ChE curriculum

PROCESS CONTROL ENGINEERING AT UT PERMIAN

CLYDE H. SPRAGUE, GEORGE H. QUENTIN AND C. M. FRY
University of Texas of the Permian Basin
Odessa, Texas 79762

THE UNIVERSITY OF TEXAS of the Permian Basin, was opened in the Fall of 1973 to serve the more than 300,000 people in the oil-rich Permian Basin, the state of Texas, and the nation. Offering programs in three colleges: Management, Arts and Education, and Science and Engineering, the university operates as an upper level institution providing junior, senior, and graduate level courses. Students are accepted after completing at least 60 hours of work at another institution, usually a junior college. Designed from the outset to provide unique and innovative programs and to employ proven teaching techniques, both new and old, the university has embarked on a number of distinctive educational and operational tracks. These are perhaps best exemplified by the program in Control Engineering. It is the purpose of this paper to describe that program.

THE NATURE OF A CONTROL ENGINEER

CONTROL ENGINEERING is a unique engineering discipline, as different from other disciplines as they are different from each other. It is inherently multidisciplinary in character requiring expertise from a number of diverse disciplines. That expertise must be brought to bear, however, in a way that is unique to control engineering. Control engineers are concerned with complex systems, systems with elements from many physical domains, systems that are almost always in a transient state, systems that must perform with precision and accuracy.

A suitable control engineering curriculum must emphasize accurate measurement and control of variables, modeling and dynamic response of elements and systems, sophisticated and functional methods of analysis and design, and the commonality of systems from all domains. To successfully build a program of this type, it is necessary to have faculty with broad experience and an interdisciplinary background and that are willing to work freely across discipline boundaries.

GENERAL GOALS

STARTING A NEW engineering program in a new university, especially one where judicious departure from tradition is not only tolerated but encouraged, provides a rare opportunity to take a new approach to engineering education. The control engineering program has attempted to take a cautious and rational approach to substantial change. Program goals, for example, call for

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technical competence in breadth and depth and a demonstrated high level of communication, management, and interactive skills. More significantly different from tradition, however, are the additional program goals of developing in graduates the desire and the ability to continue learning, of providing a program that meets efficiently the individual needs of students, and gives students with sufficient innate learning capacities a maximum chance for success. Accreditation is, of course, an important program goal.

A coherent curriculum design results when aimed toward a specific and well-defined set of

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degree objectives. From the degree objectives, it is possible to identify the supporting objectives down to the expected entrance level of students, in this case, the beginning of the junior year. These supporting objectives can be subdivided to form the courses or study areas necessary to accomplish the curriculum. Usually, a given objective specifies a broadly applicable problem-solving process and need not be tied directly to a given physical domain such as chemical, electrical, mechanical, etc. In this way, it is possible to use different applications vehicles to illustrate and learn the given process. One may learn about the basic processes in modeling and simulating second order systems, for example, by using electrical, mechanical, fluid, thermal or other systems as illustrations. The multi-disciplinary nature of control engineering makes it important to give some attention to all applications areas while placing emphasis in the areas appropriate to the individual student's goals. By specifying the appropriate set of problem-solving capabilities along with the content areas that are germane, a highly individualized curriculum can result.

The specific degree objectives are of utmost importance in the design of a curriculum and of courses for that curriculum. For those that may be interested, the objectives are included as an appendix.

STUDY PLANS AND COURSE STRUCTURE

Although only a single degree designation is currently authorized, a broad range of individual curricula is possible through formulation of a specific, individually tailored degree plan for each student. Working in close association with a faculty adviser of his or her choice, a student works out the degree plan which, while meeting all the external constraints, is best suited to the entrance competencies and career goals of the student. Personal interviews, current testing data, job experience, previous academic records, and limited special testing are currently used as bases for establishing points of entry into the program. An extensive program of pretesting will be undertaken for the first time in the Fall of 1975.

Courses designed for this program are each divided into several small modules of instruction, each module specifying carefully what is required of the student. Modules are studied in a sequence so that each builds on and reinforces the previous one and so that interrelationships among study areas are carefully delineated. Since the courses are also offered for variable credit, there are essentially no fixed course boundaries. Students may thus enter a study area at a point consistent with their background and exit when they have successfully completed the collection of modules appropriate to their specific degree plan. Additional flexibility is provided by selecting variations in objectives and application areas within a module to support a particular program. To formulate such a degree plan, the amount of credit in a given course area is specified; currently in units

L to R: Drs. Charles M. Fry, Clyde H. Sprague and George H. Quentin.

Charles Max Fry received the B.S. degree in aerospace engineering from the University of Oklahoma in 1965, the M.S. degree in mechanical engineering from Rice University in 1967, and the Electrical Engineer and Ph.D. degrees in electrical engineering from Southern Methodist University in 1972 and 1973, respectively. From 1967 to 1970 he was employed as an Aerodynamics Design Engineer with LTV Aerospace Corp., Dallas, Texas. Dr. Fry was an LTV Corporation Doctoral Fellow at Southern Methodist University from 1970 to 1973. Since 1973 he has been Assistant Professor of Engineering at U. T. Permian Basin.

Clyde H. Sprague received the B.S. degree in mechanical engineering from Kansas State University in 1958. From 1958 to 1961 he was employed at The Johns Hopkins University Applied Physics Laboratory in Silver Spring, Maryland. He received the M.S. degree in mechanical engineering from Kansas State University in 1963. From 1963 to 1973 he was with the Department of Mechanical Engineering at Kansas State University. Two years were spent on leave at Purdue University where the Ph.D. degree was completed in 1967. He moved to UT-Permian in January of 1973 as Associate Professor and Coordinator of Engineering.

George H. Quentin received the BChE (1955) from Rensselaer Polytechnic Institute, and the M.S. and Ph.D. (1965) in Chemical Engineering from Iowa State University. Background includes diversified experience with DuPont, National Distillers, and Monsanto Companies. Following several years on the Chemical Engineering Faculty at the University of New Mexico, he joined the University of Texas of the Permian Basin as an Associate Professor on the Faculty of Engineering.

of not less than 1 credit hour. This generates a conventional-looking transcript. Specific requirements for a student to earn the designated credit are worked out and contracted informally. A more formal process for this is evolving but the informal process works adequately for our small student population.

SELF-PACED INSTRUCTION AND COURSE MANAGEMENT

To use effectively the flexibility built into the course structure and degree formulation system, most course areas are offered on a continuous enrollment, self-paced basis. Consequently, students may enter the program at any time, and take up to two full semesters to complete a course under justifiable circumstances. This requires that most self-paced courses be available at all times. Simultaneous proctoring of several courses by both students and faculty results in efficient and full use of instructor time, even with small individual course enrollments.

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Good course management plays an important role in the relative success of a self-paced course. Neglect of the management aspect of self-paced course design is common and often leads to disenchantment with the method. Significant time and effort have been devoted to the evolution of a workable management system at UT Permian, and much has been accomplished. Although the system is far from perfect it is improving steadily. Management is an important component in all self-paced courses but is critical in this engineering program where most or all of a given student's load may be self-paced.

A RANGE OF DEGREE PLANS

ALTHOUGH THE CONTROL Engineering degree is of sufficient breadth to prepare students for a variety of career opportunities, all students are expected to develop control system design expertise in one or more selected applications areas. Efficient degree planning for these diverse fields of application requires significant breadth of selection in math, in engineering science, and in engineering design. This is accomplished by developing a minimal central core in each area surrounded by a coherent collection of additional work from which to choose. In visualizing this approach, it is important to recognize that there are no fixed course boundaries so great flexibility is possible.

To illustrate the breadth of possible curriculum planning, two contrasting degree plans are outlined in the table below. One is appropriate for an engineer interested in chemical process control, the other is oriented toward flight control applications in commercial or military aviation or aerospace. These degree plans should be interpreted as representative of what is planned or possible, not as specific requirements for a degree although they do indicate minimal credit in an area. It is also important to note that differences in content and objectives between equal credits in a given study area contribute to a difference in the two plans not evident in the table.

ENGINEERING DESIGN

A SIGNIFICANT PORTION of this component of each Control Engineering degree plan is devoted to formal training and realistic experience with project engineering and management. At present, the engineering management training is handled by conventionally offered, formal management courses. These will eventually be tailored to and integrated with the project engineering activity.

The engineering project experience is provided by courses in Authentic Involvement. In this area, students are organized into teams of four or five students, possibly some that are not engineers, to pursue a lengthy engineering project. Projects are solicited from industry, public service institutions or other appropriate sources. Specific criteria for screening potential projects have been established to insure their realism and suitability. Students work in teams, under faculty supervision, and as consultants to the industry. Each team is expected to carry out all of the functions of a normal project team assigned to such a problem and to conclude the project with a formal, oral and written report to the client agency.

Authentic Involvement is the capstone of the degree program and serves to reinforce previously acquired engineering competencies; to develop confidence and competence with the engineering

TABLE 1. REPRESENTATIVE BUT CONTRASTING DEGREE PLANS.

		Chemical Process Control Orientation	Flight Control Orientation
English		6	6
Humanities and Social Science	History	6	6
	Government	6	6
	Other	3-6	3-6
Basic Science	Inorganic Chemistry	8	8
	Advanced Chemistry (Physical & Organic)	8	0
Mathematics	Analytic Geometry & Calculus	9	9
		(content of advanced math selected to fit program)	
	Advanced Math	6	6
Engineering Science	Simulation	1-3	1-3
	Statics	1	1
	Dynamics	2	3
	Mech of Mat'ls	2	2-3
	Mat'ls Science	2	2-3
	Systems Analysis	4	6
	Thermodynamics	6	3
	Fluids	3	3
	Heat Transfer	3	2-3
	Electronics		3
	Measurements	0-3	3
	Separation Processes	3	
	Chemical Reactor Operations	3	
Engineering Design	Introductory Control System Design	3	3
	Computer Control	3	0-3
	Modern Control	0	3
	Engineering Management & Economics	3-6	3-6
	Engineering Project	3-6	3-6

design process; to develop and apply management, communications, and interaction skills so students experience a role as close to engineering practice as is possible in a university environment.

UNIQUE FACILITIES

ALTHOUGH FACILITIES are usually of secondary importance, those being used for this program are as unique as the program. The University is housed, almost in its entirety, within a single building. One wing is used for conventional classrooms, offices, computer center, instructional media, administrative offices, and other service facilities, the specific room configuration being established with snap-in walls easily rearranged to meet changing needs.

The laboratory wing consists of three fully carpeted floors that are totally open and without walls except for a few offices and special purpose rooms around the periphery. Laboratory activities are carried out on mobile lab benches, some with all quick-connect utilities for wet experiments, some dry for other experiments. All tables have removable tote-trays for storing collections of experimental supplies in the stockroom for individual checkout. Utility outlets and drive-in fume hoods are distributed throughout the area. Tables are designed so they may be connected to form a chain of benches for group laboratories. All other furniture in the laboratory is movable to facilitate organization of the space for immediate needs.

The laboratory facility is used by all disciplines in the University and provides, in ad-

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dition to strictly laboratory needs, proctoring areas, study carrels, open study areas, small seminar areas, media-areas; in short, all of the facilities needed to carry on individualized, self-paced, or small group course activities. In this way, the open laboratory serves almost all of the needs of the engineering program in a very efficient utilization of space, furnishings, and equipment. Only a few activities require other spaces. Since the same open laboratory is used by all disciplines in the University for all of the functions named above, there is considerable interaction among students and faculty from these different areas.

STATUS OF THE PROGRAM

THE FOREGOING discussion has laid out the design goals, curriculum objectives, and curriculum implementation features for the Control Engineering Program at UT-Permian Basin. Underway only two years, the program has not, of course, fully realized all of these ambitions. The intent of this section is to evaluate the status of the program and its future.

The ultimate evaluation of any professional program comes from the performance of its graduates in practice. Too young to have many graduates and with little time-in-service for those that have graduated, any evaluation must necessarily be very preliminary. Students in or from this program have been favorably received by industry and graduate schools. Industries participating in our Authentic Involvement program have responded favorably both to the engineering competence of our students and to their abilities to document and communicate their work. Thus the external indicators of acceptance of our students are positive.

The educational environment in our program is entirely different from what most students have previously experienced. Inevitably then, there has been a period of adaptation as students learn to function efficiently in this new environment and as the faculty adjust the environment based on student successes and reactions. Some students have been unable or unprepared to adapt and have dropped from the program, but most have learned to take advantage of the flexibility. A significant number of students, with poor initial preparation or with a long lapse in their studies, have been able to develop and to succeed in the program only because of the individual pacing, one-to-one instructor help, and the opportunity to recycle until reasonable competency is achieved. Such students, although they have excellent latent potential, would not survive in a conventional program.

Although considerable progress has been achieved toward meeting the needs and maximizing the chance for success of individual students, much remains to be done. Needed are more formal premeasure procedures, self-study packages for areas of significant prerequisite weakness, a broader range of course offerings and more variety within courses, revisions and additions to existing learning materials, a more formal and elaborate validation procedure, development of laboratory facilities, and an ever-improving course management system. These areas of development are in various stages of progress, but all are underway. Resource limitations are believed to be the primary impediments to their rapid and successful conclusion. □

APPENDIX

Curriculum objectives for the Control Engineering program are as follows.

A graduate of this program should be able to:

- **Operate successfully as a member of a project design team to construct a proposed design solution to an authentic problem and to prepare and present satisfactory oral and written reports documenting the design.**
- **Demonstrate project management skills necessary to insure the successful operation of the team in the team design activity described above.**
- **Demonstrate successful acquisition and application of information relative to a topic for which little information is available in typical literature sources.**
- **Construct and support a prediction of the possible impact on society of a major event, invention, discovery, technological change, change in government policy or law, etc.**

Sir:

Almost invariably I have found that the demonstration has been a very effective teaching tool that was well received by students. To help myself and others who share my inclination, I am attempting to edit a compilation of demonstrations. I wish to concentrate on the field of ChE as a broader coverage is probably not practical. Accordingly, I would like to ask any potential author who knows of such demonstrations to contact me. Then we can make arrangements so that a common format is used and appropriate authors credits are given.

Prof. M. Duane Horton
Brigham Young University
Provo, Utah 84602