter 8 is a nontheoretical review of press drying. The principles of operation are summarized and performance data are presented. The mechanical features of existing pilot machines and proposals for full-scale dryers as well as alternatives for improved paper densification are given.

Those persons interested in drying should find the individual contributions to this volume to be of some interest. The authors of most of the chapters are generally recognized authorities in their field. Unfortunately, much of the material seems to have been edited and/or proofread very rapidly and/or poorly as there are a number of instances of quite awkward grammar, misspelling and, something especially disconcerting, incomplete nomenclature. The text is type-set and production is good except for those few figures which are reproduced by direct photocopy. As with similar publications of this type, the price is high. Because of its restricted technical content, this volume should be perused prior to purchase. □