HANDLING LARGE CLASSES:
ISN'T IT NICE TO BE POPULAR?*

R. NEAL HOUZE
Purdue University

MOST OF US ARE PERSONALLY aware of the large increase in chemical engineering undergraduate enrollments. A recent ECPD survey showed an increase from about 15,000 undergraduates in 1974-75 to approximately 26,500 in 1977-78, a 74 percent increase. During this same period, inflation and limited financial support, among many factors, have prevented significant expansion of faculties and facilities to handle the increased loads, at least at pre-invasion levels. These, together with other pressures, have forced us to cope as best we can with much larger classes than we had previously experienced.

Many "challenges" and "opportunities" come with these larger classes. Do large class sizes automatically mean a poorer-quality educational experience for our students? What differences actually occur due to increased class sizes? How do we maintain quality in the students' educational experiences? Can we take advantage of the increased class sizes to actually improve learning? How do we personalize what is perceived by many students as an increasingly impersonal process? How can we more effectively utilize our facilities? What instructional innovations could be employed to counter the negative effects of large class sizes?

If we, as educators, have the great wisdom, knowledge and foresight which our students hope to discover in us, we might actually come up with some possible solutions. In this matter, I suppose we all qualify as experts, since we have all been forced to cope with and adjust to increased class sizes.

A group of concerned chemical engineering educators gathered at the ASEE Annual Conference at Louisiana State University to consider and discuss this very important problem. The authors, having agreed in a weak moment to serve as panelists, discussed what their respective institutions are doing to solve the problems encountered by increasing enrollments, and the following is the account of their presentations.

As a prelude to presenting the methods some of us are using to cope, let's first consider the magnitude of the problem. Figure 1 presents the enrollment statistics for the four institutions represented by the authors, Georgia Tech, Texas A & M, University of Illinois-Urbana and Purdue University. Over the past four years, the number of undergraduate chemical engineering students has more than doubled. Since the faculty sizes have not increased proportionally, the result has been a dramatic increase in class size and a strain on our facilities, particularly in laboratory space. The four institutions represented by the authors have taken two basically different approaches to cope with the increasing undergraduate classes. One is to increase the faculty and the other is to accept larger classes as a fait accompli and institute various methods to attempt to reduce the problem of insufficient student/faculty contact. The philosophy and attempts of each institution to cope are described in the following sections.

FIGURE 1. Chemical Engineering Undergraduates.

*Presented at the 1979 ASEE meeting, Baton Rouge, LA.
Ron Darby came to Texas A&M University in 1965 and attained the rank of Professor in 1970. He holds B.A., B.S. and Ph.D. degrees from Rice University. His research and interests include heat transfer, applied electrochemistry, fluid mechanics, polymer rheology, and suspensions, and he is the author of a text on "Viscoelastic Fluids."

The philosophy adopted at A & M to handle increasing enrollments has been to increase the number of faculty and the number of classes to maintain relatively small classes and a high degree of student-instructor contact. Figure 2 illustrates the results of this course of action. Prior to faculty expansion in 1976, class sizes (students/class) and the number of course sections (contact hours/FTE) were increasing. As a result of doubling the faculty (permanent plus visiting) in three years, the average class size has stabilized and the faculty work load (contact hours/FTE) has been reduced from its maximum in 1975-76.

These small class sizes provide effective student-instructor contact and we have thus been able to maintain a traditional approach to each individual class while providing the students with the level of individual attention necessary for a quality education. We have made a conscious effort to maintain quality standards by requiring a minimum grade of C in the first chemical engineering course and enforcing a minimum grade point average to enroll in senior level chemical engineering courses. Industrial recruiters will attest to the high standards and absence of grade inflation and many make upward adjustments in our students' grade point averages when comparing them with graduates of other schools.

The average class size of 28 may be deceiving; our laboratory class size is limited to 20, but the freshman introductory course averages 90. We must offer a large number of laboratory sections, and have almost reached our capacity to handle these courses without scheduling night sections. All graduate students are required to serve a minimum period as a lab instructor or teaching assistant. With a faculty member coordinating a number of lab sections, this provides an acceptable method of offering a large number of laboratory sections. Uniformity between multiple course sections is improved by assigning a course coordinator and, in some cases, giving common examinations.

These approaches have helped us maintain a quality educational experience for our students. It has also helped us keep the faculty teaching load to an acceptable level.

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R. Neal Houze is Associate Professor of ChE at Purdue University. He received his BSChE from Georgia Tech in 1960 and his MS and PhD from the University of Houston in 1966 and 1968. He is the Cooperative Engineering Education Coordinator for chemical engineering and teaches in the areas of transfer and transport operations. His current research is two-phase, gas-liquid turbulence and mass transfer.

Purdue has traditionally had relatively large chemical engineering enrollments as a result of the large size of our total undergraduate engineering program. Although our student population has not increased proportionately as much as some other institutions, we have experienced some real squeezes due to the popularity of our curriculum.

The lack of increased state funding has prevented significant expansion of the permanent faculty. The faculty size is the same as it was ten years ago. In addition, increased emphasis on research and graduate education has severely limited the ability to increase faculty teaching loads. Also, limitations in the number of graduate students, and funds to pay them, have prevented any significant increase in the number of teaching assistants. At present, there is neither a mechanism to restrict the number of students selecting chemical engineering at the end of their freshman year nor any grade point average restriction at any point during the curriculum. These factors have forced us to evolve techniques to handle students in large single-section courses.

We have approached the problem (should I say "challenge"?) in two ways: We have attempted to exert some influence on the total enrollment and we have attempted to provide better individual contact for the students to ameliorate the perceived impersonal nature of large classes.

The university has traditionally had 45-50% out-of-state students in the Schools of Engineering. Admissions are now being limited, reducing our out-of-state engineering student population to a lower percentage (20-30%). As a state-supported university, we cannot limit in-state admissions, and these have been increasing during the past few years. Consequently, we have experienced continued increases in our total engineering enrollments. Additionally, chemical engineering has increased in popularity, and a larger fraction of the freshman engineering class has been choosing our curriculum.

We have instituted a policy in our first chemical engineering course which we hope will help limit the number of students continuing in the program. The faculty has adopted the policy that this first course should be challenging, with a heavy work load consistent with the course credit. The objective is to introduce the students to the rigors of the curriculum and the chemical engineering profession. As a result of this policy, we find that a significant fraction of the incoming sophomore students withdraw from the course and transfer out of chemical engineering. We have concluded that these students lack the motivation and/or ability to accept the rather demanding nature of the chemical engineering curriculum. In spite of this policy, we find that ever-increasing numbers of students are entering chemical engineering and are able to handle the subject matter and the work load. We shudder whenever we speculate what our student population would have been had we not taken this action.

In an attempt to maintain adequate individual attention for the students, we have introduced recitation sessions into many of our large lecture courses. The large class meets in small groups of 30 to 40 students once a week. The purpose of these recitation sessions is to cover homework assignments and answer the students' questions covering the course material. At present, these recitations are staffed by faculty, not teaching assistants, with the course instructor providing...
coordination by specifying the subjects to be covered during the recitations.

We are expanding the number of chemical engineering elective courses offered each year. The increased variety of these courses, as well as the increased number, is intended to provide our students with more opportunity to interact with the faculty in small classes. The major limitation on the number of electives which can be offered is the size of the faculty and the required courses which must be staffed.

Lectures in one of our required courses have been video-taped. These lectures are broadcast on the local TV cable system and the video cassettes are available in our audio-visual center for the students. The use of these video-recorded lectures releases faculty for additional teaching. Selected problem solutions have also been video-recorded for our junior-level Transfer Operations course. The students can view these solution tapes at their convenience, alleviating some of the problems of limited faculty time to answer questions.

We maintain relatively small laboratory sections with a maximum of 24 students per section. Our laboratory courses are designed to provide the students with an opportunity to apply engineering principles in a pseudo-industrial atmosphere and small groups are essential to the achievement of our objectives in these courses.

The necessity of maintaining large lecture classes has supplied the impetus to provide our students with opportunities for quality learning experiences. The techniques we have employed have effectively ameliorated some of the negative effects of expanding enrollments, but even larger enrollments cannot be accommodated without significant alterations in our curriculum, faculty and/or facilities.

UNIVERSITY OF ILLINOIS

IMPROVING LEARNING OPPORTUNITIES WITH PLATO

MARK STADTHERR
University of Illinois, Urbana
Urbana, IL 61801

During the 1978-79 academic year, enrollment in our required courses was about 120 to 150. In most cases we handle this in one large lecture session, and then once a week break up into small discussion or recitation sessions of about 25 students. Each session is handled by a graduate student teaching assistant. In our laboratory courses, a main problem is simply one of logistics. We have begun remodeling our unit operations lab, both to provide some new experiments and also to restore others to working order. With more experiments running simultaneously, more students can be handled in a single laboratory section. The logistical problem is particularly severe in our process control laboratory, so we are undertaking similar work there; in this case incorporating a number of microprocessors.

A rather unique approach to some of the problems presented by large classes is our use of computer-aided instruction. We use the PLATO computer system, developed at the University of Illinois and now made available elsewhere by Control Data Corp. The PLATO system provides interactive self-paced instruction at a large number of terminals around campus. It has proven quite successful in teaching chemistry, physics, and other subjects.

The use of the PLATO system in our chemical engineering courses is due to the efforts of Professor Charles A. Eckert, who began work about three years ago to develop PLATO lessons for our first chemical engineering course dealing with material and energy balances. The use of these lessons began in earnest several years ago and we now have a full complement of lessons available for this course. Last spring we also began using PLATO lessons in our course on fluid mechanics and heat transfer, and last fall began using them
The use of PLATO in our ChE courses is due to the efforts of Prof. Charles E. Eckert, who began work about three years ago to develop PLATO lessons for our first ChE course dealing with material and energy balances.

in our thermodynamics course.

Each PLATO lesson consists of five or six problems of the sort normally assigned on homework problem sets. The student sits at a terminal and selects a particular problem. The problem appears on the screen and, since PLATO terminals have graphics capability, the student will typically see a diagram of the system on which the problem is based. The student is then asked for input; he may be asked to enter an equation, a numerical answer, or perhaps to touch the appropriate point on a graph or diagram (PLATO terminals have touch-sensitive screens). If the student makes a mistake that the programmer was able to anticipate, he will get feedback indicating what he did wrong. If the mistake was not one of those anticipated, or if the student is stumped at the outset and cannot enter any answer, he can press the HELP key and get a hint as to what he should do. If this hint is insufficient, he can press the HELP key again and again, each time getting a stronger hint, until finally he is essentially told the answer. These lessons are designed to allow students to work homework problems and get immediate feedback, as if he were working through the problem directly with the professor or teaching assistant. It is this kind of direct contact that is becoming increasingly infrequent because of large class size.

It should be emphasized that the PLATO material does not take the place of any lecture material, nor does it take the place of all the homework; conventional homework assignments must still be handed in. The PLATO lessons may be optional or required, at the option of the instructor. The students may work the PLATO problems as often as they like; roughly one-third of the PLATO time is used by students working problems over again. This reflects the students' use of PLATO to review for exams and to get help as they work on the conventional homework assignments. So, in a way, PLATO becomes a sort of consultant to the student, somewhere he can go for help in lieu of direct contact with the professor or teaching assistant.

The PLATO material has been rather well received by the students. The most common complaint is one of logistics since students living off-campus find it inconvenient to come to campus in the evening to use the PLATO terminals. In general, however, PLATO seems to have a positive effect on student morale.

Though PLATO may help alleviate the problem of less direct contact between student and instructor by providing an alternate means of direct and immediate feedback, it does not make the course any less impersonal. The increasingly impersonal nature of teaching in chemical engineering is quite disturbing, and there seems to be no readily apparent solution.

GEORGIA INSTITUTE OF TECHNOLOGY
PROVIDING MORE FLEXIBILITY WITH OPEN LABS
ED HARTLEY
Georgia Institute of Technology
Atlanta, GA 30332

Dr. E. M. Hartley is Associate Professor of ChE and chairman of the Pulp and Paper Engineering Program at Georgia Tech. He has been active in the reorganization and instruction of the unit operations laboratories.

UNDERGRADUATE LABORATORIES AT Georgia Tech involving the use of equipment include two in Transport Phenomena, two in Unit Operations, one in Process Control and one in Polymer Science. An undergraduate Kinetics laboratory will be included in the near future. Laboratory courses have been scheduled individually, usually for a 3 hour period during one afternoon each week, with a teaching assistant and faculty member assigned to each lab, each quarter. The large enrollment has resulted in several problems including an increased strain on equipment maintenance, too many students for the space and equipment, and increased problems with scheduling due to conflicts with other courses. A general problem has

CHEMICAL ENGINEERING EDUCATION
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been a lack of continuity in lab maintenance and supervision because of the quarterly change in personnel responsible for any given lab. Our summer program at the University College London has helped to reduce the load. Each summer, 15-20 students spend 5 weeks at UCL and the program includes lab experiences that will satisfy requirements for two or three of the five required labs at Georgia Tech.

The “Open Lab Concept” represents our attempt to deal with current problems. The labs will be staffed by teaching assistants and will be open from 1:00 p.m. to 6:00 p.m., five days a week. The teaching assistants will report to a Laboratory Coordinator who will be a member of the faculty, although perhaps not in a tenure-track position. The responsibilities of the teaching assistants will include: scheduling of experiments, maintaining supplies, maintaining order, reporting maintenance needs to faculty and/or staff, referring students to appropriate faculty members as required, enforcing safety and housekeeping requirements, and security. The teaching assistants will not be responsible for the technical nature of the experiments or for grading the reports. With the help of the teaching assistants, groups of three or four students will schedule the dates and times for their experiments at the beginning of the quarter and will be responsible for completing the experiments as scheduled. The faculty will approve the schedule to insure that the correct number and types of experiments are chosen. Each faculty member will be assigned responsibility for one or two experiments in an area of his interest for a duration of two to three years. For these experiments, the faculty will instruct teaching assistants and students as required, coordinate maintenance and grade reports.

One faculty member will be assigned to each lab course, such as Transport Phenomena I, each quarter as a course coordinator. He will determine the final grade by tabulating the grades received on each report from the faculty member responsible for the experiment. The course coordinator will approve each group’s schedule as mentioned above. In determining their schedule, the student groups will choose from a list of experiments with the requirement that at least one experiment be done from each of several areas. This system will insure that the students will interact with several faculty members during a lab course.

We are currently searching for a non-tenure-track staff member. The person in this position will serve as the laboratory coordinator, be in charge of the machine shop and electronics lab, be responsible for lab equipment maintenance and will possibly get involved in purchasing and safety. Hence this person will be in an excellent position to give the continuity to lab upkeep which has been lacking in the past.

SUMMARY: R. Neal Houze

Many techniques can be used to cope with and provide quality educational experiences for the current large numbers of chemical engineering students. The techniques employed by our institutions are attempts to use our ingenuity and our concern for our students to improve their experiences. There are many challenges facing us in the foreseeable future. We have met challenges in the past, and we will continue to do so. The real challenge is to help our students develop into mature, knowledgeable professionals. We are all involved and responsible to meet this challenge.

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