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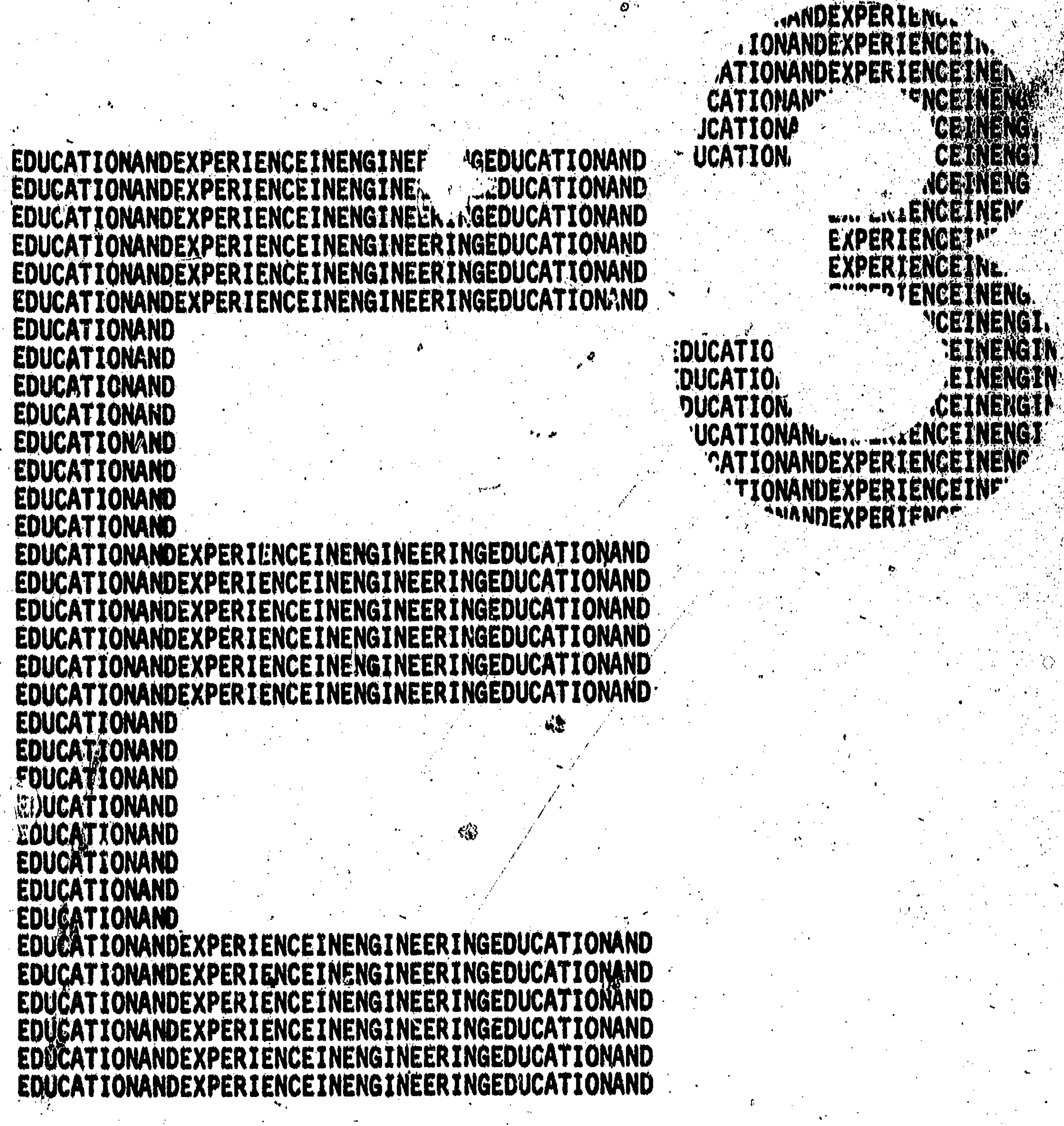
ABSTRACT

Presented is a description of the Education and Experience in Engineering (E3) Program at the Illinois Institute of Technology. Included are the objectives, how the program works, faculty, dissemination of E3 information, integration of science and technology into the E3 program, and the integration of liberal arts and engineering. A chapter is devoted to the learning modules' format, their preparation and use, and students' response to them. The cooperative evaluation process among the students, advisors, and the Review Board are included, along with the appropriate evaluation forms and first-year students' projects. (SA)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EDUCATION AND EXPERIENCE IN ENGINEERING
THE E^3 PROGRAM: PROGRAM DETAILS

Prepared by E^3 Staff

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NSF Grant No. GY9300

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Chapter I
OVERVIEW OF THE PROGRAM

The Education and Experience in Engineering (E^3) Program offers radical departures from conventional undergraduate curricula: it is interdisciplinary, it integrates liberal arts studies into the technical curriculum, and it employs new approaches to learning and learning evaluation.

This program has been in preparation for several years and has received much encouragement and support from educators in universities and government agencies. It is being supported by the National Science Foundation*.

The first year of a five-year program (one planning and four implementation years) was devoted to development and refinement of many of the educational concepts which are included in the new curriculum. The second year (the present one) is the first of implementation with 29 students participating. Thirty to thirty-five freshmen will be added each year during the next three years until the total student complement of between 140 and 150 students is reached.

The reasons for developing the new approach to undergraduate engineering education have been given elsewhere.** Here, only experiences which were obtained during the first two years of the program will be reported. The program is designed to educate highly competent engineers who

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*NSF Grant No. GY9300

**Torda, T.P. and E^3 Staff, "Education and Experience in Engineering--the E^3 Program", Illinois Institute of Technology, Chicago, Illinois, May, 1972

Torda, T.P., "An Interim Progress Report on the Education and Experience in Engineering (E^3) Program", Presented at the American Society of Mechanical Engineers Winter Annual Meeting, New York, New York, November 26-30, 1972.

not only are able to develop the necessary technology according to the needs of society, but also are able and willing to assume responsibility to assure that such innovation proceeds with a minimum of side effects harmful to the human race.

The E^3 Program

Engineers are problem-solvers and projects form the basis of the E^3 Program from entrance through graduation. The problem-solving effort is carried out by small groups consisting of undergraduate students from all four years. Supervision and guidance are supplied by faculty members from the various academic fields involved in each problem.

There are important reasons for the particular grouping of the students:

Each problem may be approached on several levels of sophistication.

Such grouping is conducive to the development of an apprentice-tutorial relationship.

It offers opportunities for consolidation of acquired knowledge (those at higher levels strengthen their knowledge and experience by repeated re-use while teaching those at lower levels of competence).

It helps develop leadership (managerial) qualities in students. The students in charge of projects act as managers and acquire the attitudes necessary for planning tasks, experience the responsibility for carrying them out, and develop an ability to inspire others and guide them to cooperative performance and group responsibility. By planned rotation of task leadership, all students have the opportunity of experiencing managerial duties and responsibilities.

The problem-solving method used throughout four years of study serves to develop creative attitudes and to increase and integrate knowledge. The problems posed are broad in scope, so that knowledge from many disciplines must be used in their solution; the problems must require new knowledge, information, attitudes, and experiences. The problem-solving process provides proper motivation for learning because the student appreciates the usefulness of various disciplines.

The project work is supplemented by lectures, directed individual study, and seminars. The lectures are given in all fields (technology, natural sciences, humanities, social sciences). The basic content of the engineering education is contained in guided self-study material, called "learning modules". Group discussions, as well as seminar presentations, are vital elements of the program at several stages of problem solving. An intensive program in the communication skills (oral, written, and graphic) is part of the education of the E^3 student. Flexible laboratory/workshop facilities are available for experimentation and model testing.

Objectives

The E^3 Program embraces two major objectives:
Education of engineers to high level interdisciplinary competence so that they may be able to solve problems within technological, social, economic, legal, etc., constraints.
Achievement of proper motivation for students to obtain this high educational level.

Great emphasis is placed on the non-technical factors involved in engineering solutions. The problem solving process helps in motivation for learning and in developing apprentice-tutorial relationship between students and faculty.

Definition of the major objectives helped in eliminating some of the conventional methods used in training engineers and allowed substitution of more appropriate techniques:

The liberal arts education is integrated into the technological curriculum.

The students learn to obtain new knowledge and apply it to the solution of the problem they attack.

Comprehensive evaluation techniques have been developed and are used as additional educational tools.

The E^3 student works on real problems and this makes his activities meaningful and rewarding.

The E^3 student works with his fellow students and faculty in small groups.

How Does E^3 Work

By the end of the first year, the participating faculty from engineering, the natural sciences, and the humanities and social sciences developed the guidelines of the planned curriculum. The processes in defining of problems, handling projects, seminars, etc., were worked out; laboratory and workshop facilities were established; evaluation of student growth and of the E^3 Program were planned.

The fall of 1972 brought the first group of students (27 freshmen and 2 sophmores) into the program and with them came the problem of settling them into a new environment and into a work style they were not used to. This problem of adaptation was approached by facing the student with four mini-projects:

Arrangement of available work space.

Internal communication.

Reference library facilities.

Participation in the management of the E^3 Program.

While the students and faculty advisers worked on the mini-projects, the main tasks of project selection, grouping of students and faculty advisers, and writing of proposals were started. First, problems are identified and presented (these may be originated by students or faculty), interested students and faculty discuss these in groups, and form a working group (4 to 6 students with 2 to 3 faculty members and possibly a graduate intern) to attempt solution of the problem in a project. A preliminary proposal is followed by an intensive study period and this culminates in writing the proposal. This document contains:

Problem definition.
Proposed mode of attack.
Resources brought to the problem.
New information needed.
Proposed time schedule.
Proposed budget.

In addition, each student has to submit an individual plan of study needed to fulfill his role in the project. This is developed by the student with his individual adviser and the Program Design Committee who are responsible for supervising the student's progress.

The preliminary proposal and, later, the proposal are submitted to the Review Board consisting of faculty and some students not connected with the particular project. The Board evaluates the appropriateness of the problem, the proposed method of attack, and the probability of achieving the expected outcome. The Review Board also keeps informed about the progress of the project. (See Chapter IV)

The Faculty

Representation is sought from each academic department on a rotating basis. While the E^3 administration insists on a part-time participation by faculty members so that each staff member preserves close contact with his department, it seems to be important that each E^3 staff member be a volunteer in order that the enthusiasm of the staff be preserved.

Dissemination of Information on E^3

Apart from publishing reports and presenting papers during national and international conferences, the most effective means of dissemination of information on the program is thought to be by personal experience. Therefore, efforts are being made to establish exchange and visiting professorships on national and international bases.

The Integration of Science and Technology into the E^3 Program

The core of the E^3 Program is the project. Owing to the nature of the problems that are tackled, there will always be a certain amount of technical knowledge that must be gained by the project team members in order for the project to be successfully completed. However, the backgrounds of the students and the faculty involved in a project team will vary widely. Some students may be seniors with an excellent grounding in the disciplines required, but others may be freshmen with little or no background. Some way must be found in order that freshmen as well as seniors be able to participate meaningf iy in project work.

It has been found that technical knowledge is most efficiently acquired by the use of educational packages known as "modules". A module consists of a set of learning instructions to the student designed so that he will be able to attain certain clearly specified learning objectives. These instructions typically consist of sets of readings of textual material, the completion of problems and exercises, or the performance of experiments. Each module is written so that an average student taking it will spend about 10 hours of study time. The student, however, proceeds through the module at his own pace. Once he feels that he has met all the learning objectives, he takes a mastery examination. In order to pass at the mastery level, approximately 90 percent accuracy is required. This would be equivalent to an "A" in a conventional program. If the student fails to meet this standard, he must continue to study and try the examination again. Only demonstrated mastery is recorded; there is no penalty for failure. A student may repeat an examination as many times as is necessary to demonstrate mastery.

Modules were written by the E^3 faculty from the mathematics, physics, chemistry, and engineering departments at IIT during the first year of the program. These are being evaluated and some will be rewritten by students as flaws are detected. The "common core" curriculum was analyzed and broken down into learning units, the modules were then built up around these learning units. At the present time, most of the freshmen and sophomore-level material in the common core curriculum exists in modular form. (See Chapter III)

As students began to formulate project proposals and to work on problem solutions, need often arose for advanced material that is ordinarily presented only in the junior or senior years in the conventional program. Examples are fluid dynamics, advanced calculus, solid state physics, materials science, etc. Need also arose for material that is not presented in the conventional curriculum at all, such as meteorology, etc. Modules in these areas were written on demand by both faculty and students. In certain areas, it was found to be more economical to present material in seminars rather than in modules. Seminars are small discussion groups led by faculty members. (See Chapter III).

When the E^3 Program has run for four years, students of all four years will be involved on project teams. Freshmen will participate in the same project alongside of seniors. It is not expected that freshmen be able to participate at the same level of sophistication as seniors, but that they should be able to understand what is going on at a qualitative or at a basic level.

In many projects, knowledge must come from the project advisers themselves. The wisdom and experience of the faculty are often crucially important in solving technological problems, formulating experiments, and making tests. This faculty-student communication is something that students in more conventional programs often do not encounter until graduate school.

The Integration of Liberal Arts and Engineering

The humanities and social sciences have had a traditionally limited role in engineering education. A clear distinction has usually been drawn between them, as "liberal arts," and the "basic sciences and mathematics." The latter have received strong emphasis as essential components of an engineer's skill base. The former, while recognized as important attributes of the liberally educated citizen, have not been regarded as central to or integrated within the engineering curriculum.

One purpose of the E^3 Program is to provide engineering education more closely related to engineering practice. The project setting within which most E^3 learning takes place is expected to prepare the student for an emergent career pattern in the engineering profession. A second purpose of the E^3 Program is to integrate the learning of basic knowledge and skills totally into the project context--the desire to seek new information and understanding is stimulated by the need to apply them to the solution of a problem. The goal is to develop a habit of close working-learning relationships which will be of significant benefit to the graduate engineer throughout his career. Finally, the E^3 Program emphasizes problem definition as the trigger for project selection and solution implementation. A detailed examination of the project "setting" as a prelude to project proposals is intended to insure that each project is needed, relevant, useful. The goal is an engineer not restricted to technical implementation, but also aware of the significance of his contributions in terms of an extra-engineering scheme of values.

The E^3 Program requires intimate involvement of the social sciences and humanities throughout, not merely as "general education" or "second stem," but as contributors to the success of all the educational goals of the program. During the course of the students' involvement in E^3 projects, they are exposed to resource persons, faculty advisers and fellow students from a variety of non-engineering disciplines and are required to incorporate ideas, techniques and information from these disciplines into their projects at every stage from conception to implementation. The students should acquire: the ability to define goals; the setting of evaluative standards for performance and the measurement of goal attainment; the security to make choices among technically feasible alternatives in terms of extra-engineering criteria of benefit or harm; and, ultimately, the enrichment and strengthening of the personal system of values which technical skill and professional expertise must serve. The project context of education in E^3 provides a means for effective integration of the social sciences and humanities into engineering education because the social sciences and humanities are necessary to effective project completion and are readily seen as relevant by the students involved in the projects. While the student is not expected to be trained as a social scientist or humanist, neither is he to regard these disciplines merely as resources, to be used as needed and ignored otherwise.

Chapter II

CHRONOLOGY OF EVENTS

The E^3 Program was offered to prospective students as a project based curriculum leading to the Bachelor of Science in Engineering degree. The program was described as one that would emphasize the multifaceted nature of most real life problems and the need for and importance of interdisciplinary interaction. Twenty-nine freshmen were enrolled into the program in September, 1972.

The E^3 staff had planned to introduce the new students to the new format through a set of short term projects. The projects concerned topics that the students could relate to immediately. The students broke up into four groups to study and propose solutions for (i) an E^3 Communication System (ii) an E^3 Resource Center (iii) Student Work Quarters and (iv) Student Participation in the Management of E^3. At the end of three weeks, students had gone through the process of submitting proposals, generating solutions, implementing recommendations and report writing. The E^3 staff was gratified to realize that no amount of lecturing could have introduced the students to these phases of project work quite as effectively.

Concurrent with work on the short projects, students also attended a series of eight seminars by outside resource persons from industry, education and government. The seminars had been planned to give the E^3 group some perspectives on the chosen theme "The Urban Community: Transportation and Pollution Control". Not all the invited speakers were very adept at lecturing to student groups, but the students' learning to look at things through the eyes of responsible senior executives and experienced professionals was a great learning experience.

At the end of this period, each student submitted two problem identifications: one in the context of transportation and the other dealing with pollution control. The problem identifications were largely derived from problems described by the outside resource persons, but also included other problems, such as auto safety and snow removal, which were relevant to students' environment and of great concern to them.

Groups were formed on the basis of the problem identifications suggested. The formation of groups involved a "step backward" in the problem solving process in that the more specific identifications were grouped together into problem areas which were broad enough to cover several of the problems identified. This procedure was considered necessary for two reasons. The problem identifications were based on personal experience more than anything else - thus importance and relevance were both interpreted in a rather subjective and personal manner. This helped students identify themselves with the problems, but objectivity and a wide perspective were considered important attributes of the professional by the E^3 staff. Going from the wide ranging outside resource presentations to the rather specific problem identifications and then going back to a somewhat more general problem area served to exemplify, explain and compare the different levels at which a problem may be attacked.

Beginning in the fourth week of the semester, the six interest groups listed in Table 1, researched their respective problem areas in great depth. Under the guidance of the faculty and with the enthusiastic participation of most of the students, the various engineering, humanistic and social aspects of each problem area were investigated with a view to defining a problem that in objective terms was relevant to "The Urban Community". After a week of preliminary work, the Auto Safety Group decided that automobile safety involved not only building safer cars, but also reducing the danger of drunk drivers. Likewise, the Mass Transit Group realized that metropolitan area rapid transit and inter-city mass transit were two rather distinct problems and that group also broke into two sub-groups.

Table 1 - Area Interest Groups and Project Groups, Autumn, 1972

Area Interest Group	Number of Student Members	Number of Faculty Members		Project Group
		Engineering & Physical Sciences	Humanities & Social Sciences	
Mass Transit	4	1	2	Coanda Transit System
	3	1	1	Dual Mode Mass Transit
Airport Access	4	2	1	Short Distance Transportation
Auto Safety and Design	2	3	1	UVDC Steering System
	2			Alcohol Detection Ignition Interlock
Auto Emissions	4	3	1	Auto Emissions
Incineration of Solid Wastes	6	3	1	Incineration of Solid Wastes
Recycling of Plastics	4	1	2	Recycling of Plastics

Most of the problem areas were global in nature and required rather extensive preliminary research before specific problems could be defined and a proposed solution spelled out. Consequently, Project Proposals were not submitted until the sixth week of the semester. The proposals were, without exception, overly ambitious and were returned for revision. The Inter-City Mass Transit Group, for example, proposed to study the Coanda Effect, deceleration, entry and egress, the formulation of transportation policy and comfort criteria, all within fifteen weeks, with four students who had had no previous background in fluid mechanics. Even after revision, the proposals remained overly ambitious, but the faculty members accepted them in the belief that this realization would soon be made by the students and further revisions would be acceptable at that stage.

All proposals were required to spell out individual student study plans. Most study plans were started in the form "I expect to learn about electronics and fluid mechanics", and did not list modules to be mastered. This was acceptable to the review boards because the E^3 staff had expected the first projects to emphasize professional skills and also to help students realize the need for and importance of more basic knowledge. And that was how it happened.

During the first project period, the module effort was erratic, but there was a substantial amount of project related learning. In the process of designing a new incinerator, the Solid Waste Disposal Group studied the chemistry of combustion, studied heat transfer and learned to make a heat balance. Before designing a steering system, the UVDC Group had to study the Ackerman mechanism, cornering forces and hydraulic circuits. Traditionally, most of these topics are covered in the junior and senior year. They did not require any great sophistication, and the activity was well motivated, spontaneous, relevant and immediately reinforced through application on the project. Furthermore, as project work progressed, students became acutely aware of the limitations imposed upon them because they did not know enough mathematics or physics. Project motivation for learning on a need to know basis had clearly been achieved. An intensive planned module effort is expected during the second year.

The eight project groups were all organized differently. In the Plastic Recycling Group, faculty and students worked closely with each other and each effort was a group activity. In the Alcohol Detection Ignition Interlock Group, the faculty were involved only as resource persons and the student effort was well coordinated, in the CTS Group the engineering and liberal arts faculty advisers offered seminar series on Fluid Mechanics and the Decision-Making Process respectively. Faculty expectation and student participation were also equally varied. Some students confused freedom with irresponsibility, but most worked on the projects diligently. Most of the engineering faculty who had had no previous experience with freshmen tended to expect too high a level of performance and not surprisingly, it was the physical sciences faculty (with great exposure to freshmen) who were most realistic in their expectations. Intragroup interaction is discussed in Chapter V.

By the end of the calendar year most projects were well defined, and the more important project related decisions had been made. It was considered appropriate to introduce the second set of projects at this point. During the first project period, several projects had already been generated by students. Thus even before the second project period was introduced formally, a group had already formed around a new camera shutter design. Another group was building up around tornado detection and a third group was forming with water quality as its focus. The student initiative was gratifying. As a result, however, a unifying theme was not possible. As the theme seminar on The City had been unsuccessful in producing student research, lack of a central theme was allowed to occur as an alternate approach.

In spite of an early initiative by the students, formal problem identifications and proposals were not prepared until after the Review Board requested them. The extent of the early groundwork was, however, evident in the fact that for most groups final proposals had been submitted and accepted by February 19. The Water Quality Group decided to continue preparatory work through the rest of the semester as a seminar and postponed project work to the summer and following year.

Beginning in February, several seminars were offered. This was encouraged on the one hand as a way of bringing the social sciences and humanities staff into the program on terrain they were familiar with, and, on the other, as an experiment to see what sorts of areas of study would be appealing to the freshman students. The overall design was as unstructured as the first semester seminar on The City had been structured. The seminars were a novelty and attracted large numbers of students, but the pressures of project work reduced these numbers significantly. (See Chapter III)

The projects in the first set were finally completed in early March and results were presented at seminars open to all IIT faculty and students. Completion and closure raised spirits in all sections and led to a surge of enthusiasm. Most final reports were not submitted until after the presentation and one final report was completed only at the end of April.

Study plans for the second project period were on the whole, more detailed and listed specific modules that students expected to master. Project related learning was, however, again important and significant.

Final reports for the second project were submitted early in May and review was completed May 11.

Chapter III

LEARNING MODULES AND SEMINARS

Learning Modules

To augment and support the technical aspects of the educational base in the E^3 curriculum, sets of self-paced instructional guides, termed "learning modules," were prepared. These modules replace the conventional lecture-recitation-quiz format of the engineering curriculum with guided and tutored independent study. They further provide organization for the subject matter of a conventional engineering curriculum in the form of self-contained components of short duration which can be combined into coherent, individually tailored programs for the E^3 students. (See Chapter IV)

Unlike conventional and "independently-paced-instruction" course material, the module subject matter is not rigidly sequenced. Rather, each module is prepared with the object of making prerequisite study a minimum. The relationship between module content and project task assignment is essential to the motivation for the self-paced study of modules. Close supervision and guidance by each student's advisor and the Program Design Committee insure adequate breadth and depth of study within the total number of completed modules required of each student. Student portfolios (profile sheets and progress charts) are maintained to assist in the advisement process.

The module concept permits the faculty to devote the majority of their effort to coaching project work and to corrective tutoring. The massive time requirements of lecturing, homework grading, and testing are eliminated in the E^3 Program. The faculty is continually generating new, and revising old, learning modules. They are also responsible for developing appropriate mastery examinations and for directing the efforts of the graduate and undergraduate students who tutor and proctor the module mastery exams.

Learning Module Format

The LM's vary substantially in format, but they all contain certain common items. These are as follows:

(1) A set of learning objectives clearly indicating the purpose of the module. Along with these objectives the modules which should precede this module in a logical sequence of study are listed. All modules are developed with the goal of minimum interdependence. This permits the student to study the LM he immediately needs rather than requiring that he first read through an extended sequence of related ideas. Within a particular area the tactic of developing one or two introductory modules and then making all following modules independent of each other is used.

(2) Directions for study--Specific page citations in referenced texts would be a minimum set of directions. The directions may contain an extended treatment of a subject for which no adequate text is available or worked out example problems or programmed instruction. Occasionally a tape cassette description of a figure, an example problem or discussion of a theory may be included. If a laboratory experiment is beneficial to the understanding of a subject, then directions for carrying out the experiment would be included.

(3) Questions for self-test--these may be located throughout the LM study directions, but at the end of the module an extended set of questions is provided for a mastery self-test. The student is expected to write out the answers to these questions as a review.

(4) The name and location of the faculty or student tutor/proctor--This person administers the mastery examination and provides remedial study material or tutors the student not achieving mastery. If the module author serves also as the tutor/proctor, then he can check on the modules' efficiency. It will be necessary at all times that every module be under the guardianship of one senior faculty who directs the tutor/proctors and maintains the module's effectiveness. Every tutor/proctor must pass the mastery examination himself with the faculty before he can work with the students.

Preparation of Modules

The steps in the preparation of a set of learning modules to cover a certain subject are as follows:

1. Corresponding courses in the standard curriculum are broken down into skeletal modules by faculty responsible for those courses. The skeletal module is in essence a very detailed course outline which lists (for approximately one week segments) the following items:*

   a. title
   b. abstract
   c. prerequisite modules
   d. learning units
   e. learning objectives
   f. resource material
   g. directions to the student
   h. exercises
   i. time required

2. An E^3 staff member is assigned to develop learning modules to cover a particular set of courses. He restructures the content of the skeletal modules and prepares an initial draft. A conscious effort is made at this time to insure that a module is prepared which is appropriate to the level of the prospective student user. In order to encourage beginning students and build their confidence with this new type of education, the first (zero prerequisite) modules are designed to be simple and of short duration.

3. The contents of the first-draft modules are correlated with the skeletal modules, and necessary corrections, additions, and re-definitions are made. Thought was given to the idea of having no mathematics modules as such, but rather to integrate mathematics into the science modules. This approach was ultimately rejected because of the necessity of considerable duplication (for example, the derivative can arise from many physical problems) and because the mathematics learned in the context of, say, dynamics, might not be easily transferable by the student to an electricity problem. Consequently, it was decided to have separate mathematics modules which would be corequisites to the science modules. Thus, ideally, the student would first see the need for a physical concept in his engineering project and be referred to a physics module which would develop the concept to the point where more mathematics was necessary. If the student had not already taken the corequisite mathematics module he would then do so and, upon completing it, return to the physics module.

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* "Manual of Content Analysis," E^3 Staff, August 12, 1971.

4. The modules are reviewed by graduate students or faculty for readability, correctness, consistency of length of treatment and degree of difficulty, interest, and aptness of listed prerequisties. The reviewers confer with the original authors toward the preparation of a revised draft.

5. The learning modules are made available to students and are revised based on the feedback from students regarding ease of usage and understanding, time required for completion, and correctness of prerequisites.

Initially, the module effort was spread among all ten participating Engineering and Physical Science faculty. Very soon, however, by a process of natural selection, the module effort came to be borne by two recent Ph.D's and four other faculty members. The E^3 experience suggests the preferred way for writing modules is to assign the task to interested and qualified individuals as a primary responsibility rather than as an "also to be done" task. At present 352 modules are available to students. They cover over 60% of the common core material at IIT, and all freshman courses have been modularized. Modules are also available for certain non-core material e.g. material processing, Analog Computation, Economics, Psychology, Philosophy and proposal writing.

Use of Learning Modules

If properly selected and planned, each project demands new knowledge of all students for the performance of their tasks. While preparing the project proposal, students list the modules that are relevant to their project tasks and which they expect to master during that project period. The list of modules is an important part of the study plan prepared by the student with the guidance and the supervision of the students' adviser and the Program Design Committee.

Students study the modules at their own pace. When a student considers himself as having attained all the learning objectives, he requests an examination. The examination is evaluated immediately in the presence of the student. If the performance in the examination is not satisfactory, immediate feedback is provided by the proctor and remedial study is suggested. The procedure is repeated until mastery is achieved. There is no penalty for unsatisfactory performance and no limit on the number of times a student may request reexamination. Upon satisfactory performance in an examination, the student is given credit in his profile for that module and he may continue with further module study. Only mastery of material is recorded in the student's portfolio.

Student Response to Modules

At the end of the first academic year (April 30), over three hundred and fifty modules had been mastered by twenty-four students. Half the student group had mastered twelve or more modules, and one student mastered forty-four modules. The largest number of modules mastered in any one month period was eighty-one for February. An almost equal number of modules were mastered in Physics (97) and Mathematics (117). Other relevant data is presented in Fig. 1 and Tables 2, 3, and 4.

Table 2 - Student Involvement in Module Mastery

Monthly Period	# of Students who Mastered Modules in a Given Area					
	Math.	Chem.	Physics	Basic Elec.	Other Areas	All Areas
10/72	8	5	7	0	0	11
11/72	13	3	10	5	0	20
12/72	10	3	10	5	2	16
1/73	4	0	3	0	3	8
2/73	15	0	7	11	1	20
3/73	5	1	5	6	4	15
4/73	7	1	6	9	3	16

Table 3 - Number of Modules Mastered in Each Monthly Period in Different Areas

Area / Period	Physics	Math.	Chem.	Basic Elec.	Other	All Areas
10/72	14	15	0	0	0	29
11/72	22	34	6	10	2	74
12/72	23	22	0	16	2	63
1/73	4	14	0	7	5	30
2/73	16	18	0	46	1	81
3/73	6	7	1	12	5	31
4/73	12	7	1	31	5	56
Total	97	117	8	122	20	364

Table 4 - Summary of Learning Module Study

Period	Number of Modules Mastered	Number of Students who Mastered Modules	Modules Mastered by Twelve or More Students
10/72	29	11	0
11/72	74	18	3
12/72	63	18	4
1/73	30	8	4
2/73	81	20	9
3/73	31	15	11
4/73	56	16	12

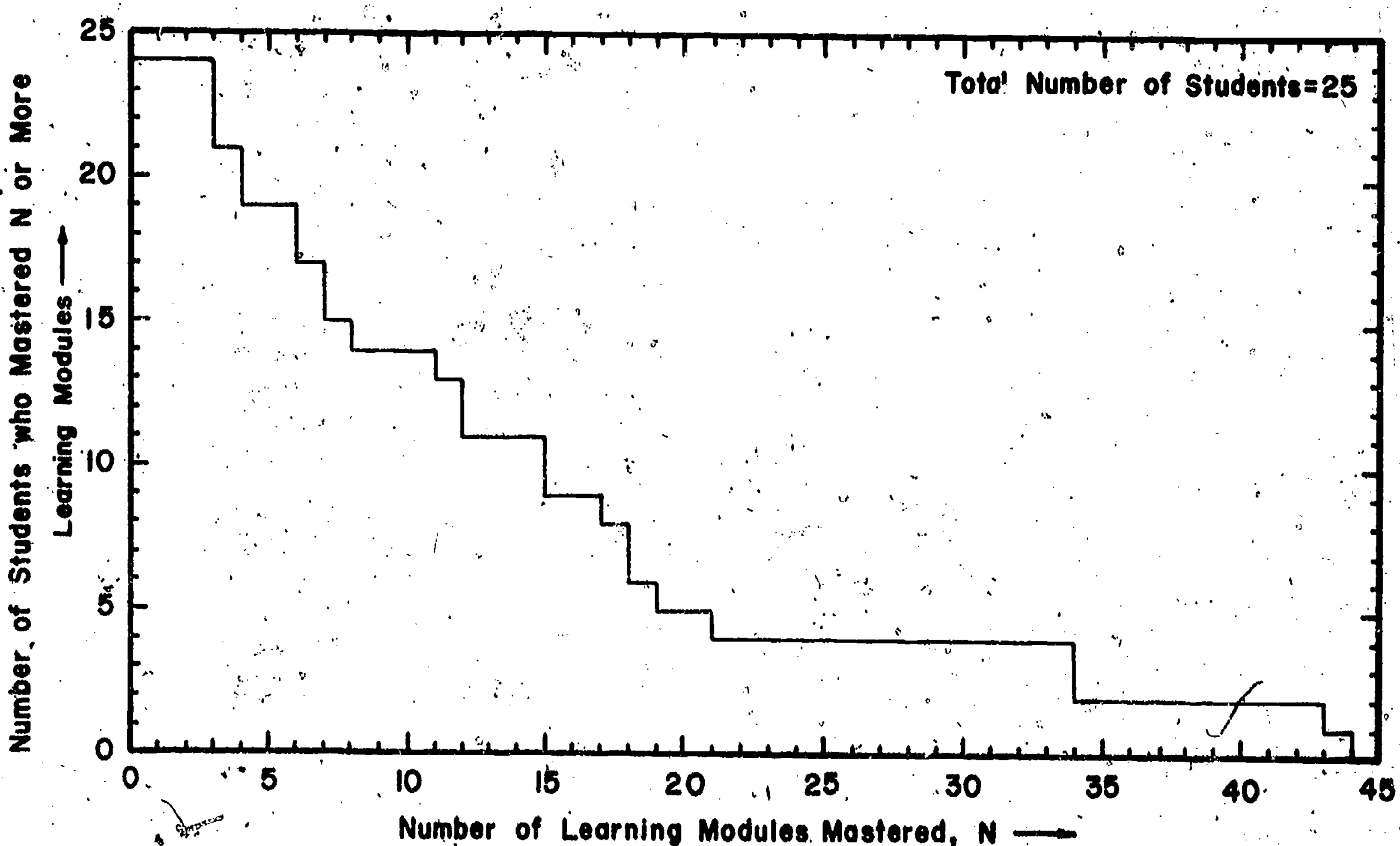

Fig. 1 Cumulative Distribution Curve for Learning Modules Mastered by Students as of April 30, 1973

Initially, students were hesitant to take mastery exams, but the hesitation generally disappeared after the first few mastery exams. The pass rate has gradually improved from 75% in December 1972 to better than 80% as of April, 1973. Most students like the module format and, most important, realize the need for and role of module study in their overall curriculum. An accelerated pace of module study is expected during the second year.

Seminars

There are various areas of learning which are covered adequately by neither learning modules nor project activity. During the first year of the Program, seminars were employed to fill gaps left open by other instructional means.

Seminars were used in three principal areas of instruction: background, liberal arts, and skills.

Background

In the first instance, they provided background information in fields relevant to projects and proposed projects. These background seminars dealt with the state of the art, the basics in various relevant disciplines, and a foundation upon which to build future projects. They included an interdisciplinary seminar on The City, taught by all E^3 faculty from liberal arts and one member from environmental engineering. The theme areas of the first semester were transportation and pollution control in the city, and this seminar was designed to present the various approaches taken by different disciplines to the study of urban phenonema.

A seminar on Water Quality grew out of student interest related to a series of projects connected with water resources planned for 1973-74. A chemist and an environmental engineer teamed up to provide background for these projects by dealing with water chemistry, pathogens in water, and nutrient cycles in water. The seminar included information on the procedures of water testing and a visit to the Chicago Sanitary District treatment facility and laboratories for first-hand observation. As the seminar moved toward the preparation of a proposal, a political scientist joined to raise questions about and provide information on the role of populations interacting with water systems.

The third background seminar offered during the year dealt with Health Care Delivery in the United States. This seminar grew out of a project concerned with medical diagnostic instruments, but was open to all students for use in future projects.

Liberal Arts

A second kind of seminar offered dealt with knowledge from traditional disciplines in the liberal arts. There were four such seminars: The Short Novel, Theories of Personality, Corruption in the City, and Philosophy of Space and Time. The need or desire for knowledge in these areas would not ordinarily be elicited by specific projects, but the information and skills acquired could prove useful to a variety of future projects. In addition, they fulfill a general education function nowhere else satisfied.

Seminars consisted of a series of weekly meetings devoted to discussions, centered about assigned readings and papers presented by students. It is worth noting that the Space-Time seminar was led jointly by a philosopher and a physicist. The seminar on Theories of Personality was conducted by graduate students.

Skills

A third type of seminar was devoted to the acquisition of skills necessary for the students in their project work, but learned most readily in a seminar-workshop setting. There were six such seminars: photography, instrumentation, Fortran, IITRAN, analog computation and pre-calculus mathematics. IITRAN was taught by a student who has advanced knowledge of that computer language. The other seminars were taught by individual faculty members. Generally, the format was a series of weekly meetings at which techniques were discussed and students showed their work. The instrumentation seminar used a brief and intensive format.

All of the seminars carried credit for a student enrolled, based on his or her completion of the assigned activities and participation in the seminar.

Chapter IV

MONITORING AND EVALUATION

In the E^3 Program students are regularly evaluated on a variety of levels for differing purposes. The process of evaluation can be roughly divided into three overlapping time-frames: short term (weekly to bi-weekly); intermediate (semester or project basis); long range (yearly or multi-year).

Short term evaluation is provided by the faculty project advisors, learning module proctors, fellow students and the Review Board. Seminar leaders evaluate their students on a weekly or bi-weekly basis as well as on the totality of their work for the seminar. The Review Board and the faculty project advisors are primarily responsible for evaluating the student's performance in his projects and in his efforts for the entire semester. Long range planning and evaluation was originally the province of the student's own faculty advisor, although this responsibility will now be shared with the new Program Design Committee.

Program Design Committee

This committee will consist of four members, one from the liberal arts and three from engineering and science disciplines considered formative in engineering education. The central task of the Program Design Committee is to supervise the curriculum of each student by guarding against the possibility of overspecialization at the expense of common core coverage. The Committee will have the records of each student's work (projects, modules, seminars) and will suggest different areas of education and experience from those previously undertaken. The formation of this committee is a response to the difficulties encountered by the students' own faculty advisors in functioning as long range curriculum planners; it is anticipated that faculty advisors will continue as personal advisors and counselors to their students.

Review Board

Another important change that has taken place during this first year concerns the Review Board. This group is responsible for project monitoring and evaluation; it judges the suitability of project proposals, and by means of project group meetings, appraises ongoing projects, interim reports submitted by team members, evaluates the final presentation and final report, and distributes the credit for the student's project work. Originally each project had its own Review Board composed of students, liberal arts and technical faculty. This arrangement was adopted in order to sample and assess various methods of interaction among evaluators and participants on project teams. This arrangement developed two primary shortcomings. There was a lack of uniform procedures and judgments applied to the different projects, and the burden on Review Board members resulting from their own project tasks and other duties were such that important evaluative decisions were frequently delayed. The present Review Board consists of students (a different one for each project) and two permanent faculty members, one from engineering and one from the liberal arts. These two faculty members are relieved of project advising duties.

In terms of student perception, the most important function of the Review Board is the distribution of credit at the conclusion of a project. The evaluation process is a cooperative procedure shared between the students, their advisors and the Board. Students and faculty prepare a credit memorandum for submission to the Board with credit allocations for each student in the areas of Professional Project, Engineering and Physical Sciences, and Humanities and Social Sciences. Any module or seminar credit earned during the course of the project is included on the credit memo. Working with this document, the Board meets with the entire project team and makes its suggestions concerning the distribution of hours of credit. If there are any discrepancies between the Board's recommendations and those of the project team, they are thoroughly discussed and adjusted to the satisfaction of the entire group. (See Appendix B for evaluation forms)

The students also have the more immediate and less collective evaluations of their fellow students, their learning module proctors and their faculty project advisors who guide them. Working within the relatively small project groups, students and faculty quickly come to know and to communicate the strengths and weakness of each other.

Learning module proctors will either personally assist or suggest sources of aid to those students who do not achieve mastery; obviously, when a student successfully completes a module, this is a form of positive evaluation.

Seminars provide another source of evaluation, exposing the student to the judgments of others, generally in a specialized field or technique. All evaluators are in formal as well as informal contact with one another; judgments that have been formed concerning a student are passed on to all members of the staff. In this manner, the E^3 student is subject to a variety of evaluations, in differing settings, that will enable him to come to know his own abilities and weaknesses.

"Attrition"

Twenty-nine students entered the program in the fall of 1972. Out of these two were transfer students of sophomore standing from other colleges and another two were second semester freshmen transferring from other programs within IIT.

By the end of the first year, six students transferred to the regular engineering program and no particular difficulty is anticipated for any of these. Ordinarily, such transfers within the first two years occur frequently and these do not enter any of the attrition statistics. One student is transferring to physics and, for family reasons, will transfer to a school in a different city. Again mostly for family reasons, one successful student decided to enter the armed services, a plan he contemplated for quite some time even before entering IIT. To date, there are only three students who left the program and will have to start over as freshmen if ever they re-enter college.

There are people who erroneously look for a comparison of "attrition" from the E^3 program and compare it with attrition in regular IIT curricula. Since there are no models for E^3 students, nor are there any valid criteria for selection of these, it is a useless exercise to pursue such comparisons. But even with these false measures the program seems to be successful, since only three failures can be reported out of twenty-nine students. Again, it should be reported that transfers within the first two years do not ordinarily enter statistics and, therefore, the 10% loss of students in the E^3 Program is small compared to the over 30% loss in regular curricula.

Chapter V

E^3 EXPERIENCES AND IMPRESSIONS

In moving beyond the formal organization of the E^3 Program to consider the informal structure and processes, three areas may be chosen as especially salient for an understanding of the program. Two of these concern the faculty-student relationship in the program and relate to two aspects of that relationship: student advising and teaching. A third concerns the relationships that have emerged among the faculty in the program.

As indicated elsewhere, the faculty serve as advisors to the student project groups. Perhaps the only generalization that can be made about the relationships between students and faculty in the project groups is that those relationships are characterized by immense variation. Not only have faculty seen themselves in a variety of roles, but also they have exhibited a variety of approaches in dealing with students. In the former category, six roles seem to have emerged. Faculty have seen themselves as: resources, participants, father/mother confessors, evaluators, upper-division students, and supervisors.

Those who have seen themselves as <u>knowledge resources</u> have dealt with students largely as producers of demands upon their knowledge, contacts, bibliographic resources, and expertise. Their contacts with project students have consisted largely of occasions upon which they responded to formal requests for information or assistance in rather strictly defined areas of expertise.

Because of the small size of some project groups, a deep interest in the project itself, or an eagerness to be an active part of the project, some faculty have immersed themselves in the day-to-day conduct of the project as active <u>participants</u>. This role has been taken by relatively few of the faculty, largely, it would seem, because of a genuine lack of time or a feeling that their active participation in the actual work of the project would overshadow or intimidate freshman students.

The role of <u>father/mother confessor</u> has been taken by most, but not all, of the faculty at one time or another. The fact that all but two of the students are freshmen, with typical freshman doubts and fears, has made this role a prominent one in our first year. The fact that a program relying heavily upon self-motivation, self-scheduling, and ambiguous goals was a novel and unsettling experience for most, if not all, of the students, has also contributed to the need for such confessors. Specialization in this role emerged as the year wore on, largely through a process of self-selection. The ultimate father confessor remains, of course, the director of the program.

The role of <u>evaluator</u> was thrust upon all the faculty, willing and unwilling alike. As the duty of assigning credit for project experience falls upon project advisors, individual student advisors, and the Review Board, we have all been cast as evaluators.

The program is designed to heighten and take advantage of the learning relationships that develop between freshmen, sophomores, juniors and seniors. It relies heavily upon the ability of those who know to share knowledge with those who do not. In the first year, in which only freshmen were admitted to the program, the faculty were asked to serve as <u>upper classmen</u>, to provide the formal and informal kinds of experience that freshmen would normally receive. Due to the fact that faculty were wearing so many other hats (especially the evaluation hat), that considerable demands were being made upon their time, and that they had not been undergraduate students for a long time, they proved, virtually without exception, incapable of playing student friend and mentor. While this was a problem for some of the students, who had clearly looked forward to such advice and assistance, we take faint joy in noting that the problem is self-solving.

Finally, the role of supervisor emerged as one which was comfortable to a number of faculty, especially those with industrial experience or lots of graduate students. Those who saw the program as a series of research teams tended to view themselves, and to be viewed by students in turn, as industrial supervisors. They became the actual project leaders, whether or not they held that title within the group. The projects with strong faculty supervision of this type showed little difference in terms of output or anxiety from those in which the faculty eschewed this role. The faculty, however, demonstrated greater anxiety when the projects floundered and it appeared that the outcome would not be a clear and demonstrably valuable product or model.

As different faculty models were encouraged by the very design of the program, we did not feel it appropriate to impose any particular patterns of exchange with the students, even had it been possible. Thus faculty were allowed to be directive or non-directive, supportive or non-supportive, formal or casual with the students. Some faculty are called by first names, some are called at home at night, some lunch with students, and so forth. Others remain aloof, but still effective. Some remain aloof and ineffective--they will be leaving the program of their own volition.

With each project having two or more faculty as advisors, the combinations of relationships which emerged were numerous. Despite the short-run disadvantages which arose from such unstandardized relationships (incorrect information, conflicting orders, misunderstandings, and so forth), the students came to have an understanding of the faculty as persons, beyond the merely functional understanding which characterizes much of what passes for student-faculty contacts. The faculty are not seen as information-imparting, evaluating, and directing functions. And the students are not seen as learning functions. This, it seems to us, is a critically important goal which we shall try to maintain as new students are admitted and the faculty-student ratio changes.

The second major area of faculty-student interaction that has emerged as interesting for observers is that dealing with the actual teaching that goes on in E^3. For many years, college teachers have complained about the fact that traditional classrooms have had a teacher-student ratio that renders effective teaching difficult, especially on the lower levels of a student's program.

Experience in the E^3 Program has led us to believe that this complaint is an oversimplified, if not inaccurate, one. We have discovered that the elusive paradise of low faculty-student ratio has remained, in many cases, elusive, even when faculty-student ratio is greatly changed. There are three reasons for this situation, one of which is peculiar to the program. The other two factors are true for more common reasons.

The program has been staffed by faculty borrowed on a one-third or two-thirds basis from various departments. That is, we have had part-time faculty teaching full-time students. Aside from the problems created by the fact that E^3 teaching can be quite time-consuming, the students have been faced with role models who are part-time participants in the program. This has been necessary for several reasons, not the least of which are the size of our grant and our desire that staff maintain their close relationships with their disciplines.

More important as a reason for the elusiveness of teaching paradise is the fact that, for better or worse, we have all spent a good deal of time and effort becoming effective classroom teachers. It is not surprising that the faculty drawn to the program have been those with a serious interest in teaching undergraduates. As a result, the program has recruited faculty who have developed successful techniques for classrooms. Faced with a drastically different challenge, some of the staff have found that their best efforts were inappropriate. On some occasions, the faculty have turned the project groups into classes in an attempt to impart information successfully. This is not to say, of course, that such an approach is never appropriate. However, most of our teaching has not been done in such settings, and the effort to work with small groups has gone on.

Perhaps the most critical element of the faculty-student teaching relationship which we have had to overcome in the program is that aspect dealing with control over the teaching situation. In traditional classroom teaching, courses are built by faculty, outlined and paced by faculty, and evaluated by faculty. While most universities by now have student course evaluation, the power to offer courses, design curriculum, and to decide what shall be taught in connection with what has lain with the faculty. This question of what goes with what has been seriously challenged by our experiences in the program. Modules have been designed to eliminate much of the ossification that characterizes course and textbook design by making units of information as separable as possible. That is, we have succeeded in eliminating unnecessary prerequisites. As teachers, however, we still have some firm notions about what goes with what, and our very patterns of thought and teaching are affected by our experiences in learning and in teaching relatively large units of instruction--courses.

In the E^3 Program, the staff has had to respond to demands for teaching in terms of isolated questions, unconnected information, and on-the-spot knowledge and references. There is no doubt that the staff has been seriously challenged to examine its assumptions about the inter-connectedness of various bits of knowledge and to face the fact that hitherto unconnected bits are indeed connected in ways that they were not aware of. This is not something entirely novel to the staff, as most of them have had experience with laboratory and field research, or consulting. What has been novel is being faced with this challenge in the daily and repeated act of teaching freshman students--students relatively free of assumptions and preconceptions about the order or context in which formal knowledge is gained.

For many faculty, this loss of control over the context of knowledge presented a serious challenge. Most responded successfully, spending great amounts of time trying to explain to students why one bit of information was part of something larger. In this very effort, faculty discovered ways of rearranging subject matter that may never have occurred to them in the normal course of classroom teaching. There is a great likelihood that their classroom teaching will change as a result of E^3. A few did not successfully survive the challenge, it must be admitted, and they look forward to a return to the orderly and autonomous world of the classroom. What was universally discovered is that responding to demand learning is time-consuming. After all, demand learning, while advantageous to the student, also implies the presence of one upon whom the demand is made, the presence of a responding teacher. Self-paced learning modules could not satisfy these demands by themselves.

It has been anticipated from the inception of the program that some faculty will find it difficult to adjust to the E^3 process. Some attrition was expected and, indeed, occurred. This attrition should not be confused with the planned rotation of some of the faculty each year, but it is connected with that process. Faculty members who are too directing, impatient with the pace at which different students learn or perform, or who are too tied up with designing "gadgets" or pet solutions, are incapable of adjusting to the true problem solving process. Some of the faculty members from engineering, therefore, rationalize that they will not be rewarded by administration for participation in the E^3 Program* and express the wish to go back to regular teaching, research, writing books, etc.

During this first year of experience the faculty attrition rate was not greater than anticipated. From the engineering and physical sciences, out of 10 part-time faculty, 4 faculty are being exchanged. From the liberal arts faculty of 9, 2 faculty are being exchanged, with a reduction of 1. One of the liberal arts faculty members is leaving IIT for personal reasons.

Underlying the different ways in which the faculty related to the students, both as teachers and as advisors, were some basically differing conceptions on several basic issues regarding the university. These differences became apparent when the prospective faculty first got together to prepare for the first year of the program, the planning year, prior to the arrival of the first students. There were varying views of what higher education is, what undergraduate students are, what the role of the university in society is, what the appropriate social atmosphere for learning is, and even what a full-time position on the faculty means in terms of commitment of time and energy.

That these differences quickly emerged, generally on the implicit rather than the explicit level, was not surprising, in view of the fact that the planning year involved a large group of faculty drawn from the sciences, engineering, the social sciences and humanities. These questions provided the ground for some serious clashes during the planning year, especially during the summer preceding the academic

* This assumption is not true. Successful participation in the E^3 Program has been rewarded by offering tenure and/or advancement and certainly salary raises after the first year of participation.

year of planning. The participating faculty were, however, characterized by genuine pluralism as the discussion moved from issue to issue. That is, many of the issues were cross-cutting. As the planning year progressed, the faculty became increasingly busy with establishing the nuts and bolts of the program. In most cases, disagreements were repressed rather than resolved.

We quickly learned, however, that the repression of conflict could not be confused with its resolution, and that agreement on particulars was wholly consistent with disagreement on basics. The basic disagreements reemerged in two different ways when the students appeared and the first academic year got under way. First, despite our best plans, there inevitably arose questions for decision that had not been anticipated. The relative emphasis on projects, modules, and seminars was one of these. Another had to do with the appropriate indices of effort and progress on the part of the students. Another involved the relationship of the program to the rest of the university.

Secondly, when implementation of our plans became our primary activity, we found an inevitable disjunction between theory and practice. We quickly discovered that there were among us talented practitioners and talented theorists, but that these talents were not so commonly joined in the same persons. Those whose fundamental orientations were based on praxis often proved to have the more ready answers when novel and unanticipated problems arose. Indeed, the day-to-day care of the program has lain primarily with those whose orientation was practical.

As the planning progressed, we also discovered wide variations in the commitment to collective action and collective decision-making on the part of various faculty members. Fortunately, a program of the complexity of E^3 made it possible for us to engage in a considerable degree of division of labor. This was a valuable device for avoiding stressful friction and disagreement on basics. It should also be noted that the basic disagreements that were and are exhibited are of such a fundamental nature that they do not lend themselves to the development of consensus among a group of faculty from different disciplines. These basic issues are likely to remain with the program permanently, and those of us who thought that the program could not go forward without unanimity have since reconsidered this position, having discovered that serious and important teaching and learning proceed in a less than "best" of all possible worlds.

APPENDIX A

Abstracts of First Year Projects

During the first year students worked on two sets of projects. All projects within the first set (numbers 1 to 8) related to the common theme: "The Urban Community: Transportation and Pollution Control". The second set of projects (numbers 9 to 13) was initiated in February, 1973. These projects were not interrelated. The abstracts are quoted under the project group names.

1. Alcohol Detection Ignition Interlock

The literature was reviewed to establish a correlation between blood alcohol and driving ability and between breath alcohol and blood alcohol. The Ignition Interlock described would prevent a driver with blood alcohol greater than the legal limit from starting the car. In an emergency the interlock device may be by-passed but flashing lights would alert other drivers to the fact.

2. Steering System for the Urban Vehicle Project

The design of a hydraulic steering system for Illinois Institute of Technology's entry to the Urban Vehicle Design Competition is described. The proposed design allows all four wheels to be turned sideways for a parallel parking maneuver. In normal driving conditions the steering mechanism is essentially conventional. Safety devices that require positive action to put the vehicle in the parking mode are incorporated. The hydraulic circuits are described in detail.

3. Dual Mode Mass Transit

The purpose of the Dual Mode/Bike 'N' Bus project was to suggest an improved commuter transportation system through the use of the bicycle. One area of work was in redesigning the bicycle for greater stability. This work resulted in accessory wheels which were of some improvement, but could not be considered a finalized solution. The next area of work was in designing a system for loading bicycles onto buses. This resulted in a motor-winch-cable system for lifting bicycles from the street to the roof of the bus. The designs were never operative, but problems could be eliminated with more time and effort. The final area of work was on a cover-all suit that would protect the rider from the weather. The suit's construction was completed, but testing was inconclusive as to its effectiveness. Extensive work and insight were achieved though substantial additional development is required.

4. Short Distan... Transportation

The purpose of this research was to determine the optimal system for moving people short distances. The system would be applicable in large parking lots as at airports or shopping center, office complexes, and college campuses. The system should accomodate luggage and be smooth, safe, convenient and inexpensive. The distance covered is approximately one half mile and high speeds are not necessary nor desired once normal walking rate has been surpassed.

Based on an ideal parking-to-destination arrangement, a scheme was developed for the assignment of a bus/conveyor system to various sections of the lot. Each system will connect to a main conveyor which will then take the passengers to a distribution point in the main facility. Every bus of the system will connect with the conveyor trunk line at a single bus terminal at the end of the trunk. Each feeder conveyor from within selected sections of the lot will connect by way of an accelerating belt to the main conveyor at intervals along the main belt. This line will be faster than the feeder conveyors.

An attempt at an improved redesign of the buses presently in use at O'Hare ariport was undertaken. These buses are representative of those used at many major airports. Bus modifications were studied in conjunction with the major thrust of the investigation.

5. Coanda Tube System

This report describes project studies to investigate aspects of a proposed new type of mass transportation system, based on the Coanda Principle. Aspects researched and described are: vent position effects, vent aperture effects, and design/implementation considerations.

Studies of the Decision Making Process, the Formulation of Transportation Goals and of Human Factors in the Design of a Coanda Tube System are also included.

6. Plastic Recycling

The Plastic Recycling project had a dual focus. One major area of effort was designed to examine the possibility of a recycling plant for household waste plastics, which plant would be small enough to be placed within urban neighborhoods. The other focus was on the qualities of household plastic wastes, and the possible treatment methods for converting these wastes into useful resources. In the latter effort, shredding and heat compacting tests were done on unsorted plastic wastes. In addition, a collection campaign was conducted in a local housing development, and the participants were questioned as to their responses to the campaign. A simple laboratory compactor was built, and an existing shredder (commercially available) was modified for use with household plastic wastes. The research and testing findings were inconclusive, but indicated that collection and processing could probably be established on a neighborhoou basis. It is doubtful that the operation could be profitable economically, although it would reduce the amount of household waste which would have to be hauled by scavengers.

7. Solid Waste Incineration

The problem of safe and efficient processing of solid wastes is examined for both the United States in general and Mercy Hospital at 2600 So. Michigan, Chicago, in particular. On the basis of criteria established, incineration is suggested as the most promising technique. Modification of the present incinerator at Mercy was decided on as the best way of achieving the optimum acceptable incinerator. A model of the Mercy incinerator was constructed, and the proposed modifications are detailed.

8. Auto Emissions

Using federal standards for hydrocarbons, nitrogen oxides, and lead as a base point, the project examined alternative modes of reducing emissions from internal combustion engines. The project specifically studied the effects of temperature of intake air on combustion and emission. An air heater was designed, constructed, and attached to a small four cycle engine. Extensive instrumentation was attached to measure intake temperature, extent of combustion, temperature of exhaust gas, and speed of the engine. Test runs were made holding engine speed and intake temperature constant. Findings indicate that air inlet temperature was inversely related to percent fuel combustion and that engine speed was directly related to percent fuel combustion.

9. Camera Shutter Design

This project is a preliminary study on the feasability of a non-mechanical camera shutter. The main thrust of this project is in the field of liquid-crystal technology.

10. Noise Control in Industry

The following report describes the research made by the Noise Control in Industry Group (NCIG), into the serious problem of noise pollution in industrial environments. The psychological and physiological effects of noise on man were studied. A preliminary testing program was developed to test various machines and determine their noise levels. After preliminary testing a specific machine was chosen and re-tested to isolate the noise sources. To alleviate the noise, a control device was designed and tested. A cost benefit analysis is also included.

11. Tornado Study

The Tornado Study project resulted in the preliminary design of a tornado detection/warning system incorporating the sferics detection method and an integrated warning system based on fundamental sociological considerations.

12. Vestibular System Testing

Testing the Vestibular System involves testing the response to angular accelerations and the response to linear accelerations.

The response to angular accelerations may be tested by blowing heated air into the ear and measuring the nystagmus. The groups efforts were directed towards developing a reliable Air Caloric Test device and designing torsion and vertical swings that could be used for mechanical vestibular system testing.

The Air Caloric test device consists of a gun which heats the supply air, a control system that controls the temperature of the air leaving the thermal gun and electrodes and recorders that measure the nystagmus. An automatic programmable sequencing device that automatically changes the air temperature in some desired manner was also designed.

The mechanical test device consists of a combination vertical and rotary swing. For testing the response to angular acceleration a torsion spring is used and for testing the response to linear accelerations the torsion spring is disengaged and a linear spring is used.

13. Dual Mode Vehicle

This is a report on the design of a mechanical steering system and of the suspension for an automobile which could move perpendicular to its longitudinal axis for a parallel parking maneuver. A scale model of a conventional car was modified to incorporate this feature. Cost estimates are included.

APPENDIX B

Evaluation Forms

PROJECT FINAL REVIEW AND CREDIT ALLOCATION PROCEDURES

PROJECT GROUP ACTIONS

The first step in the project review procedures is submission of the final project report to the E^3 Review Board. At this stage the report has been approved by the project advisors and is intended for acceptance without modification. The Review Board returns the project report either approved as submitted or with a request for revisal.

When the report is re-submitted to the Review Board, it is accompanied by the following documents:

1. The Credit Request Form - The credit request form is prepared by the student, initialed by the appropriate advisors (project advisors, module coordinator, seminar leaders, and faculty advisors) and submitted to the review board. It contains a listing of credit requested and the activities justifying this credit award.

2. The Faculty Project Advisor Assessment - A CIRCE form rating the contribution of each faculty project advisor prepared by the student.

3. The Student Log Inventory - A CIRCE form for the student to summarize and evaluate his or her own contribution to the project.

4. The Student Project Participation Evaluation Inventory - A CIRCE form for the faculty project advisors to summarize and evaluate each students' contribution to the project. The faculty advisors independently prepare this form for each student in the project group.

5. The Transcript Summary - A short document which summarizes in narrative form the student's project experience explaining the credit allocated.

REVIEW BOARD ACTIONS

When the Review Board receives the re-submitted report and the above documents, it approves (or modifies) item (1) and the final report. The appropriate documents are then given to the E^3 Administrator for credit assignment and filing in the student portfolios.

Steering Committee
April 6, 1973

E^3 TRANSCRIPT SUMMARY

Student________________________________ Project Period__________

Project Title ______________________________

Project Advisors ____________________________________

Review Board Members __________________________________

Student Project Participation Evaluation Inventory

E^3 Program 1972-73

Student Name:______________________________

Project:_________________________________

Duration:________________to______________

Project Faculty Adivosrs:__________________________________

The following ratings represent the project faculty advisors' evaluation of the student's participation in project activities.

	Inadequate 1	Fair 2	Good 3	Excellent 4
Involvement and commitment	1	2	3	4
Comprehension of project content	1	2	3	4
Ability to integrate and synthesize material	1	2	3	4
Creativeness, originality and innovativeness	1	2	3	4
Quality of team work	1	2	3	4
Quality of individual work	1	2	3	4
Overall project participation rating	1	2	3	4

Comments:

E^3 CREDIT REQUEST

Student ______________________________ Project Period ______________

Project Title ______________________________

Project Advisors ______________________________

Review Board Members ______________________________

	Credit Suggested	Credit Awarded	Approvals		
			Project Advisors	Faculty Adivsors	Review Board
Professional & Project					
Humanities, Social Science					
Engineering and Physical Science					
TOTAL					

Module or Seminar	Credit	OK'd by	Module or Seminar	Credit	OK'd by

Steering Committee
April 6, 1973

FACULTY ADVISOR ASSESSMENT

E^3 PROGRAM 1973

Faculty Member: ______________________________
(Ratee)

Student's Name: ______________________________
(Rater)

Project Title: ______________________________

Project Duration: ______________ to ______________

Instructions: This inventory should be completed at the termination of a project. It should be completed for the project advisor and for any additional faculty members closely associated with the project, i.e., a separate inventory for each.

In terms of the above project, assess the faculty advisor or other appropriate faculty members on the following dimensions by circling the appropriate rating-scale category and by providing a written explanation if necessary.

Item	Inadequate 1	Fair 2	Good 3	Excellent 4
Involvement and commitment	1	2	3	4
Comprehension of project content	1	2	3	4
Ability to integrate and synthesize material	1	2	3	4
Creativeness, originality and innovativeness	1	2	3	4
Quality of team work	1	2	3	4
Quality of individual work	1	2	3	4
Overall project participation rating	1	2	3	4

Instructions: Rate the quality of the advisor's functioning in each of the following capacities. Indicate your choices by placing a (✓) in the appropriate categories.

ROLES	Portion of Time Engaged in Role			Proficiency			
	Frequently	Sometimes	Seldom	Superior	Good	Adequate	Inadequate
1. Advisor							
2. Cohort							
3. Coordinator							
4. Director							
5. Evaluator							
6. Expert							
7. Facilitator							
8. Leader							
9. Organizer							
10. Resource person							
11. Sounding-board							
12. Teacher							
13. Team member							
14. Tutor							

<u>Instructions:</u> Indicate your preference of roles for this faculty advisor: Place a (✓) in the appropriate category.

ROLES	Very Desirable	Desirable	Cannot Tell	Undesirable	Very Undesirable
1. Advisor					
2. Cohort					
3. Coordinator					
4. Director					
5. Evaluator					
6. Expert					
7. Facilitator					
8. Leader					
9. Organizer					
10. Resource person					
11. Sounding-board					
12. Teacher					
13. Team member					
14. Tutor					

TA:bb

Student Log Evaluation Inventory

E^3 Project 1972-73

Student's Name: ______________________

Project Title: ______________________

Duration of Project: ______________ to ______________

Today's Date: ______________________

Please summarize your experiences to the above project by answering the following items. Use your E^3 log as a reference in organizing your responses.

a. List and describe several of the resources you found most helpful in your work on this project.

b. List and describe briefly several ideas that you generated as a result of your project work.

c. List and describe briefly several of the accomplishments that best represent your efforts on this project.

d. Rate the quality of your contributions to the project team by circling one:

Excellent Good Fair Poor

Defend your rating with data from your log and be sure to make reference to your original contract in the proposal.

e. As a result of your project work, what did you learn?

jeh