MODULAR INSTRUCTION UNDER RESTRICTED CONDITIONS

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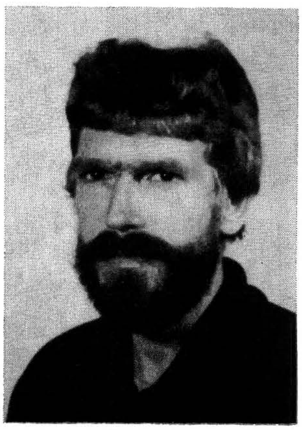
DUE TO THE ECONOMIC recession and cuts in educational budgets, discussions on the efficiency of the education system (especially with regard to faculty time) have only recently been started in the Western world. For developing countries, however, this is not only a well known problem but only one of many problems. Besides having a small faculty, underpaid and overoccupied with additional activities, universities often face such conditions as inhomogeneous classes (in capability as well as in motivation), low staff-student ratios, rapidly increasing enrollments, and the need for more graduates.



Tjipto Utomo graduated from high school in 1941 but had to suspend his academic activities during the second World War and the following struggle for independence. He began university studies in 1950 and graduated from the chemical engineering department of the Institute of Technology Bandung in 1957. He obtained his MChE degree in 1959 from the University of Louisville and is presently a professor at the Institute of Technology Bandung. **(L)**

Kees T. A. Ruijter is a graduate in chemistry from the University of Amsterdam. During the years of 1979-1983 he worked in the Dutch-Indonesian program on upgrading chemical engineering education in Indonesia. Before that he was with the Twente University of Technology (Holland) working on the development of chemical engineering education and he has now returned there. His main areas of interest are lab course improvement, efficiency of the learning-teaching process, and curriculum evaluation and development. **(R)**

In a cooperative project between the Bandung Institute of Technology (ITB) and technical universities in The Netherlands, the educational system was improved gradually within these restrictive conditions [1]. One of the main features, a modified modular instructional system, is the subject of this article.

THE TRANSPORT PHENOMENA COURSE

The transport phenomena (T.P.) course is a fourth semester course. However, because the first year is a common basic science program for all ITB students, it is their first real confrontation with engineering concepts. For this reason and because less than 30% of the students passed yearly, the T.P. course was chosen as our pilot course.

In the first phase of reconstruction the course and its context were thoroughly evaluated. Some measures were investigated in an experimental set-up and implemented step-wise. The main findings were

1. **Only a few students perform at an acceptable level. Many students know the principles and laws but cannot apply them in any situation.**
   We decided to restrict the number of topics to be discussed and to require the students to perform at a higher level of competence.
2. **The individual differences in student performance are enormous (despite the common first year program).**
   To minimize this problem we developed a modular instruction scheme enabling the students to study at their own pace.
3. **The students (80%) are not able to read English texts.**
   Also, because the lecture as a source of informa-

tion is inadequate for an inhomogeneous class, we decided that all information (text, examples, exercises and solutions) should be made available on paper.

4. Students do not solve the problems systematically and they have difficulty in describing physical phenomena in mathematical terms.

   For this we adopted a methodology for solving science problems and modified it for the T.P. problems [2, 3].

5. Individual guidance of students working on problems is quite effective but cannot be applied to exercises at home because of lack of tutors.

   An instructional scheme was developed wherein the presentation of theory and applications by the teacher was followed directly by individual exercises in class and continued at home.

6. The usual norm-referenced grading procedure appears to be inadequate to evaluate effectiveness of learning and instruction and is demotivating for the students.

   In grading the module exams we applied the criterion-referenced performance assessment. As criterion we chose 60%, the minimum level of mastery necessary to take the following module.

MODULAR INSTRUCTION

Modularization is a classical solution for the problem of an inhomogeneous student population. Students in such a group differ in capability, intelligence, and motivation, resulting in different time requirements for study. In a modular scheme the allowed time is made to correspond with the students' required time. The course is divided into modules, enabling students to choose more or less individual paths [4]. However, we could not apply all principles of modular instruction because

- ITB students are not able to study on their own (they have never studied in instructional schemes other than the lecture).
- Faculty time is very restricted and assistants, proctors, or administrative staff are not available.

Therefore we limited the number of examinations and the opportunity for remedial instruction and developed a teacher-paced modular system. The contents of the T.P. course are very suitable for modularization because of the similarity among the three sections: transfer of momentum, heat, and mass. After the first part the other two can be presented by analogy.

The contents were divided into 6 modules; 3 modules covering the basics of momentum, heat, and mass transfer; 2 covering extensions and applications of these; and the 6th module (C-2, extension of mass transfer) is postponed to the unit operations courses. The first module is a small module, to encourage the students to start their study immediately. The students can concentrate on the macro-balance approach and by the time they are acquainted with this concept and the new instructional system, the micro-balance approach is introduced (see Table 1).

We developed a teacher-paced modular system which allows the students to study on a full or a 60% pace (a 2 gear-system).

TABLE 1
Contents of 5 Modules

MODULE	SUBJECT
A-1	INTRODUCTION
	Transport phenomena
	Laws of conservation
	MOMENTUM TRANSPORT
	Laminar flow
	Sample problems
	Abstract and exercise
	Dimensional analysis
	Exercise
A-2	Flow in pipes
	Turbulent flow
	Pressure drop in tube flow
	Flow in conduits with varying cross section
	Sample problems
	Abstract and exercise
	Flow around objects
	Exercise
B-1	MICROBALANCES
	Introduction
	Equation of Continuity
	Equation of Motion
	Application of the equation
	Abstract and exercise
	HEAT TRANSPORT
	Introduction
	Equation of Energy
	Application of the equation of energy
	Abstract and exercise
B-2	Unsteady state conduction
	Heat transfer by convection
	Radiation
	Abstract and exercise
C-1	MASS TRANSPORT
	Diffusion
	Mass transfer
	Coefficient of mass transfer
	The film theory
	Concentration distribution
	Unsteady state diffusion
	Mass transfer by convection
	Simultaneous heat and mass transfer
	Abstract and exercise

The examination procedure forces the students to concentrate on the basic modules. Only students who pass the first module (A-1) are allowed to proceed to the second module (A-2). The others must repeat the A-1 exam, which is scheduled at the same time as the regular module A-2 exam. This procedure requires the least possible time from the lecturer. For the same reason, no remedial instruction for repeating students is organized. The printed text and work-out exercises should enable them to prepare for the repetition. As a consequence, as many students as possible who are starting to study heat transfer have passed module A-1 and have a proper comprehension of the essentials of momentum transfer. The procedure for the second section is quite similar.

A calculation showed that the examination for modular instruction should consume no more instructor time than examination by the former method, if 60% of the group passes on the first attempt.

Since 1981 all homework problems have been directly related to classroom exercise. Feedback on the exercises was provided in class and in the lecture notes (answers), while many worked-out problems were shown in show-windows. All problems were worked out in four phases: analysis, plan, elaboration, evaluation. Only a precise result in one phase allows the problem solver to proceed to the next phase. The results at each phase enable the instructor to provide adequate feedback and allows the students to look for adequate information about their solving process. This problem solving scheme was also followed for examinations.

RESULTS

The module test results of 1981 are shown in Table 2. The student performances were acceptable except for modules B-2 and C. Here a final module effect, "we have got the ticket," seems likely.

After the tests only 66% had to repeat two modules or less. Most of them were able to pass the respective parts of the final exam and thus the whole course. This and the overall effect of the reconstruction is shown in Table 3.

By means of questionnaires, interviews, and analysis of examination results, other information was collected on

- **TIME SPENT Students did not feel the modular system forced them to spend more time on transport phenomena.**
- **PROBLEM SOLVING The plan phase was very difficult for the students. The lecturer considers the systematical method on problem solving not only as a means for learning but also as a sound tool for instruction and explanation to the students.**
- **ATTENDANCE AT LECTURES/INSTRUCTIONS The number of students attending the lectures during the semester was higher than before. The decrease in attendance during modules B-2 and C was partly caused by the interference of laboratory activities. This explains the lower scores on these modules.**
- **ACCEPTANCE Students and lecturer were very positive about the reconstructed course and the modular system.**

TABLE 2
1981 Module Test Results

MODULE	STUDENTS WITH SCORE ABOVE 60% First attempt	Second attempt	Final exam	% Students passed (N=135)
A-1	95 (70%)	34	1	96
A-2	67 (70%)*	**	35	67
B-1	97 (72%)	26	1	92
B-2	55 (57%)	**	1	41
C	27 (20%)	**	77	77

*Percentage of number of participants in the examination. Here 67 passed out of 95 students allowed to participate.
**For these modules the final exam is the second attempt.

CONCLUSIONS

The examination results of the reconstructed courses and the general acceptance show that the modular T.P. course is a substantially improved course. The better performance of the students is not a result of an increase in their efforts or the

TABLE 3
Distribution of Final Grades for the TP Course During and After 1980

GRADE	1980	1981	1982
A	0%	3.3%	21.0%
B	2.5%	30.1%	29.5%
C	18.5%	46.3%	27.6%
(A+B+C)	(21.0%)	(79.7%)	(78.1%)
D	25.2%	12.2%	5.7%
E	30.3%	0%	4.8%
F	23.5%	8.1%	11.4%

A/B/C—Passed: D—Passed conditionally: E/F—Failed.

activities of the teacher, but by a more efficient use of the students' and lecturer's time; i.e. the internal efficiency of the instructional process has been improved.

The main feature of the new course is the modular system. We developed a teacher-paced modular system which allows the students to study on a full or a 60% pace (a 2 gear-system). Remedial teaching was not applied. This system resulted in a constant study load in transport phenomena during the semester and few students lost the junction in an early phase as they had in the past. We may conclude that it is worthwhile to apply a modular scheme, even under very restricted conditions of faculty time. □

ACKNOWLEDGMENT

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LITERATURE

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ChE book reviews

THE HISTORY OF CHEMICAL ENGINEERING AT CARNEGIE-MELLON UNIVERSITY

By Robert R. Rothfus
Carnegie-Mellon University,
Pittsburgh, PA 15213, 302 pages

Reviewed by
Robert B. Beckmann
University of Maryland

The author, Robert R. Rothfus has been associated with the chemical engineering program at Carnegie-Mellon, as a graduate student and faculty member, for over forty years, a period that covers over half the Chemical Engineering programs total existence and almost the entire period of its existence as a separate department. The book was obviously a labor of love to Professor Rothfus as evidenced by its attention to statistical detail and anecdotes as well as historical development.

The first part of the book outlines the historical development of the school beginning with Andrew Carnegie's original offer to establish an institution for technical education on 15 November 1900 and traces the development from the "Carnegie Technical Schools" to the transition (1912) to Carnegie Institute of Technology and the final transition (1967) to Carnegie Mellon University. Following the detailed development to University status the book turns to the historical growth and development of the original School of Applied Science . . . one of the four original Schools founded by the Carnegie gift . . . to the current College of Engineering. The first diplomas in Chemical Engineering Practice were awarded in 1908 along with the initial "Diplomas" in the Civil, Electrical, Mechanical and Metallurgical Practice fields. Included are statistical and organizational details relating to the various departments, research laboratories, interdisciplinary programs, the academic calendar, tuition and enrollments.

The development and growth of the Chemical Engineering Department is chronicled in Chapter 4, beginning with the original Chemical Practice program in 1905 and the transition to Chemical Engineering in 1910. The chapter divides the history of the Department into quantum periods depending upon who was the chief administrative officer of the department during that period. The problems, issues and accomplishments of each period are well chronicled. The development is carried through 1980.

Part Two of the book, which comprises over 40 percent of the total pages is devoted to an exhaustive presentation of departmental statistics from its inception through 1980. The various chapters include such topics as enrollment and degrees granted, the faculty over the years, the changing undergraduate curriculum and graduate instruction, research activities and financial support and anecdotal sections devoted to departmental "personalities" and a recalling of the unusual, comical and tragicomical events over the years. The Appendices, about a third of the book, are devoted to a complete delineation of faculty, staff and students (graduate and undergraduate) by name and years of service, or graduation, who have been a part of the Carnegie Story in chemical engineering.

Continued on page 48.