The Dartmouth concept: learning in the real world

With the city as their laboratory, engineering students learn to cope with the urban problems that eventually, as professionals, they will be called upon to help solve

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In an innovative program Dartmouth engineering students are sent to Jersey City, where they spend a term divided between teaching and performing an engineering task within the city administration. They help to coach inner-city high school seniors in the material of the "Man-Made World," and teach them the computer language, Basic, together with hands-on operation of a terminal connected to a time-sharing computer system. They also evaluate and help to develop methods for improving the operations of municipal offices and functions that come under the control of the Jersey City government. The program is designed to give the student a foretaste of the challenges he will face as an engineer once he leaves the cloistered halls of learning for the real world.

"Involvement." Perhaps that is the key word differentiating tomorrow's, and hopefully today's, engineer from his counterpart of yesterday. No longer can he be content to sit behind his desk or drawing board, or white-coated in his laboratory, busily designing new devices and evolving new theories for society's use without considering whether they are also for society's benefit. Haunted by the specter of technology uncontrolled, the engineer has finally realized that he cannot remain an abstraction but that he is a vital, and concerned, part of the world in which he lives. And this is an awareness that must begin in the engineering classroom.

One interesting step in this direction has been taken by Dartmouth College's Thayer School of Engineering in a program originally set up in cooperation with Tuskegee Institute.[1] More recently the school has become involved in a similar program in Jersey City in which Dartmouth students are encouraged to learn by doing, by becoming immersed in the actual everyday problems of urban life, because these are the problems that they, as practicing engineers, will be called upon to solve—transportation snarls, communication foul-ups, housing inadequacies, protection deficiencies, etc., etc.

The Dartmouth concept

Because Dartmouth College is somewhat removed from any large metropolitan area, it affords an unreal, ivory tower environment in which to try to bring any relevancy to teachings about the true crisis that confronts the cities, and the nation, today. The desire to involve the student in the world outside was the motivating factor in the founding of the Jersey City Urban Education Center of Dartmouth College some two years ago to provide a residential setting in which Dartmouth students can spend a term living and teaching, as well as learning, in a typical U.S. city.

The initial program began with undergraduates who did student teaching at a public elementary school, and also acted as coaches or tutors to the students after class. In addition, they participated in a number of community activities such as adult education and expanding recreational opportunities in the residential area. It was realized quite early in the program that it was necessary to reach a larger audience, and it was also felt that one of the major needs of the Jersey City school system was to improve the education of its children in the areas of mathematics, science, and languages. As a result, the engineering program currently is represented in Jersey City by the presence of six students each year (two per term) who help to teach an engineering-oriented course, at two of the city high schools, which is based on the Engineering Concepts Curriculum, "Man-Made World." In addition, the students also are involved with the city's problems as participants in a regular engineering-oriented project.

It also was felt that a time-shared computer would be extremely useful to the program and so a terminal was

established in the residence and connected to the central time-sharing facility on the Dartmouth campus in Hanover, N.H. Another acoustically operated terminal was provided for use within the city hall in Jersey City or any of its agencies.

The student in the city

Explaining a man-made world. The subject course, "The Man-Made World" developed at Brooklyn Polytechnic Institute, broadly speaking is a presentation of some of the concepts underlying the technological developments that pervade our society.[2] It serves two rather distinct purposes: (1) it attempts to show the student who is not interested in pursuing science further what science and technology are about and what they can be expected to do; and (2) it shows a student who may be considering further work in science and engineering, as opposed to physics and chemistry, what he can expect and some of the specific techniques used.

The course is divided into three parts. The first deals primarily with the development of engineering concepts, including decision making, optimization, modeling, the use of the analog computer to make models, and, briefly, graphs and their use in predicting trends. The second part is concerned mostly with an introduction to computers, logical thought and logic circuits, the binary number system, memory, the organization of a computer, programming, and some simple programming languages. The third book deals mainly with the concepts associated with systems—feedback, stability, the interaction of men and machines. The laboratory manual that goes along with the course develops experiments related to each of these three texts and involves equipment such as an oscilloscope, a signal generator, an analog computer, a logic circuit board, tuned circuits, resistors, and a simple microphone.

Man-Made World has been taught at more than 100 schools in the last few years, most of them schools in well-to-do residential areas, parochial schools, or private schools. Whenever it had been attempted in an inner-city school it did not succeed very well, mostly because of poor-quality teaching, lack of equipment, and poor preparation of the students in mathematics and English. The Dartmouth students, by coaching or tutoring, were able to help explain the material and thereby compensate for the inadequacies of the teachers. They also were involved in drills and preparation and evaluation of laboratories, and in additional teaching. For example, they were to instruct the students in the computer language, Basic, and the application of time-sharing to some of their problems.

Two classes were selected, one at Lincoln High School and the other at Ferris High School, and the Dartmouth students worked with both black and white teachers. Lincoln is an old school located in a predominantly black area that contains one of the larger populations of academically oriented, and thus possibly college-bound, students. Ferris is a brand-new school, situated in a primarily Spanish-speaking section, whose quality of instruction and students suffers from a difficulty in communicating, and which, therefore, tends to have students with vocational interests. Each school had a professional teacher responsible for the course as a whole, and for the lecture aspect in particular, who had been trained at a six-week summer institute at B.P.I.

The teacher at Lincoln High was definitely a superior teacher. He was young, enthusiastic, and understood the students well. In class he involved them to a great extent and tended to conduct the sessions rather freely. However, this caused some difficulty because the course demands much more class preparation than the teacher had been accustomed to requiring. Also, this teacher's training had been in biology, so his background in many areas covered by Man-Made World, particularly mathematics, was weak. This was to be expected and was part of the justification for the presence of the Dartmouth students, whose relationship with the teacher was excellent; the class of 14, two of whom were black, performed admirably. There is no question but that the course was an unqualified success at Lincoln High School. Indeed, during a strike in the Jersey City school system, Lincoln students in the Man-Made World class continued to visit the residence to work with the computer on the course material.

The conditions at Ferris were different in many respects. The teacher's training was in chemistry, which tended also to minimize his interest in mathematics. In addition, the quality of the students' work was somewhat poorer than that at Lincoln and their general competence in English was inferior. There were 13 students in the class—two black, six Spanish-speaking, and the rest white. The class essentially was taken over by the Dartmouth students, partly because of the teacher's inability to communicate the material to the class and partly because of his lack of confidence. Since the Dartmouth students are not professional teachers, the quality of the instruction suffered greatly. The involvement of the class by the professional teacher was minimal. The lectures became just lectures, parroting the material of the text. Because of the poor reading ability of the Ferris pupils, the students were forced to spend a great deal of time outside of class merely explaining the content of the lectures, and not necessarily expanding upon the material. The class at Ferris was not nearly as successful as that at Lincoln, and it is fairly obvious that without the Dartmouth students it would have been a complete failure. However, compared with the general quality of work at Ferris, it was received well and the students there gained a great deal from it.

Computer magic 'turns them on.' Because of the lack of school funds for the purpose, Dartmouth College purchased sufficient equipment for each classroom and loaned it to the Jersey City school system. In addition, a time-shared computer was located in the Jersey City residence of the Dartmouth students to which the high school students and their teachers were given access. The effect of being able to use a computer was magical in every instance in "turning students on" about the course. This part of the program was certainly novel, not only to the Man-Made World, but to the inner-city youngsters whose normal access to complex equipment is quite limited. The very fact that much of the equipment was portable and that, at least at Lincoln, the students were permitted to take it home to work on problems at their leisure was highly motivating.[3]

Both classes suffered from a tremendous lack of background. Specifically, they had some difficulty in reading, and enormous difficulty with mathematics, although supposedly they were high school seniors. Actually, their reading level was such that they probably would have no real problem with most high school courses; however, the

Man-Made World was written by engineers and scientists accustomed to writing for technical journals. Although the vocabulary is carefully controlled and free of unnecessary jargon, the style is formal and quite dense. Most students complained that they could not understand the material, and many probably gave up after the first few weeks.

The lack of mathematical background is far more significant. The concepts of the course are not primarily mathematical but the examples selected for illustration necessarily use some elementary algebra. The students supposedly had taken that course, and most had taken or were taking intermediate algebra—but they seemed to have learned very little. In many cases, they were not comfortable even with arithmetic. None of them would apply any mathematics unless forced to and they refused to accept the fundamental idea that mathematical solutions are desirable. Many of the points illustrated by the examples got lost because the students spent so much time and effort in trying to follow the mathematics.

In an attempt to remedy the situation to some degree and also to demonstrate the role of the computer, computer programs were developed that included teaching of simple mathematics as well as some of the material of the Man-Made World. The availability of these programs and the fact that the students were able to use them made a tremendous difference in their eagerness to do problems.

Late in the academic year about a dozen students from Jersey City visited Dartmouth for two days and spent most of their time working at the teletypewriters. Undoubtedly, the introduction of the computer was one of the high points of the course and the students responded very favorably to the possibility of extended use of this medium, which would seem to indicate that further utilization of computer-aided instruction is certainly warranted in this type of environment.

The student and the city

While he is in Jersey City, the engineering student really has three roles to play. First, he lives in the residence and experiences the city and its problems firsthand by being a part of them for a term. Second, he helps to teach an innovative course relating to the applications of technology in our modern society, thus interacting with inner-city youngsters and providing guidance in material that is difficult for them and, at the same time, expanding their horizons by demonstrating the use of the computer. And, as an engineer, he has still another role—to engage in a task that draws upon his abilities to evaluate, organize, fabricate, and use both oral and written skills in conveying the results of an investigation to those who must use these results. Since it is this area that is most closely related to his previous training, the engineering student can utilize the skills that differentiate him from the other Dartmouth students who participate in the Jersey City program.

As of this writing, more than a dozen engineering stud-

The Dartmouth engineering program

At Dartmouth, the student interested in engineering spends his first four years studying mainly in the natural sciences but with stress on the humanities and social sciences also. In most cases, he then graduates with the A.B. degree, with a major in engineering science and heavy nonscience emphasis. He thus is not really considered an engineer until he has had an additional year of technical education, which he usually elects to take at Dartmouth's Thayer School of Engineering where he receives the bachelor of engineering degree. During that fifth year he is responsible for seven courses, plus two courses that count as a project—which must demonstrate the ability to select a problem, evaluate alternative methods for its solution, develop the technical considerations, usually fabricate a feasibility model or prototype, and write a report, which is essentially an abbreviated thesis, as well as make an oral presentation. Also, during his first four years at Dartmouth, the student is not a major in a particular engineering field but is studying subjects applicable to any engineering discipline. In the fifth year, if he so chooses, he specializes either in a standard engineering major or in a more narrow field such as computer science, electronic devices, electronic circuits, etc.

Because of the nature of the curriculum, the student has various opportunities to work on independent projects as part of his normal academic career, and also can arrange to spend a term off-campus in programs such as the one in Jersey City.

Engineering students as interns

Two kinds of students participate in the engineering version of the Jersey City program. The first is the undergraduate who has already taken most of the mathematics, physics, and other prerequisites, as well as a number of engineering courses, and whose immersion in the Jersey City situation counts toward the satisfaction of the requirements for his degree. The other type is a graduate student who either goes to Jersey City to carry out, in part, a project in which he already is engaged or to find a suitable project relating to his particular interests.

The student enrolled in the Jersey City program receives credit for a normal term's work, which consists of three courses—in this case education courses that count to satisfy partially his requirements in the social sciences. (Dartmouth operates on the three-terms-per-year basis.) He has obligations to provide written reports on three facets of his experiences: residential; student teaching; and evaluation of text material that pertains to life in the urban environment and to the black–white experience as it relates to this community. If the student is an undergraduate, the education courses can be replaced, at least partially, by his project work, so that one of the reports typically is evaluated by the engineering faculty and deals with an engineering project in which the student was engaged while in Jersey City.

ents have been sent to Jersey City and six major projects carried out. All of the projects utilized the computer, partly because this was something with which our students were familiar, and partly because the administrators of the city government and its agencies require more knowledge about it. The first three projects also were chosen to involve the student with different agencies so that more interaction between the Thayer School and the city administration could take place. To insure proper communication in this cooperative effort, the director of finance, whose department is primarily concerned with the support of the program, and the writer have been overseeing its general operation. Student reports have been submitted to the director and his staff, and in some instances have actually resulted in positive actions.

The first pair of students was concerned with operations research at the Jersey City Medical Center, a complex of many buildings that currently provides some 500 beds. The chief facility for handling most of the city's medical needs, the center is run by a board most of whose members are also part of the city administration. An executive director, who is a civil servant, oversees the daily operations of the hospital. One of the biggest obstacles in trying to evaluate the efficiency of the operation was that there was no one source of information; people who were supposed to know did not themselves have a clear understanding of their organization. Thus, the students' initial task was to gather information on the day-to-day functions of hospital personnel by analyzing the intercommunication forms that were passed from department to department and by interviewing head nurses, doctors, the data-processing staff, kitchen help, and even orderlies. The resulting report contains some 80 pages, in addition to appendixes that consist of flow charts of the operation as well as copies of the some 200 different forms that exist in the hospital.[4]

The center's director maintains that the report has been valuable in helping him to assess the efficiency of his procedures and also in preparing to implement improved data processing in the medical center. The city administrators also have indicated that this effort, although it only skims the surface, has provided much more data about the conduct of the medical center than they had ever had previously. They would like to have the effort continued to obtain more specific details so that some of the recommendations of the report can be carried out and fuller use of expanded computing facilities within the hospital complex can be effected.

A second team of students worked on different problems. One team member was a senior whose area of interest was in the city planning office, for whom he developed a computerized survey tabulation system. Briefly, this meant preparing for computer access the information contained in a survey of some 25 percent of Jersey City's families, which included not only demographic but also economic and geographic information. One of the student's first functions was to put the material into usable form for evaluation, which also entailed the development of many of the necessary sorting and statistical programs. Again, this activity culminated in a report whose value is such that the planning office has made it part of its official records, and it is being used in some model city planning.[5]

The second student was working on his bachelor-of-engineering project, which consisted of trying to use computer-assisted instruction techniques to aid in teaching the material of the Man-Made World. As another task, he chose to work in conjunction with one of his tutorial graduate courses in the business school as an aide in the Inner City Business Project. The aim of this group was to inform local residents about the rules and regulations relating to the development and running of minority business enterprises. Again, the indications are that he performed very well in a number of instances, particularly those related to semitechnical activities.[6]

The other area of his work was concerned with computer-assisted instruction in Jersey City.[7] Four computer programs designed to help teach engineering concepts to high school students were written in Basic for use with the Dartmouth time-sharing system. In this application, the computer is used in a conversational mode and a scanning technique utilized that recognizes regular English tests for both questions and answers. The first program, which deals with the concept of what a computer is, teaches that it is only an inanimate machine that can add, subtract, compare, and store numbers, but must be told what to do. It introduces the word "program" and also the binary number system. The second and third programs teach elementary logic, truth tables, word statements, and circuit diagrams. The fourth program, written after the experience in Jersey City in attempting to teach the subject, involves the conversion of binary to decimal numbers. Although it is shorter and covers much less material than the other programs, it provides a drill feature that allows the student to practice this kind of conversion for as long as he wishes and gives him immediate verification of his answers.

The third team of students worked on a project concerned with the analysis and improvement of the acquisition and storage of land bank information. Briefly, it involved the preparation—for future computer implementa-

The Man-Made World

"Survival of our civilization and of each of us as individuals depends upon our ability to adapt to these technological developments and to control the changes they produce within our society. An understanding of advances being made now and those under development for the future must be made accessible to all groups.... Within a democratic process such control can be realized only with public understanding of the nature, the capabilities, the limitations, and the trends of technology.

"The Man-Made World is intended as part of the cultural curriculum—as a course for all citizens who will take part in guiding the currents of our society. It attempts to introduce to senior high school students a sense of the complexity of technological problems and some of the methods being used to solve them. The authors [of the course books] are engineers, scientists, and educators who are convinced that the world is increasingly shaped by technical accomplishment."

From the ECCP Newsletter

tion—of information regarding city-owned properties that had been acquired primarily through failure by their owners to pay taxes.[8] The most important portion of the task initially consisted of determining exactly which information was important and what the best form for this information would be. One of the goals was to make it readily available for bimonthly public sales of these excess properties. The eventual computerized system for this project will be implemented by the city's new NCR computers. Indications are that the project was very useful and will be continued for subsequent students, who will write codes and systemize the data for computer entry and retrieval. One of the students who worked on this project also was interested in developing programs relating to computer-assisted instruction in languages and mathematics and several programs were written to teach such skills.[9]

These tasks are indicative of the kinds and breadth of projects that can be carried out by engineering students within the framework of city government. From the city's point of view, its money has been well spent and the indications of continuing cooperation with the Thayer School are quite strong.

In general

The Dartmouth program described here provides a new way to educate the future engineer while involving him in trying to help some less fortunate members of society. The program also takes advantage of the student's engineering skills to furnish some needed services within the city administration of a large urban center. The role of the engineering student in Jersey City is multifaceted. He becomes aware of the problems of the city and, in addition, makes a contribution in attempting to solve some of these problems in a specific area in which he can practice his technical expertise. He comes to realize that economic and technological considerations are not the only important requisites for successful engineering achievement, but that social and political aspects, and day-to-day realities, must be considered. He interacts with the immediate neighborhood of his residence, which is in a poorer section of the city, and shares the daily tribulations of his neighbors concerning such simple things as garbage collection and street cleaning, fire and police protection, and the inaccessibility of economical food and clothing distribution centers.

As another facet of his experience, he helps to teach an engineering-oriented concepts course to high school students whose need for the material is great but whose educational background is limited. He functions as an aide to the teacher and as a coach for the students, and learns that his main problem is to get technical information across to an audience that is grossly inadequate in mathematics as well as in simple English and reading and writing skills. This realization can be pertinent to his own work at the university for he can then appreciate the fact that many prerequisites are important even though initially they appear to be of peripheral value to the study of a given subject. By bringing to bear some of the modern technology involved with the digital computer, he becomes interested in computer-assisted instruction, which appears to have many advantages in teaching under such circumstances.

What has happened, then, is that the engineering student is put into a situation in which he not only is teaching, but is being taught; he not only is serving, but is receiving knowledge that will be of future value. It is certainly to be hoped that many of these students will choose to return to the city environment to apply this knowledge in an effort to alleviate some of the ills of urban society.

The Dartmouth–Jersey City program works because the students give as much as they receive, learn as much as they teach, and act as much as they are acted upon. It is an excellent example of practical engineering and demonstrates the opportunities that exist for engineers to help remake our society, our so-called "Man-Made World," into a more nearly ideal environment for us all.

This project was partially supported by the American Telephone and Telegraph Company and the City of Jersey City, N.J.

REFERENCES

1. Manasse, F. K., "Getting engineering students involved: The Dartmouth/Tuskegee program," *IEEE Spectrum*, vol. 7, pp. 59–64, Dec. 1970.

2. Engineering Concepts Curriculum Project, *The Man-Made World*. New York: McGraw-Hill, 1968.

3. *Commun. Business*, N.J. Bell Telephone Co., p. 12, spring 1970.

4. Roitman, Peter, and Hoots, Geoffrey, "Operations research on the Jersey City Medical Center," Thayer School Rept., June 1970.

5. Corson, Bruce, "A user's manual for a computerized survey tabulation system," senior thesis and Thayer School Rept., June 1970.

6. Andrus, William, "Jersey City, the minority businessman and the engineer," Thayer School Rept., May 1970.

7. Andrus, William, "Computer assisted instruction in Jersey City," B.E. thesis (supported by ARPA cont. F44620-68-C-0015), June 1970.

8. Urion, Henry, and Yule, Chris, "The analysis and improvement of acquiring and storing land bank information," Thayer School Rept., July 1970.

9. Urion, Henry, B.E. thesis (supported by ARPA contract), Sept. 1970.

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