Arbeitspapiere

AP_WI0882

Helmut Winkler

13

INTERACTION OF THEORY AND PRACTICE IN THE U.S. ENGINEERING EDUCATION

August 1982

Arbeitspapiere des Wissenschaftlichen Zentrums für Berufs- und Hochschulforschung an der Gesamthochschule Kassel

Nr. 13

Helmut Winkler

INTERACTION OF THEORY AND PRACTICE IN THE U.S. ENGINEERING EDUCATION

13

August 1982

Wissenschaftliches Zentrum für
Berufs- und Hochschulforschung
Gesamthochschule Kassel
Henschelstraße 2

3500 Kassel
Tel.: (05 61) 8 04 - 24 15

C o n t e n t

		Page
1.	Preface	1
1.1	Leading Questions	3
1.2	The Program Evaluation Process	4
1.3	Purposes and Philosophy	7
1.4	Design and Methodology	8
1.5	Limitations of the Study	9
2.	The U.S. System of Higher Education	10
2.1	Recent Trends in Higher Education	12
2.2	Development in the Field of Engineering Education	14
2.3	Three Ways of Engineering Education	21
3.	The Concept to integrate Theory and Practice	30
3.1	Experiental Learning Objectives	32
3.2	Patterns of Involvement	33
3.3	Patterns of Operation	37
3.4	Cooperative Education	40
4.	Programs for Interaction of Theory and Practice in Engineering Education	48
4.1	The first Idea, the first Program: University of Cincinnati	48
4.2	The Largest Program: Northeastern University Boston	57
4.3	A Very Unique Program: La Guardia Community College New York City	66
4.4	The Harvey Mudd College Clinic Program	71
4.5	The Kansas State University Design Laboratory	73
4.6	The Worcester Polytechnic Institute PLAN-Program	75
4.7	The West Virginia University PRIDE-Program	78
4.8	Three Different Programs at Massachusetts Institute of Technology	80

5. Benefits, Success, and Problems of Programs 91
5.1 Expected Outcomes 91
5.2 Evaluation of Co-op-Education Programs 92
5.3 Evaluation of Other Programs 98

6. Final Remarks from a German Viewpoint 105

7. Epilogue 108

Appendix: Bibliography 109

1. Preface

In the beginning of the year 1980 the author got the chance to travel through the United States taking a look on programs in the field of engineering and technical education under the viewpoint of the relationship between theory and practice. The trip was financed by the Fulbright-Commission and organized by the Office of the Council of International Exchange of Scholars as a special program for German Educational Experts. I wish to thank for this arrangement, especially Mrs. Margot U. Marino, and also all persons I have interviewed for all the support in my work.

The programs I have seen can be summarized under the expression "Experiential Learning" and have been operationalized in the most cases as programs for "Cooperative Education".

During my stay in the U.S. I had to develop my first questionary prepared in West-Germany to a more fitting set of questions, especially in the field of evaluation of the benefits, the successes and the problems of these programs for I have arosed more questions by getting more and more informations the longer I was there.

The outcome of this survey may be interesting for all persons engaged in the development of the programs in the U.S. for they are presented as questions and suggestions from the viewpoint of a foreigner with probably an open eye for things; you may overlook some things being involved in a well-going program. The outcome also can transport some ideas about the American trial for solution of the problem to connect theory and practice to the West-German system of engineering education.

The visited Institutions have been:

- Center for International Exchange of Scholars, Washington D.C.
- Educational Research and Information Center, Washington D.C.
- The House of Representatives, Rayburn Bldg., Washington D.C.
- Gallaudet College for the Deaf, Washington D.C.
- Ministry of Health, Education & Welfare, Office of Education, Washington D.C.

- American Society of Engineering Education, Washington D.C.
- American Council of Education, Washington D.C.
- Ministry of HEW, Education Dept., Office of Cooperative Education, Work Experience and Work Study Programs, Washington D.C.
- New Jersey Institute of Technology, Newark, N.J.
- Stevens Institute of Technology, Hoboken, N.Y.
- Northeastern University, Boston, MA.
- Massachusetts Institute of Technology, Cambridge,MA.
- La Guardia Community College, La Guardia, NYC.
- Columbia University, NYC.
- City University of New York, Graduate Center, NYC.
- University of Michigan, Ann Arbor, MI.
- Washtenaw Community College, MI.
- University of California Los Angeles, LA, CA.
- California Institute of Technology, Pasadena, CA.
- University of California, Irvine, CA.
- Unified School District Office, Los Angeles, CA.
- University of Cincinnati, Ohio
- State University of Florida, Tallahassee, Fla.
- Florida State Board of Architecture, Tallahassee, Fla.
- Florida Manpower Services Council, Tallahassee, Fla.
- State Office of Vocational Education & Research, Tallahassee, Fla.

In all institutions I found very helpful advisors and guidance by well informed persons whom I have to appreciate all given informations.

1.1 Leading Questions

Led by a comparative approach to analyze this problem circle this study should find out either comparable or different program elements, which have been developed in different attempts to integrate theory and practice in engineering education. At first the main questions of this study have been arosen by following the recent discussion within the Federal Republic of Germany about similar problems. But during my stay in the U.S. it seemed to be worthwhile to add further questions fitting closer to the American situation. Especially the hints from colleges at LaGuardia Community College in NYC - stemming from their impressive experience in operation and evaluation of a "Cooperative-Education-Program" - have been proved as rather helpful (e.g. Learning Objectives: commitment of participating employers).

One question of my own repertoire regrettably remained nearly without response, possibly for its merely orientation towards the German discussion: Role of Unions in experiental learning programs?

My first catalogue of questions, prepared before entering the U.S., was as follows:

(1) Can you give a precise specification of the educational goals and objectives of your program?

(2) How do you evaluate the results, outcomes, benefits, obstacles, efforts, impacts of the program and how do you evaluate the learning achievements of the students, teachers and administrators in this program.

(3) What are the interests of the involved groups (students, professors, counselors and advisors, representatives of industry, state and government) in this program and what are the benefits they get?

(4) What are the costs of this program and how is it financed?

Further questions have been developed during my stay in the U.S. and during preparation of this report studying the existing reference material.

1.2 The Program Evaluation Process

Different experienced-based programs have been created to concentrate on new learning outcomes - especially those in the upper ranges of various learning hierarchies and those most necessary for practicing engineers. The difference between those programs has to be seen first in their intensity of involvement into real, practical work, second in the pedagogization of these practical experiences.

The intensity spreads from career and job-orientation and -information programs, simulation programs, project-study-programs, research-participation programs, work-study programs to internship-programs and full structured cooperative education programs.

The pedagogization of the practical parts of these programs varies also widely, referring to the formal or informal goals of the respective programs.

Related to the pedagogic goals, an evaluation can be founded on the use of learning taxonomies (see Fig. on the next page) of Bloom et al. and Gagné *).

Recently a number of taxonomies (classifications of educational objectives) have emerged to document the learning sequence followed by students in the learning process.**) Probably the most familiar and well-known is Bloom's taxonomy for the cognitive domain. It has been followed by taxonomies for the affective domain, the psychomotoric domain, and just recently the experiential domain. Each of these taxonomies traces the levels of increasing sophistication that learners pass through as they proceed from the beginning of their awareness to the limit of behavioral change.

---

*) Gagné, R.W., "The Conditions of Learning", N.Y., Holt Rinehart Winston, Inc., 1965

**) Generally these taxonomies should be used only as an instrument helping to formulate learning objectives; in the U.S.A. meanwhile they are also used for evaluation.

A. COMPARISON OF THE TAXONOMIES OF LEARNING

Level	Cognitive[1]	Affective[2]	Psychomotor[3]	Experiential[4]
I	Knowledge	Receiving (Attention)	Perception	Exposure (Comprehension)
II	Comprehension	Responding (Willingness)	Set (Willingness)	Participation (Application)
III	Application	Valuing (Acceptance) Commitment	Guided Response	Identification (Involvement)
IV	Analysis	Organization (Importance)	Mechanical Response (Habitual)	Internalization (Adoption)
V	Synthesis	Characterization (Adoption)	Overt Response (Perfection)	Dissemination (Commitment)
VI	Evaluation			

B. GAGNÉ'S LEARNING HIERARCHY

I	Response	Imitate
II	Association	Name
III	Discrimination	Select
IV	Behavior Chains	Order
V	Classification	Identify
VI	Principles	Apply a rule
VII	Problem Solving	Apply principles

---

[1]Bloom, B.S., et al., "Taxonomy of Educational Objectives Handbook: Cognitive Domain," McKay, New York, 1956.

[2]Krathwohl ., et al., "Taxonomy of Educational Objectives Handbook: Affective Domain," McKay, New York, 1964.

[3]Simpson, E.J., "The Classification of Educational Objectives, Psychomotor Domain," Project Report, University of Illinois, 1966.

[4]Steinaker, N. Bell, "A Proposed Taxonomy of Educational Objectives: The Experiential Domain," Educational Technology, January, 1975, pp. 14-16

Although the authors of the taxonomies have filled in a rather elaborate sequence of steps and branches, the trajectory of the learner can be summarized in five or six major steps or levels. Table A shows a rather cryptic summary of the levels for each of the four basic taxonomies. There are a number of ways that some understandings can be derived from the taxonomy table. The objective here, however, is merely to provide a rather simplistic "layman's" interpretation. At least it may give some credibility to the logic that is involved in the development of an effective learning activity.

The first three levels in the taxonomy table could be interpreted as child-level activities of learning in each of the domains. That is, these levels have a specific training orientation towards the obtaining of skills - repeatable and usable skills. These three levels involve most manipulative, habit forming, non-judgmental activities. Some of the studies of pedagogical activities claim that most of the learning activities employed in courses of higher education rarely exceed Level III and are primarily devoted to the skill acquisition level. This is especially true in courses at the freshman, sophomore, and junior years.

Levels IV,V and VI in the taxonomy table might be interpreted as adult learning activities. These involve the complex mental skills that are required to synthesize, combine, transfer and adapt knowledge from one situation to another with skill and sophistication. To put it another way, levels I,II and III involve training and Levels IV,V and VI involve education. In the three upper levels we see some overlap and correlation between the cognitive levels of analysis, synthesis, and evaluation and the corresponding levels in the other three domains. In any of the domains, these upper levels involve the application of the skills that were derived in the first three levels. It is these three upper levels that develop the decision-making and problem-solving attributes that are so highly valued in graduates of engineering and other professional schools. These are the attributes that are developed by engineering design experience.

These sophisticated skills require learning activities that have a component of individualized interaction with situations that are realistic, open-ended, complex, unstructured and perhaps even undefined. It requires a mental activity that is at the very top of Gagné's learning hierarchy (Table 3), that is, problem-solving or the application of principles. The learner is now put into an apprenticeship role to practice the implementation of his previously obtained skills. The professor's role at these learning levels is that of coach, mentor, master tutor, consultant as opposed to the trainer-instructor role at the lower three levels of the hierarchy. Since the desired attributes obtained in learning activities in the upper levels of the taxonomy are essentially derived by involving the student in complex, problem-solving, decision-making activities, it follows then that an experiential learning activity is a revelant and perhaps a necessary component of the learning program.

Thereby those programs initiated departures from traditional classroom and laboratory curricula stimulate curiosity and create high expectations. What are the features of exemplary experiential programs and how do they actually work? Where do they fit into the traditional curriculum? Are new learning outcomes really accomplished and how well? What programs require more effort and resources than traditional approaches? Generally, what impact on students, faculty and the institution results from experience-based learning? These questions shaped the purposes and conduct of this study, as well as the more operational questions formulated for the interviews (see: preface).

1. 3 Purposes and Philosophy

Several objectives were set in the development of the study. First, the study was designed to describe, in some detail, the structure and activities of engineering programs exemplifying different approaches to experiential learning. Second, the learning outcomes of this approach needed identification, especially in comparison to the regular curriculum. Next, the activities producing these outcomes needed exploration and more precise identification. Finally, the broad impact of experiential learning on student and faculty roles and on the institution needed clarification.

The purposes could best be met through a systematic, analytical and comparative study producing merely qualitative information to clarify what experiential engineering education is in general and the program alternatives are in particular. By design, the study was exploratory, satisfying certain curiosities and stimulating others, yet testing no hypotheses. The intent was to establish a basis for judgment and decision about the role experiental learning should play in Higher Education.

1.4 Design and Methodology

With this general approach, 10 different programs or models of experiential education were chosen for the survey (see Chapter4). For comparison, other studies about similar programs have been reviewed. Each program either exemplified an established and successful experiential model or represented a unique approach to experiential learning.

Due to the circumstance and the organization of the study-trip, the majority of interviees have been involved educators (professors, officials in programs), only in some cases occassionaly participating students could be asked. Therefore, interviewees were neither randomly nor purposely chosen, the criteria was to get as many informations as possible in a short time, so the interviewees should be well informed about the visited program. Naturally involvement produces not only information and insight, it often causes proud of the "own" program. So the study boasts no claim for generality.

No instrument interviews have been developed, but 7 general questions were asked of all interviewers:

1. - 4. : the already formulated questions, described above (see page 3), additional questions have been:
5. If the program relies on education provided off-campus, how can the employers be made responsible to care seriously about the educative objectives ?
6. What emphasis lies on the support of social competence (interpersonal skills) of the students and what results do you have ?
7. What are the influence and the role of trade unions in this program ?

Generally one interview lasted one hour. In addition to interview data, published information on the program, some self-evaluation - reports, and other reference material was gathered, either in advance on the site of visits or after visiting.

1.5 Limitations of the Study

The limitation of all evaluation studies is shaped by purposes and constraints and produced results are reflecting these conditions. This study has substantial limitations which should be noted before interpreting the results:

- The major limitation concerns the occasional, not random, not purposive, selection of interviewees (organization of interviews by the Central Office of the Council for International Exchange of Scholars with minor influence by the interviewer).
- Interpretations from interviews are done under the perspective of a foreigner, rather experienced in similar programs in Western Europe but not well experienced in the US-system;
- The data also reflects the biases of the interviewees - usually a positive bias toward experiential learning.

Additional data also comes primarily from the self-reports or self-evaluation of program participants.

- The data are incomplete for they don't contain opinions, experiences, and judgments of persons who are non-participating, have left the program, or have been involved in an unsuccessful process.
- Lastly, a lot of numbers presented in the report cannot be claimed as precise, actual, or consistant due to the oral interview situation. Thus, data trends and patterns, rather than statistically significant differences, are identified and discussed.

Therefore the report provides mainly descriptive information on program activities plus suggestive information on important teaching/learning outcomes and relationships. Many of these issues need further research.

Maybe the results may provide some insights for teachers and administrators involved in comparable activities of experiential learning and for researchers investigating the dynamics of the teaching/learning process.

2. The U.S. System of Higher Education

In the higher education "systems" one can find two rivaling principles. The first concept (mostly the traditional), views higher education as a field independent of society, self-directed, slow to respond to the fashions and currents of the day, housed in a set of unique and selective institutions whose sole purpose is to foster the highest levels of intellectual development and achievement, especially supporting all fields of pure and applied scientific research. The second concept, often heavily contradictory to the first, views higher education essentially as a social service, an activity that should be pragmatically and fluidly related to the ever-changing needs of the society, available to all and closely responsive to the popolar will.

This duality of approach exists in most countries, but in the U.S. it is more visible so that the foreign visitor and even many

Americans are at first a little bit confused by the great variety and diversification of the "system" of higher education. This "system" seems to be often both dynamic and conservative, responsive to society and aloof from it, hospitable to change and slow to abandon traditional values, pliable and inflexible, democratic and elitist, nonselective and selective. So there exist a lot of different institutions of higher education in the U.S., each with a slightly different concept or a special emphasis. Today there are nearly 3000 accredited institutions of higher education, amounting to a very small number of the greatest and finest research-orientated universities and also a large number of small, nearly unknown colleges with only a few students.

But nevertheless you can find a "system" in this diversified area (s. Fig. 1).

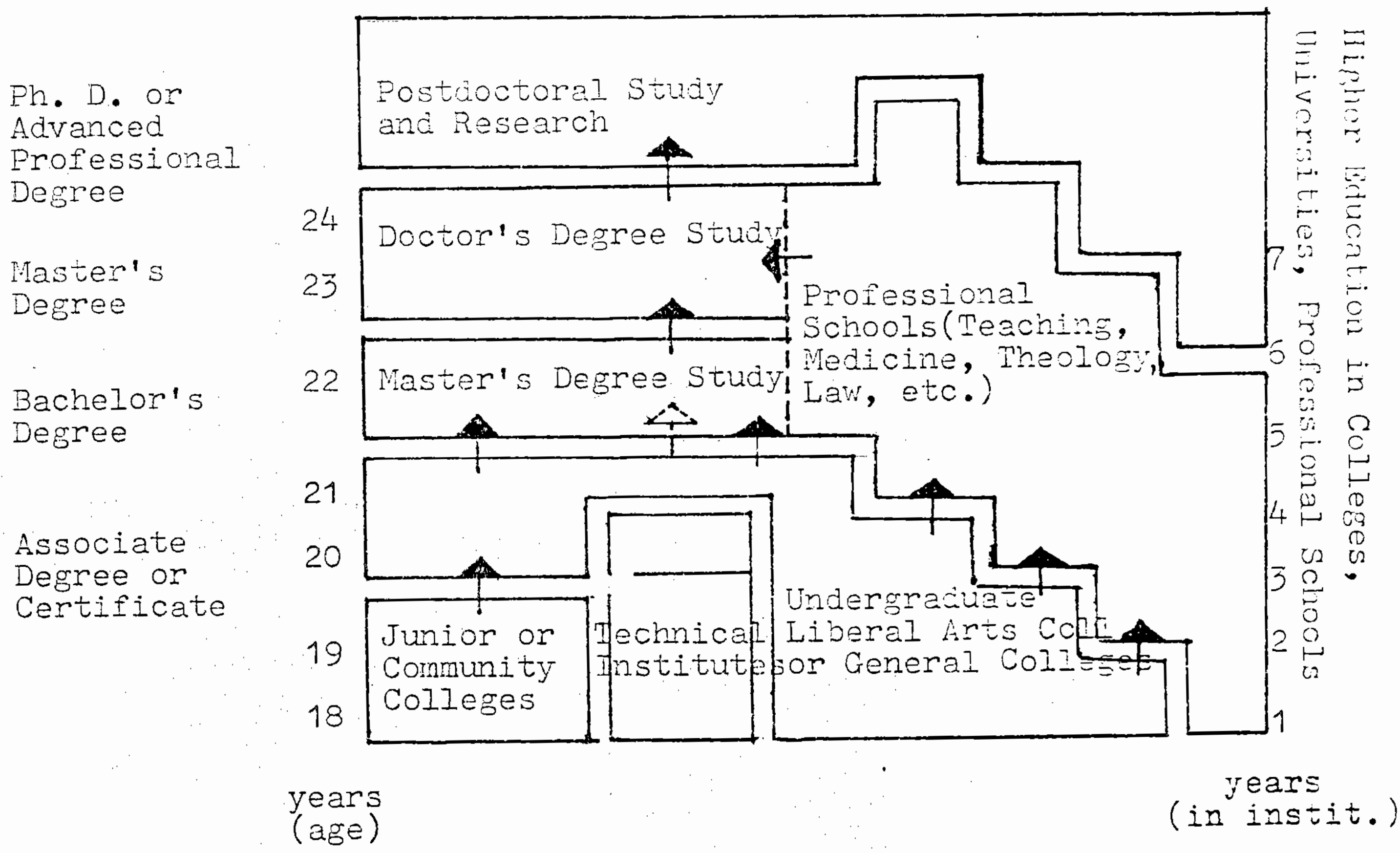


Fig. 1: The System of Higher Education in the United States

Generally speaking there are three main kinds of degree-granting institutions of higher education in the United States:

the 2-year community or junior college,
the 4-year undergraduate college,

and the university, which normally includes undergraduate education as well as graduate and professional education. There are both public and private institutions in each category with no official or implied distinction in quality between them. Both categories include a wide range of institutions.

Engineering education is found in all sorts and levels of those institutions, or in a broader sense of technical education even in the field of the high school system, where there are some activities in so called pre-engineering programs.
Sometimes the engineering education is isolated from the other academic studies, especially in the institutes of technology, which are very special and sometimes also very close to the needs of a special labour-market. We have also special institutes of engineering education in the field of the armed forces.

But nevertheless the engineering curricula seem to be nearly the same in most institutions. Even in comparison with the German engineering education you will find more similarities: in the first two years a lot of basic sciences and later on a very slight specialization in applied engineering sciences. A real specialization can only be approached in postgraduate studies and there are lots of different curricula, often related to the special or traditional emphasis of an institution or related to the needs of the regional labour-market especially the fields of interests of the nearby industries.

2.1 Recent Trends in Higher Education

In all discussions about the present and the future of the system of higher education, there is one dominant factor: the expected declining number of enrollment in all institutions of higher education, especially in the next decade. One of the last publi-

cations of the Carnegie Council about the future of higher education(4) reckons with a decrease of 5-15% of total student enrollment for the next ten years. Depending on the supports, funds and gifts mainly related to the total number of students, the institutions of higher education are pressed to compete against one another to get more students. So there are many programs to attract new students, especially that type of programs for the so-called 'nontraditional student'. One expects a growing number of minorities, women and adults in the system of higher education, attracted by special programs and supported in their specific interests.
In the field of the undergraduate programs there is more attention to the area of preoccupational courses, vocational courses and career development courses and also a growing number of study programs leading to a professional area.

In the graduate programs the number of part-time students is rising, often there are significantly more foreign students than in the undergraduate programs trying to gain high degrees in education and there are also a lot of courses in continuing education for adults already working.

Some institutions and very often the community colleges or junior colleges are engaged in special supporting courses for "high-risk-students", handicapped students or disabled persons. Also the number of students who need "remedial education" has grown constantly, due to the fact that the total ratio students/nonstudents of each vintage has risen markably. In some cases the average decline in the scores of the Scholastic Aptitude Test is 9% during the last decade. That may be also an effect of the liberalisation in the high school system, but also an effect of the total increase of participation in education: if you have a higher percentage of students of the same age, you must have a decline in the average abilities and skills. So those programs are also mostly related to an educational policy of equal opportunity and promotion for the weaker students.

Surveyors of the status of higher education in the United States see some general tendencies and trends and also some problems. On another place (see(34)) we have given an overview in an outlined manner, here we will give only some summarized remarks:

- tendency of increasing support and funding of higher education by the states and the Federal Government instead of self-support;
- raised interests in evaluation, efficiency improvement, and planning, programming, and budgeting of higher education;
- problem of declining numbers of students;
- tendency of more and more bureaucracy and governmental regulations, loss of academic freedom and autonomy of colleges and universities;
- stiffening processes among the faculty staffs because of shrinking opportunities of universities to create new faculty positions due to shrinking funds;
- weakening process in scholastic aptitudes of freshmen as one unwanted result of the open-admission-policy;
- growing numbers of such "nontraditional" students as minorities, female students, and adults;
- shrinking interest in graduate courses because of good chances for Bachelors (B.S.) in the job market for engineers;
- problems of financing higher education in times of inflation and less enrollments.

Some of these tendencies and problems are also existing in special forms. We will discuss the special problems and tendencies in engineering education in the following chapter.

2.2 Development in the Field of Engineering Education

Formal education for engineering in the United States began during the early 19th century with the establishment of curricula at the United States Military Academy. Civil engineering, mechanical engineering, electrical engineering, mining and metallurgy, chemical engineering, industrial, agricultural, sanitary, and such specialities as ceramic engineering, textile engineering, nuclear engineering, and aerospace engineering have followed, some appearing only recently. In the last decade cross disciplinary programs such as biomedical engineering, environmental engineering, computer engineering, and systems engineering have emerged.

Over the past 175 years, engineering education has undergone three major phases of transition, though hardly distinguishable by precise boundaries.

(1) The empiricism phase - transition from apprentice training to formal training and creation of engineering schools (late 19th - 20th century).
(2) The engineering science phase - approach of engineering education to science and major development of graduate studies in engineering (following World War II).
(3) The socio-technical phase - application of engineering methodologies to a broad spectrum of societal problems; development of interfaces between engineering and all other societal activities (beginning in the middle and late 1960's).

During the last phase, epitomized by the creation of IRRPOS (Interdisciplinary Research Relevant to Problems of Our Society) in 1969, and RANN (Research Applied to National Needs) in 1971 within NSF, engineering research activities have begun to broaden from those based purely on math and science to those that are "applied" and more socially relevant. Engineering education, too, is beginning to interface more with society at large. More and more programs, research or educational, are directed at the socio-technological interface. In the last five years, for example, foundations such as Sloan and Carnegie have funded the establishment of such multi-disciplinary programs.

The development of interfaces between engineering and other professions, particularly those of humanistic and societal relevance, is the beginning of a new form of liberal education in engineering. Movement toward interfacing engineering with law and the legal profession, with medicine and health care delivery in the U.S., with management and administration, business or governmental, with problems of national concerns and policy, with humanities and social sciences to the extent of establishing a new program in "social engineering " and with a whole host of other professions appears upon the scene.

In his study of engineering curricula between 1946-1947 and 1966-1967 Roy observed that in 1947-1967 the curricula or nearly all engineering schools in the U.S. could be represented by like patterns of course specification and credit requirements. This is still true. One reason for this, undoubtedly, are the ECPD requirements for accreditation of basic level engineering curricula. In 1973, 225 of the 280 engineering colleges offered ECPD accredited programs at the baccalaureate level(22). The specific requirements for these programs are as follows:

(1) Minimum of one full year of math and physical science
(2) One year of engineering science
(3) One half year of design
(4) One half year or more of humanities and social sciences (excluding industrial management, personnel administration, finance, and business). (1)

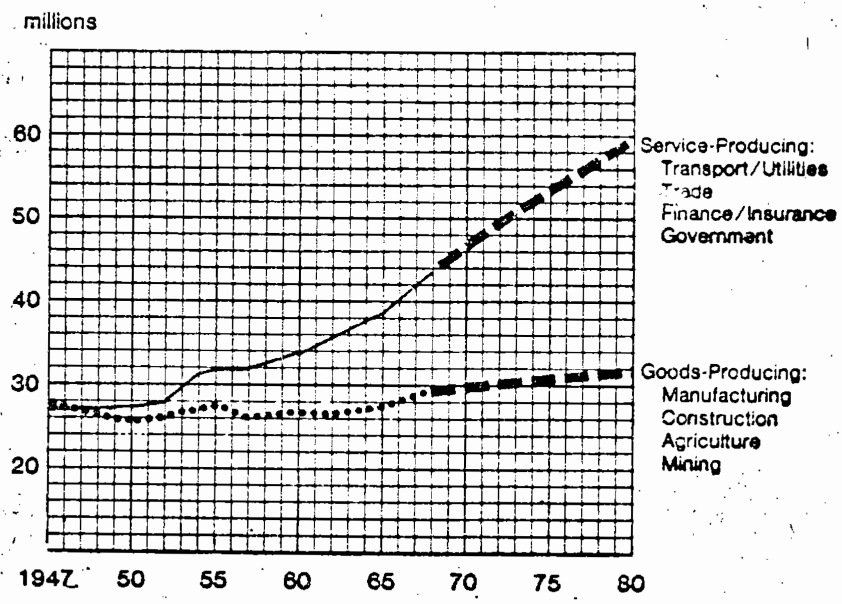
Other surveyors of the recent trend see mainly the influence of governmental research policy as a determining factor for engineering education (e.g. the ASEE(2)).
They argue, that engineering education in the post-war period has been heavily influenced by governmental funded noncivilian research-work in the field of "high technologies"(defense, health and space programs), mostly in large scale projects.

But things have changed and the growth of this type of research and development has stopped.

Some other changes also occured:
- change of the relationship between the production of services and that of goods:

Fig. 2.:

Employment Trends in Goods-Producing and Service-Producing Industries: 1947 - 1980 (projected for service economy, 3% unemployment)



Source: "U.S. Economy in 1980" Bureau of Labor Statistics.

- the rate of productivity growth has been lower than in other major industrial nations;
- Rising costs for imported raw material and energy, and
- "Changes in the way in which Americans look at their world are becoming important to engineering and promise to become even more so in the future, not only in concern for the environment but in a general concern for the quality of the goods and services available. The modern <u>environmental movement</u> is only about 11 years old, but it has already had a big effect on both engineering practice and education. The rapidly increasing concern on the part of the consumer about the quality, safety, and reliability of the products he buys also will have an effect on product design"(2).

A short review of the recent history also unveils some further trends:

" The period following World WarII was characterized by the almost universal acceptance of the science-math based engineering degree program. The curricula that had developed by the late

1960's were more scientific than empirical, more content- than process-oriented, more theoretical than practical, more analytical than experimental, more specialized than general, with emphasis on analysis rather than synthesis or design, and on basic rather than applied research.

The development of engineering education during this period converged in other ways. Engineering degree programs were developed in a small number of disciplines (civil, mechanical, electrical, etc., and usually in a one-to -one correspondence with a department) and were much alike from one institution to another. Courses with virtually the same content were arranged in the same sequence and were taught by the same techniques. A student in a given discipline did much the same thing in the same way in one institution as his contemporary in another institution.

Aiding this convergence was the wide acceptance by engineering educators of the ECPD criteria for accreditation. By 1973, there were about 280 engineering colleges of which 225 offered ECPD accredited programs at the baccalaureate level. Many of those not accredited aspired to be and had designed their programs accordingly. ECPD also encouraged the upgrading of faculty by hiring only Ph. D.'s and, as mentioned above, since most Ph. D.'s are graduates of a few research oriented universities, a further contribution to uniformity was made.

During the postwar period, credit hour requirements for baccalaureate degrees in engineering were reduced. Several Schools which had adopted five-year baccalaureate programs abandoned them and many schools brought the number of required credit hours more in line with those in the liberal arts. Reasons included putting engineering into a better competitive position with science programs and permitting more effort to be devoted to graduate programs. In reducing the credit hours, however, something had to give, and generally, it was application, while theory was retained.

Unnoticed by most engineering educators, a gap was created in the supply of technical manpower by narrowing the role of engineering education to include only science-math based programs. Into this gap moved community colleges, technical institutes, and some four-year institutions with two- and four-year programs leading to associate and baccalaureate degrees in engineering technology and industrial technology. Industry, hiring according to its needs, filled many jobs formerly filled by engineering graduates with graduates from these programs.

Engineering technology and industrial technology programs have been growing up largely independent of, perhaps in spite of, engineering colleges, although there are notable exceptions. More recently, some engineering colleges have embraced engineering technology for reasons ranging from well-thought-out plans to reintegrate the profession to desperate moves to increase enrollment by any means. Other engineering colleges have spurned the movement as beneath their dignity. ECPD has embraced engineering technology by offering to accredit programs although by different criteria than engineering. Industrial technology programs are accredited by a totally separate organization and seem likely to stay outside the scope of most engineering colleges.

A more recent movement to broaden traditional engineering programs has been the development of interdisciplinary degree programs which often interface with areas not normally associated with engineering. These programs permit students to cross departmental boundaries selecting courses from any department that meet predetermined but individualized career objectives. An engineering student may combine discipline areas in engineering, prepare for graduate work in medicine, law, or business, or combine political science, economics, or psychology with engineering. Some of the most exciting work is occurring at the masters level where nonengineering undergraduates are participating in engineering programs or where undergraduate engineers and nonengineers are studying public or social systems together for degree programs in policy or planning.

The success of such programs has influenced more traditional discipline-oriented programs to increase flexibility. Long course sequences with interlocking prerequisites have been shortened. Options and free electives have replaced some required courses. New teaching techniques, course organizations, and grading systems introduced flexibility even where course requirements have remained rigid.

Just as interdisciplinary efforts and moves toward more flexibility are picking up speed, ECPD has stepped in with its plan for advanced level accreditation. The criteria for advanced level accreditation extend to five-year programs are much the same definition of engineering that now applies to four-year programs. Concerned about overemphasis on analysis at the expense of design, ECPD has chosen to strengthen the design requirement somewhat but otherwise the criteria are very much the same. Many schools, now alert to the narrowness and uniformity resulting from widespread acceptance of the four-year criteria, oppose advanced level accreditation. They argue that it is at best unnecessary and at worst harmful because it would tend to stifle attempts of engineering to respond to rapidly changing societal needs. The issue is whether some of the most exciting technically based programs developing in engineering colleges will remain in or be forced outside the scope of ECPD-defined engineering education.

Another trend toward breaking the lockstep of uniformity in engineering is the continued growth of co-op programs and the evolution of new programs requiring industrial internships and other forms of industry-college interaction. Students, perhaps more than the professors, have appreciated the need for a closer integration of education with practice and have supported these programs enthusiastically. New avenues of industry-college interaction are being sought."(1)

2.3 Three Ways of Engineering Education

Highly qualified manpower in the field of engineering and technology can be roughly divided into two groups:
Engineers and technicians. Especially in the United states with its emphasis on professionalization, only the graduation after at least 4 years study at university or engineering college entitles someone to call himself an professional engineer. Junior technical college or community colleges are educating therefore only so-called 'semi-professionals', who are gaining only an associate degree. In Germany we have had and have still another division among the group of engineers: one type of engineer is qualified for mostly research-oriented work by a fully academic study, another one is more trained to fulfill jobs in close relationship to production within a "short-cycle-education"-program lasting three years. Beside this we have the technician for assistant work.
This second division within the group of engineers seemed to be fairly unknown in the US as the two following definitions prove. One definition describes the fully academically educated engineer, the other one the engineering technician. These two types of engineers are mainly discriminated by their relationship towards either research and development or practice and production.

First definition:

"A Professional Engineer is competent by virtue of his fundamental mental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending, managing, and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others. His education will have been such as to make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information, and applying it independently. He is thus placed in a position to make contributions to the development of engineering science or its applications. His education and training will have been such that he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch. In due time he will be able to give authoritative technical advice and to assume responsibility for the direction of important tasks in his branch." (13)

Second definition:

"An Engineering Technician is one who can apply in a responsible manner proved techniques which are commonly understood by those who are expert in a branch of engineering, or those techniques specially prescribed by professional engineers. Under general professional-engineering direction, or following established engineering techniques, he is capable of carrying out duties which may be found among the list of examples set out below. In carrying out many of these duties, competent supervision of the work of skilled craftsmen will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a task in the light of well-established practice. An engineering technician requires an education and training sufficient to enable him to understand the reasons for and purpose of the operations for which he is responsible. The following duties are considered as typical of those carried out by engineering technicians:

Working on design and development of engineering plant and structures; erecting and commissioning of engineering equipment and structures; engineering drawing; estimating, inspecting and testing engineering construction and equipment; use of surveying instruments, operating, maintaining, and repairing engineering machinery, plant, and engineering services, and locating defects therein; activities connected with research and development, testing of materials and components, and sales engineering, servicing equipment, and advising consumers."(13)

But nowadays there is a growing demand for a third type of engineer with not only highly developed technical qualifications but also nontechnical abilities in other fields related to economic, sociological, medical, managerial, political or legal affairs. Following this demand a third way of engineering education has been developed, and we find it under the name of the so-called "technologist" - programs. The ASEE has given a proposal ((2)) for that kind of program with the following founding:

"The Need for a New Program

The basic conclusions derived from an examination of existing conditions are:

1) the problem/ solution orientation of engineering has important applications in the area of nonphysical as well as physical system;
2) engineering education now fails to introduce students adequately to the design process, particularly to the design of sociotechnical systems, or to integrate study of social, legal, and political systems or of the arts into their technical education;
3) a Bachelor of Science degree in engineering is being viewed more and more as a professional degree with the majority of those who wish to practice engineering continuing through a master's program;
4) a broad technical education should become increasingly attractive as preparation for one of the nontechnical professions or as an alternative to a liberal arts education."(2)

2.3.1 The Theoretical/Scientific Approach

The American industry depends mainly on exporting higher sophisticated products to other countries with lower technological standards. One can hear the word from a "fourth industrial revolution" or a "third wave", that means that the U.S. industry has reached now a point, where a change from mass-production of industrial products towards the development of mostly information-processing devices is going on. The U.S. has the highest growth rate in the fields of data-processing and also a lot of attempts in research and development in that field. The most engineering education programs are closely related to those fields and to other fields, where the use of higher sophisticated technology is common as in the aerospace industry and even in the fields of production, maintenance and manufacturing.

So Institutes of technology (mostly private) like MIT (Massachusetts Institute of Technology), or Caltech (California Institute of Technology) have programs of engineering education with a very high emphasis on research and development of new technologies. They are very selective, so that they can work with very bright students and on very demanding programs. Some of them accept only students in higher classes and have no freshman or junior classes. In special programs like UROP (Undergraduate Research Opportunity Program) at MIT the student can participate in the research programs of the faculty members so he can make his first experiences in the field of science and research. The professional goals of the students are to be a researcher or a professor. The relationship to the workplaces in the field of producing industry is very loose but for some students there are opportunities in so-called 'internships', mostly provided in cooperation with firms, factories and offices with a high emphasis on research and development. The students often make their master's thesis in projects of practical relevance or in the field of advanced research.
The typical undergraduate program curriculum appears very similar to the curriculum of the German Dipl. Ing. with a little bit more basic orientation.

But there are already some critics against those 'traditional' programs. In a study of the ASEE we found the statement, that one can see two general shortcomings in that kind of engineering education. The study-group came to two conclusions:
"The <u>first</u> is that engineering education, as traditionally defined, occupies a much too narrow role in the total spectrum of technically oriented education needed by today's and tomorrow's society. The rigorous, science-based programs characteristic of the past quarter century must be augmented to take account of social changes, changes of the engineer's role in society, changes in individual values, and newly emerging national concerns such as energy and resource conservation, environmental quality, urban design, and other problems interfacing technology and society.

The engineer's education must emphasize affective as well as cognitive skills, methodology and process as well as content, specialization not at the expense of generalization, and analysis in the context of synthesis. Above all, it must be one which produces engineers able to work with others in complex and controversial situations, engineers imbued with a sense of national concern and social responsibility, not only as human beings but also as engineers engaged in problem-solving.

The most pressing present need is to lift and broaden the horizons of engineering curricula and of the engineering educators responsible for the design and implementation of these curricula.

The second shortcoming has to do with the nature of the educational process itself. We feel that society and technology change so fast, the educational problem is so complex, and the need is so great, that engineering degree programs that prepare a student for career entry can only do a part of the job. We see, therefore, the need for a much greater emphasis on the continuing education of the engineer as a professional and as a person after career entry."(1)

The solution for the first problems has been seen as change from traditional engineering education towards a more liberal version of the theoretical approach and for the second problem by emphasizing "recurrent education" for engineers as a life-time of learning.

Other proposals prefer the idea of "biased qualifications" as built up by a first Degree(B.S.) in an engineering field and an additional specialization in a nontechnical major like business-administration, medicine, management or others.

2.3.2 The Cooperative Education for Engineers

Other institutions of engineering education provide more practical oriented curricula, for there are also a lot of work places for engineers in the fields of production, manufacturing and maintenance with close relationship to the materials-technology, the planning of production, the guidance of manufacturing processes and the construction or design of new products. Those fields need engineers with more interests and abilities and emphasis on the more practical aspects of the profession.

Just as industrial experience should play a greater role in the standards of faculty preparation, industrial experience should play a greater role in the educational process itself. Students should have far greater opportunities for meaningful experiences in the world of work as a part of their formal engineering education. Besides the learning value of direct experience, the improvement of motivation for regular course work plus the chance for career selection and/or exploration are especially important.

Industrial internships are gaining favour as part of the degree requirement, particularly in some graduate programs. Project courses, often in direct cooperation with industry, are multiplying. These efforts should be encouraged as beneficial to the personal and professional development of the student.

So there is a number of institutions with a higher emphasis on the relationship between the workplace of an engineer and his education. One of their objectives is also to get students with some practical or vocational experience. So some institutions of higher education, mainly in the field of engineering education and also in other fields, have planned and organized the so-called 'cooperative education'. These programs are flourishing. In baccalaureate engineering programs, the number of schools offering a cooperative curriculum has increased from 27 to 153 between the years 1950 and 1970. Not all industries are willing to support such programs, but those that do, cite the following reasons for their participation: facilitation of recruitment, enactment of cooperative responsibility, productivity of student employees.

In these programs the student not only has his program in the university, but also has to go into the field of practical work. In these internships he will make experiences he can never have in the formal system of education. The first programs are very old (since 1906 in the University of Cincinnati, see chpt. 3.4) and have begun as work-study-programs where the students shall make experiences in the work-place. Later on not only this educational goal was important for these programs. They are now made up as 'structured experiential learning'. The student can improve his skills in real work situations, he can find out, what 'work' is, he will learn to work together with other persons (interpersonal skills or competences), he will find out what career expectations engineers can have and then he will return to the university with an idea about the importance and relevance of the contents of his formal educational process.

A cooperative engineering program can also provide a key communication link between schools and industry.

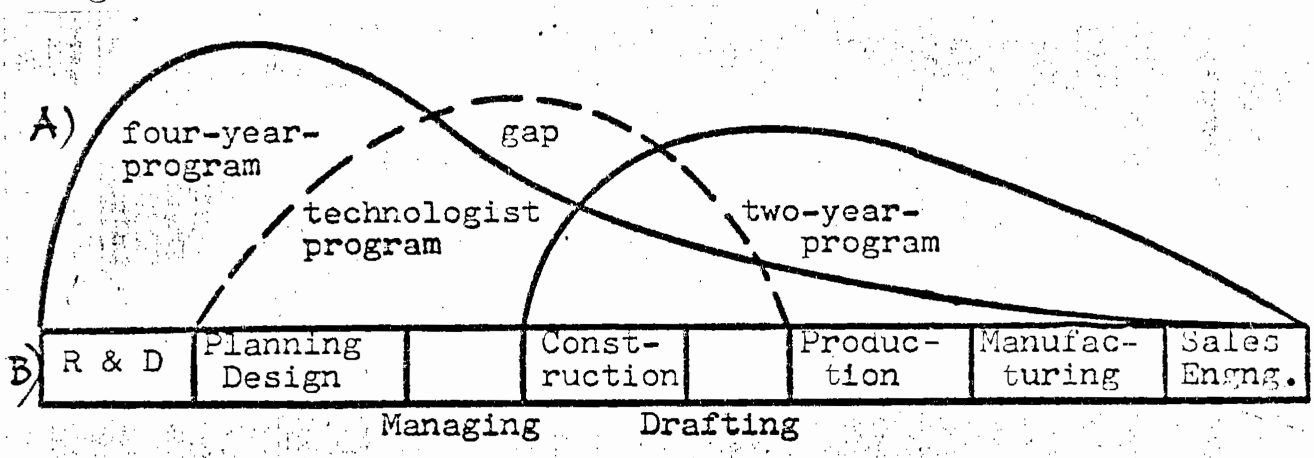
A further use of cooperative education is to increase minority enrollments in engineering. Many industries are particularly receptive to such programs as vehicles for affirmative action.

In some institutions these programs are mandatory for all students, but in others they are optional and there are differences in the educational goals between the different institutions (see chpt.4) but in general we can say that this is a second way of engineering education with a more practical(and sometimes even vocational) orientation in competition with the classical or traditional way of scientific and research-oriented engineering education.

2.3.3 The Technologist-Programs

The cooperative education programs for engineers are in their curriculum very similar to the traditional programs, the difference lies only in the internships during the studies. But there is a need for other qualifications for specialized engineers. It is a need of the labour market for there is still that gap between the two-year-programs and the four-year-programs:

Fig. 3:



A) Orientation of Education

B) Work areas for Engineers

In Germany we have the "short-cycle" higher education for engineers in the 'Fachhochschulen' with a program that deals with the more vocational areas of technical work and education. The 'grad. Ing.'(engineer graduate) from the German engineering education is world famous for his special abilities in problem-solving in the field of production, design and maintenance of production plants. In the U.S. there is only the "long-cycle" higher education for engineers (four-year undergraduate programs) or the very short cycle in the two-year colleges with the associate degree that enables the students only to fulfill supporting jobs in the field of technical work. As technicians, the absolvents of an associate degree work at the drawing board, in the manufacturing process and as helpers of engineers but not as engineers themselves. This gap between the professional engineers and the technicians must be filled out especially in the field of management of all those processes related to the fields of construction, design and production-control. Not only in the classical fields of engineering work but also in the field of implementing technical devices in other work areas, for example, in business administration with the invention of new computers and organizational change, a new type of "technologist" is needed.

Some institutions have developed special programs for engineering education in the field of systems planning and management. And there is a tendency to enforce that direction. "In several fields of professional work the thinking of engineers may solve problems for which other professionals are not so well prepared.

As far as we can see (following(1)), there exist two sorts of "technology"-programs:

"a. Programs and Curricula in Engineering Technology

Engineering technology stresses production and applications. Programs in engineering technology, both at the two-year associate degree level and at the four-year baccalaureate degree level, and both accreditable by ECPD, have grown rapidly, particularly in the last five years. As late as 1967, for example, there were only 2 curricula in engineering technology at 1 school, accredited by ECPD at the baccalaureate level and 193 programs at 61 schools at the associate level, whereas in 1973, there were 81 programs at 24 schools and 321 programs at 105 schools, respectively. The number of institutions which offer four-year baccalaureate degree programs in engineering technology was reported to be 95. In 1971-1972, there were 22,578 associate degrees and 5,487 baccalaureate degrees awarded in engineering technology compared to 44,190 engineering bachelor's degrees awarded in the country. There were 149,251 students in associate degree and 27,628 in baccalaureate degree programs in technology, compared with 208,876 students enrolled in engineering programs. Technology programs will probably continue to increase in the immediate future, due to increased recognition and an improved employment picture.

b. Programs and Curricula in Industrial Technology

Four-year baccalaureate degree programs in industrial technology have appeared in the last fifteen years. While the engineering technology graduates support engineering, the industrial technology program emphasizes production management and operates on the interface between engineering and business administration. In a sense, it fills a need once filled by industrial engineering

Programs.

The typical industrial technology curriculum contains about 50 % mathematics, science, and technical courses, while the engineering technology program has about 70 % in these areas. The industrial technology curriculum has several business type courses, much like the four-year engineering curriculum of 20 to 30 years ago. Industrial technology programs are accredited by NAIT (National Association of Industrial Technology)". (1)

3. The Concept to integrate Theory and Practice

One of the most recent issues in higher education is the issue of 'experiential learning' related to the idea of joining theory and practice. The leading idea is to give the possibility of work experience within the curriculum in higher education. A lot of programs are following this idea as:

- teaching occupational and paraprofessional subjects (mostly performed in the community colleges),
- apprenticeships and internships during the studies,
- cooperative education (more than 1100 colleges now),
- crediting precollege activities(crediting life experience),
- career education, and others.

The idea is to give credits not only for the duration and attendence in academic studies but also for real experiences in the world of work or in simulated situations with the same tasks like in practical work. Emphasis is not only laid on the participation in productive work but also in the development of so-called 'interpersonnel skills' and abilities to work together with other people in groups in factories and business.

Theoretical and analytical, methodological, and contentional problems to realize those programs arose mainly from two areas:

- the development of adequate measurements to judge about the learning achievements in the work-field and
- development of methods to evaluate the success of programs in this field in comparison to other more 'traditional' curricula in higher education.

A lot of work in this field has been done by a large joint-venture research-project, called CAEL(Cooperative Assessment of Experiential Learning), which was conducted by the Educational Testing Service together with about 160 Colleges, funded by the Carnegie Foundation, the Ford Foundation and the Lilly Endowment in the years 1974 to 1977.

Our view is more narrow and closer related to special programs, which are in the field of cooperative education with experiental phases in the 'real' world.

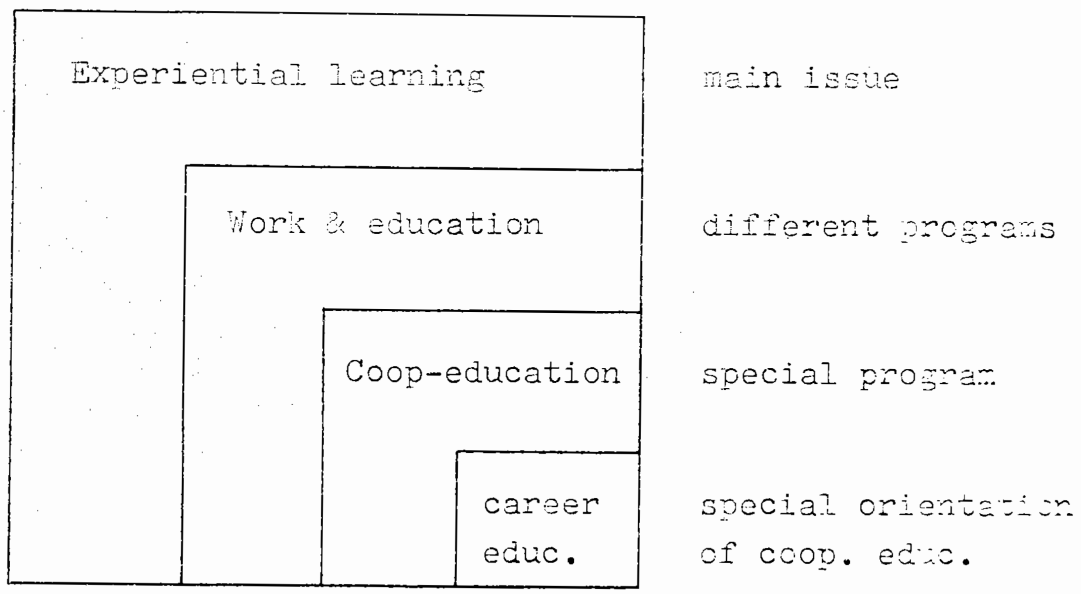


Fig. 4: Field of Activities for Linking Theory and Practice in Higher Education

3.1 Experiential Learning Objectives

A learning program that accommodates the upper levels of the learning hierarchy has the potential of accommodating and enhancing a large inventory of skills and attributes that are valued in a professional education. Each of the following are skills and attributes that can be reinforced by a well-designed experiential learning program:

- problem-solving skills
- interpersonal awareness
- creative expression
- communication skills
- technical skills
- self-confidence building
- computation skills
- engineering fundamentals
- organizational skills
- leadership skills
- professional ethics
- engineering judgment

Any combination, or all these skills, can be program objectives when designing an experiential learning activity. They, in fact, represent a rather definitive attribute inventory for defining the desired competencies of a graduate engineer.

All of these skills are valued for succeeding as a professional. All must be learned by involvement and experience. All are the interactive, interpersonal, communicative skills that an engineer must attain to be a successful achiever.

Typically, these skills are acquired "on-the-job" after schooling and the obtained degrees of proficiencies are randomly scattered and essentially accidental. These functional attributes are usually not consciously set as learning objectives within engineering degree programs. Yet, all are as essential to success as the technical skills of the engineering disciplines.

An experiential learning activity can be designed to assure that the students have an opportunity to develop these attributes. The advantage of involvement during schooling is the opportunity to critique and diagnose the outcomes, "close-the-loop", and reinforce the successes.

3.2 Patterns of Involvement

The various models of experiential learning activities group into two classes: simulations, and authentic involvement. Simulations consist of contrived situations that are carefully designed to meet selected learning objectives and are under close faculty control. The authentic involvement activities expose the student to real situations with totally open-ended outcome, although the faculty may influence the selection of the situations and set performance criteria to assure that positive learning objectives are met.
Simulated experiential learning activities are almost totally classroom or laboratory based, originating with and managed by the faculty. They are a widely used learning activity. Thus, several models have emerged:

a) Experimental laboratory - This is the most common model of experiential learning. Basically,it involves an investigation either totally contrived by the instructor or jointly developed by the students and the instructor. It essentially focuses on or is limited to a particular apparatus, system, or instrumentation that is available or can be readily assembled in the laboratory. The activities may include testing new products, trouble-shooting operational problems, designing and developing apparatus or instruments, exploring an idea, investigating the effects of parameter changes on a system, etc.

b) Guided design - This is also a widely employed learning activity. It is centered on an instructor-contrived design situation. The students are involved in conducting a study and developing a solution. The solution may range from conceiving some feasible alternatives to the development of a complete design including analysis, dimensional synthesis, and shop drawings. Involvement ranges from step-by-step guidance by the instructor to achieve a predetermined solution to an open-ended competition between student teams judged by panels of practicing engineers. In all cases, the instructor establishes an explicit set of activities and criteria to assure specific learning outcomes.

c) Case studies - Patterned after the case study methods pioneered in the management schools, these activities involve a role-play wherein the students are placed in a similar design situation to that of engineers in a real company. After the students have arrived at a solution, their decisions, results, or proposals are compared to the solution that was actually adopted by the company that had the problem. The instructor may draw upon a library of elaborately researched and documented case histories in the literature or develop case histories in the literature or develop cases from his own or colleagues' industrial experience.

d) Games - These activities involve live, interactive participation in continued simulations of design situations. The essential characteristic is that it simulates the dynamics of real situations by introducing additional parameters, constraints, or outcomes at each decision point. The simulator may be the instructor, or a team of instructors who provide the data dynamics, a computer model, or a game apparatus where new data and consequences are introduced by random techniques (roll of dice or drawing cards, etc.). The students may be in competition with each other to achieve the most favorable or desired outcome. The use of elaborate computer models has increased the potential of this type of experiential learning by providing a wide range of alternatives at each step based on rational data or computations.

Authentic involvement activities are drawn completely from real, live, on-going situations. It always involves a "client" who has a real need to obtain a solution that has not yet been determined. The clients may be an industrial firm, a governmental agency, civic organization, an institution, or a private individual. The student may do all or part of the work on campus, or may be involved in periods of on-site activity, or full employment during the study. It may vary from a required, work experience with no faculty involvement to a total degree program commitment replacing all formal course work.

The most common and widely adopted authentic involvement activities in engineering have been the alternating work and study programs. The best known are the classic cooperative education or "co-op" programs. There is, however, an increasing interest in other models of "real" involvement that has produced several innovative alternatives, including:

a) Internships - an on-site apprentice activity under the direct supervision of a practitioner in the discipline. It usually involves a specified period of time with employment status while on leave from the academic program.

It usually has little or no faculty involvement, academic content, or course credit. The placement of students is usually done by professional advisors who monitor the work experience to insure it meets the overall objectives. Internships are a required activity in health and teaching. They are optional in engineering, varying widely from a few weeks summer employment, or several "work" sessions per week during one term, to alternating work and campus terms throughout a five-year period.

b) Consulting - this class of activities involves a campus-based, faculty supervised, problem-solving experience, where all problems are solicited from an outside client. Students may be assigned to work on the problems individually or in teams. There is no student employment involved. The client may be asked to support minor direct costs, such as phone calls, clerical expenses, and one or more student site visits. The students are in a role of a professional engineering consultant, the faculty in a role of "chief engineer." The project assignments may extend over more than one term but are usually confined to what can be done in one enrollment period. There is no obligation to provide an acceptable solution or meet any client deadline. The students present a written and oral report to the client at the end of the term with whatever results they were able to obtain.

c) Clinics or design centers - this is an on-campus, faculty administered, funded enterprise to undertake Engineering studies for sponsor-clients. It is an engineering design activity similar in operation to graduate level sponsored research projects. The clinic or center negotiates contracts to deliver a specified design, or study, or problem solution. Students may be involved in all phases from proposal writing and contract negotiations to delivery of the final report. The funding may support all direct and indirect costs of the project although the students usually are not employed by the project since they receive course credit. The faculty has direct responsibility to the client to assure that contractual obligations are met.

3.3 Patterns of Operation

Experiential learning programs by their nature provide an open-ended opportunity for innovative operational styles. The overall objective of creating a broad spectrum of experiences for the student also provides a creative opportunity for the faculty in developing the entire package. Thus there is no standard operating procedure. Each is custom tailored to the circumstances surrounding the type of experience the model is to provide.

The simulation models tend to follow the classical academic procedures used for laboratory classes - i.e., regularly scheduled weekly class periods, instructor supervised activities, individual and team assignments, with most of the student's work accomplished during lab hours.

Since the authentic involvement models involve open-ended, unstructured activities, originating off-campus, the patterns of operation and student involvement may vary considerably. There is less need for faculty-dominated class meetings and organized activities. Most of the work is self-scheduled and self-paced by the students as demanded by their project. The involvement is more like an engineer's work pattern than a student's work pattern. The faculty member's role is more managerial and advisory than instructional.

How much experiential learning activity a degree program should contain is the source of great debate and perhaps some controversy. Some of the most innovative models are totally experiential with no formal courses or curriculum. The co-op programs at the other extreme have little, if any, course involvement in the curriculum. Other programs may vary in credit-hour allocation from a minimum of two lab credits at the senior year to one or more course equivalents each term. The underlying objective is to provide a demand-to-know and a growth experience.

There is no "too soon to start" time since experiential learning begins at birth. The programs that employ experiential learning activities every year structure the rigor of involvement to match the levels of maturity as the student progresses. The existing programs demonstrate that it is possible to substitute experiential learning activities for formal course activities and still achieve the necessary and desired learning outcomes.

The student in experiential learning is subjected to a strong demand for self-management. The objective is to enhance enterprise, initiative, self-reliance, and resourcefulness by creating an environment that demands it. The activity schedule must be flexible enough to allow the student to plan and choose to suit his own needs and abilities as well as the demands of the project.

The role of the faculty member is primarily supervisory and advisory. He must manage the program to assure that the learning environment provides the opportunities for the student to gain the appropriate experiences to meet the desired objectives. Beyond that he should serve only as a consultant to the students and an evaluator of achievement. His role should be quite similar to the role he plays as supervisor of graduate students engaged in sponsored research.

One of the most important responsibilities a faculty member has is evaluation of performance. Evaluation of performance in experiential learning is far more challenging than in formal instruction. The very nature of the activities emphasizes performances that will inevitably demand subjective assessment. Two needs must be served: to provide an on-going critique and reinforcement (feed-back), and to provide a terminal assessment of competency and accomplishment(closure).

There are two basic principles that must be employed in conducting the evaluation process: define the learning outcomes to be achieved, and state how the rating or assessment will be determined. The greatest sin of all is to keep it a secret from the learner.

Since this type of learning is so complex and the outcomes are essentially performance-based, it will be necessary to rely on the subjective opinions of as many observers as possible.

Rating sheets, listing all the attributes to be assessed, should be periodically solicited from the student's teammates, from the supervising faculty and clients, including a self-assessment from each student. Periodic written and oral progress reports should be critiqued by panels of students, faculty, and professional consultants and/or clients.

The terminal competency assessment should provide two kinds of information: a profile of the student's relative abilities in the various performance attributes defined for the learning experience, and an overall summative ranking or judgment of his contribution and ability to do. The profile is a collective judgment of operational strengths and weaknesses. The summative judgment may be a ranking in his class, a letter grade, or some defined index of relativity to compare him to his competition and gauge his potential.

An effective assessment system is crucial to a successful experiential learning-program. The most useful guideline to use in constructing an effective evaluation procedure is to equate it as closely as possible to the techniques and procedures associated with good management practice in industry. The crux of these procedures is that both employer and employee are in the act - both agree on the ground rules - and both contribute to the process.

3.4 Cooperative Education

In our study this area of practice-oriented curriculum should be described more in detail for its importance and size has remarkably grown over the last 60 years. This type of educational programs is very similar to so-called "sandwich-courses", as we call it within the European discussion: phases of academic study are interwoven with phases of learning within real work-situations. The importance of this program is due to two main aspects:

- The high magnitude of involvement into practical work outside university is not only uncommon, but also very typical for a country where pragmatic thinking was and is mostly preferred against sophisticated and/or very idealistic or principly founded solutions- in my opinion we find here a typical American program.
- Programs of cooperative education are now provided by nearly 1200 institutions of higher education within the USA. The idea has grown up meanwhile towards the status of a 'movement': its followers and protagonists have formed an association, they publish their own scientific journal, there are numerous national and international seminars and congresses, the pro - grammatic ideas are transferred to foreign countries, and all supporters are deeply convinced, that these programs have mostly only benefits for their participants. If one considers these facts by tracing comparative studies in the field of higher education, one cannot miss a very close view into the idea, structure, and operation of these programs.

Within these programs especially one point is emphasized: The student should make first professional work-experiences during his/her studies at university. At first this idea was dominated by the consideration, that work during academic studies could provide the necessary income especially for students with lower social background, an idea, which we would nominate as a work-study- program (Werkstudium). Later on these programs have been developed to more and more pedagogic-didactic founded study-activities in the work area, closely connected with the academic curriculum.

As mentioned above, the first program was introduced at the University of Cincinnati in 1906 by Dean Herman Schneider.

3.4.1 Definitions of Cooperative Education

There is a lot of confusion about the different expressions in this field; we will understand the different issues as follows:

- cooperative education: program with work-experience as a structured learning process
- work-study programs: work as experience in itself
- internship programs: formalized work-study programs
- experiental learning: term of educational policy for all programs with emphasis on joining theoretical/academic studies with work experiences.

Even if there are slight differences in the opinions about the sense of coop-ed-programs (so defines LaGuardia Community College its program as "field laboratry" with the goal to apply the skills, learned in the classroom; whereas Northeastern University in Boston should name their program as "field of scientific reflection"), but mainly the definitions are as clearly as follows:

1. definition - "Cooperative education is a unique educational process designed to enhance optimum individual adjustment toward self-realization and career development by means of integrating classroom study with planned and supervised practical experience in vocational, educational, or cultural activies outside of the formal classroom environment". (32)

2. definition - The National Commission for Cooperative Education has established the following definition of cooperative education: "It is that educational plan in industry, business, government, or service-type work situations. The work experience constitutes a regular and essential element in the educative process and some minimum amount of work experience and minimum standards of

performance are included in the requirements of the institution for a degree. In addition, there must be a liaison between the administration of the institution and the employing firm.
The essential criteria are that the work experience be considered an integral part of the educational process, and that the institution take a definite responsibility for this integration.
It is called cooperative education because it is dependent upon the cooperation of employers and educators in combining to form a superior total education program for the students."(35)

3.4.2 The Reasons for Cooperative Education

So far as we can see it, there are two main reasons for the implementation of coop-programs and they have been seen already by Herman Schneider:

"1. Classroom education can never hope to teach all the elements of knowledge required for a successful career in any profession. Practical on-the-job experience with successful professionals in the field is a necessary supplement to classroom instruction.

2. Since the high cost of education is a paramount problem in this country, most students must work part-time while attending classes in order to earn a portion of the cost of their college education. With very few exceptions, these part-time jobs are not related to their career objectives and have little transfer value to the educational program of the students." (32)

3.4.3 The Advantages of Coop-Ed-Programs

In 1961, a national two-year study of cooperative education to determine the validity of its claimed educational advantages was published by James W.Wilson and Edward H. Lyons. The authors see mainly the following advantages:

"Advantages to students

1. Gives Reality to Learning
2. Increases Educational Motivation
3. Develops Greater Social Skills

4. Accelerates Maturation
5. Provides Orientation to the World of Work
6. Provides Financial Aid
7. Provides Useful Employment Contracts

* Advantages to employers

1. Provides A Good Source of Labor Supply
2. Facilitates Recruitment and Retention
3. Permits Better Utilization of Personnel

* Advantages to educational institutions

1. Permits More Effective Use of Plant Facilities
2. Encourages Greater Community Support
3. Provides Benefits to the Teaching Faculty " *)

3.4.4 Historical Background of Cooperative Education

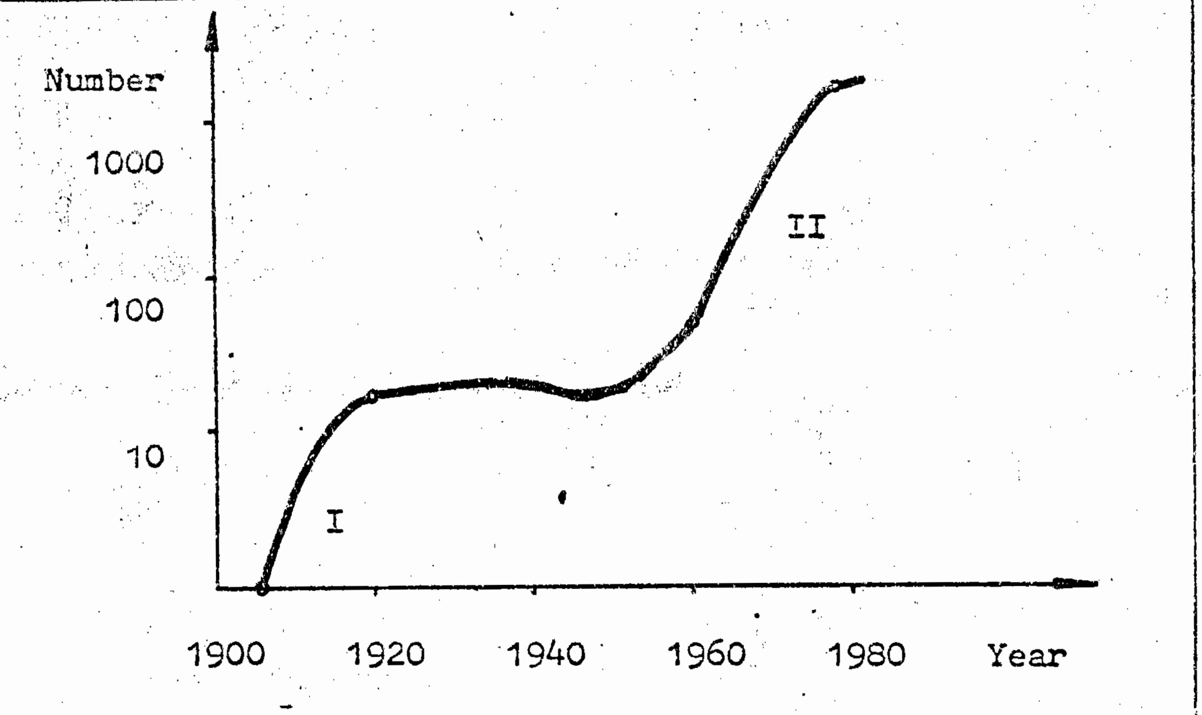
Cooperative education was founded at the University of Cincinnati in 1906 by Herman Schneider. Its first period of growth from 1906 to 1942 was moderate but steady.
Eight out of ten institutions that began the program continued its operation, and by 1942, there were 30 successful programs. Even the severe depression of the 1930's, when jobs were difficult to find, failed to halt the growth pattern.

The second growth period in the cooperative education movement began in 1946, after the end of World War II. During the war years most coooperative programs were discontinued in favor of an emergency acceleration of academic programs. This second period, which has continued to the present time, has been characterized by an acceleration of growth, as the total of participating colleges and universities rose from 29 in 1946 to over 900 in 1975 (see the following figure).

---

*)Complete findings of this study are contained in Wilson and Lyons' book entitled: Work-Study College Programs: Appraisal and Report on the Study of Cooperative Education, New York: Harper & Brothers, 1961, p.240

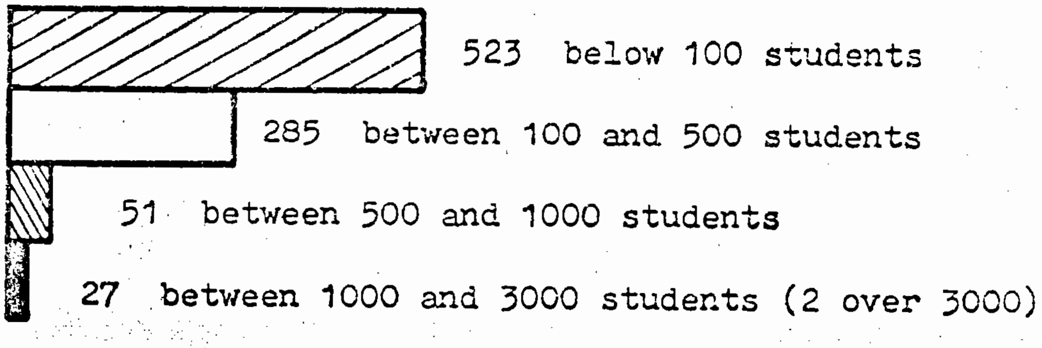
Fig. 5: Numbers of Institutions with Coop. Education



Legend: I. First invention
II. After World War II

<u>Present status</u> - Currently in 1979, there are more than 1100 colleges, community colleges, and universities in the United States offering cooperative education programs to a total enrollment of 225,000 students. Since first-year students are usually not engaged in the alternating work-study phase of the program, these 140,000 students are currently earning a gross income of S 450,000 per year and are placed with over 30,000 employers stretching from coast to coast (see the following figure).

Fig. 6: Institutions with Cooperative Education



Tot. Enr. ca. 180,000 students (1978)

The oldest: University of Cincinnati, since 1906
The greatest: Northeastern University Boston, 8244 students,
University of Waterloo, Canada, 5940 students.

Source: Undergraduate Programs of Cooperative Education in the United States & Canada. Sixth Ed. 1978.
The Cooperative Education Research Center, Northeastern University, Boston, Massachusetts 02115.

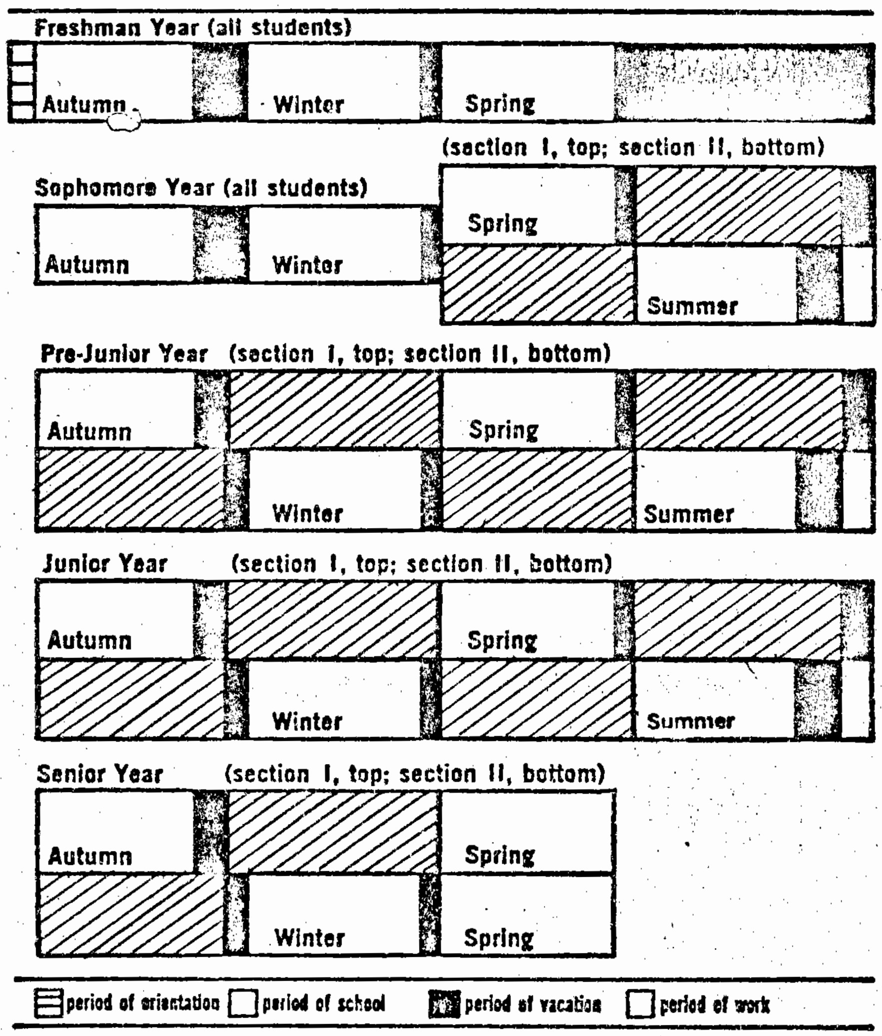
3.4.5 Operation of Coop-Ed-Programs

Basically, the cooperative plan operates as follows: a full-time job is obtained by the cooperative institution in an industrial concern, business firm, government agency, or service -type organization. This assignment is usually shared by a "pair of students," or "two-man team" on an alternating basis. While one student is working on the job, his partner(alternate) is attending classes. At the end of a specified period of time, the students change places. This permits the cooperative assignment to be covered the year round by a pair of students.

Although most cooperative institutions employ the "two-man team" system, it is important to note that this procedure is not a fundamental principle of the cooperative plan. The essential feature is not the pairing of students on cooperative assignments, but the alternation between regularly scheduled periods of off-campus employment and regularly scheduled periods of classroom study at the college (see the following picture of a typical calendar):

Figure 7: University of Cincinnati Professional Practice Program.

Five-Year Degree Program



Source: *University of Cincinnati Bulletin*, 1971, p. 13.

The full-time schooling within the first year also provides time for an effective orientation program as well as preliminary screening of the student's interests, needs, and qualifications for cooperative placement.

Cooperative institutions differ in their administrative and operating requirements because they either offer a mandatory or an optional type program.

The cooperative plan may also be on a contractual basis between cooperative employers and the educational institution. It is also quite common to find the cooperative plan offered in some, but not all, academic departments within a school or college.

There is no basic difference between a cooperative program of education and a conventional type program in terms of academic requirements and course content. However, there are two basic requirements which must be followed pursuant to the role of practical experience in the cooperative program.

"1. Operational factors - The practical experience must be considered as an integral part of the educational process. There must be certain minimum standards of performance included in the requirements of the institution for graduation. The institution must assume the responsibility for integrating the periods of practical experience into the regular educational program.

2. Emphasis on educational values - Educational values must be paramount considerations in the cooperative placement of students in order to facilitate the effective integration of cooperative employment and classroom study. The practical experience should be concerned with a socially desirable activity, and it should be realistic, productive, and progressive in responsibility." *)

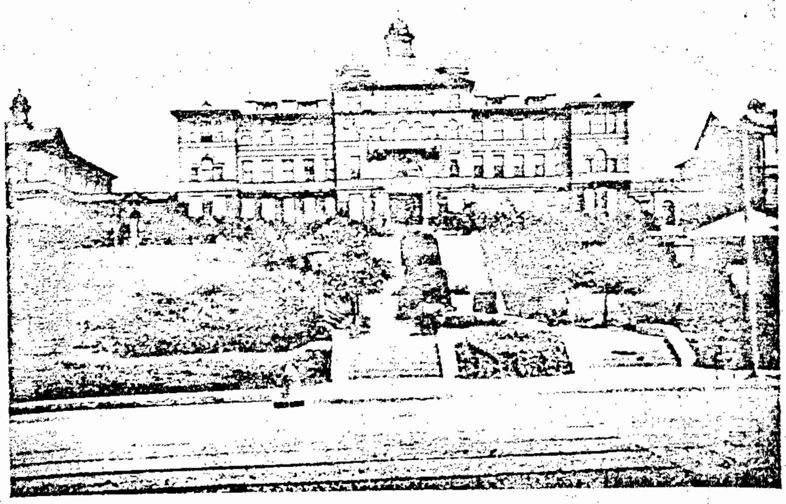
----

*) Wilson, James W. and Lyons, Edward H. Work-Study College Programs: Appraisal and Report of the Study of Cooperative Education, New York: Harper & Brothers, 1961,p.19.

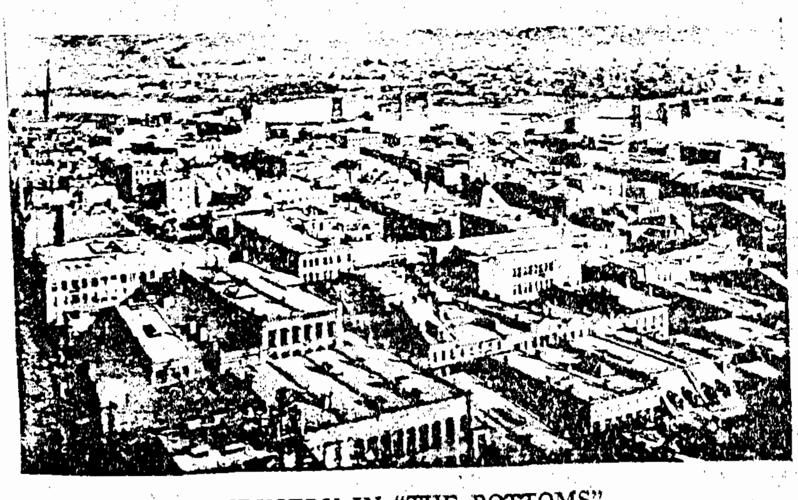
4. Programs for Interaction of Theory and Practice in Engineering Education

4.1 The first Idea, the first Program: University of Cincinnati

In the beginning of this century a professor named Herman Schneider at the University of Cincinnati (at that time Lehigh University) had the idea of joining theory and practice in engineering education while seeing the broad difference between the industry in the "bottoms" and the college on the "hilltop" (as not only an geological formation in the town). As he saw it, his practical question was: "How could theoretical knowledge and first-hand experience be hitched together?"(30)



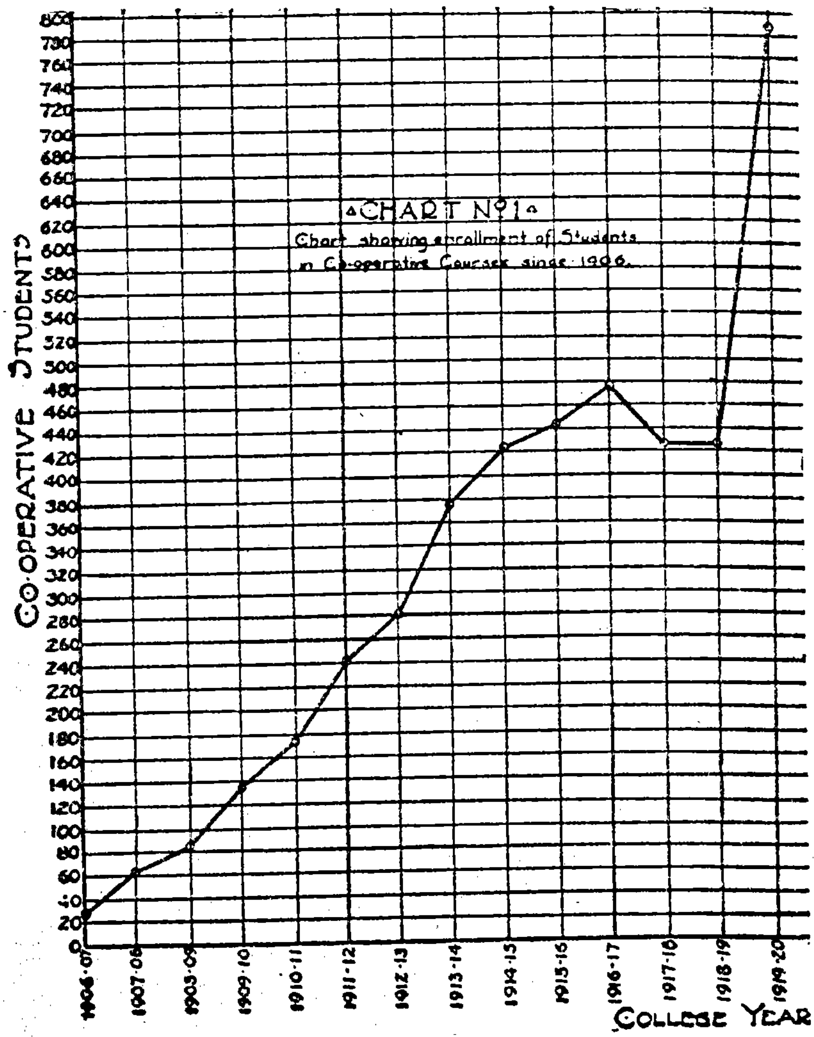
"COLLEGE ON THE HILLTOP"



INDUSTRY IN "THE BOTTOMS"

By answering this question for himself and following the advice of a lot of partners in discussion - mainly out of the field of industry - he developed the plan of 'Cooperative Education'. The plan was realized in the year 1906 and in the following years a steady growing number of students participated in this program. (see Fig.8)

Fig. 8: Enrollment of Students in Co-operative Courses since 1906



4.1.1 Experiences with the Program

Then Dean Herman Schneider revised the running program and improved some weaknesses by the gained experiences. In one of his proposals he wrote:

" Of the advantages to the student, those which had proved most important, were the following:

1. A natural method of arriving at a suitable type of work through:
   (a) Contact with actual industry;
   (b) Practical tests of his own inclinations and adaptability;
   (c) Intelligent participation in the shaping of his own preliminary training. (It should be noted that this kind of academic self-determination is very different from a free elective system, since the wisdom or unwisdom of the student's preference is verified experimentally.)
2. The opportunity of gaining a maximum of educational content from his industrial environment, and hence:
   (a) A vitalizing of his theoretical studies through acquaintance with their practical applications;
   (b) A stimulus toward original investigation.
3. An understanding of the human factor in industry, made possible by:
   (a) Direct labor experience on equal terms with other employees;
   (b) Firsthand contact with problems of labor management.
4. Acquisition of certain disciplinary values as a result of his shop experience, including chiefly:
   (a) The habit of industry;
   (b) A sense of responsibility;
   (c) A feeling of self-reliance.

5. Acquisition of certain economic values, such as:
   (a) An opportunity for partical, or even total, self-support;
   (b) Enhanced earning capacity and bargaining power at graduation in proportion to his outside experience and his consequent advancement beyond the apprentice stage of employment.

ADVANTAGES TO THE FIRM

Even if the employing firm did not receive any recompense beyond a day's work for a day's wages, the existence of the cooperative plan would have economic justification. As a matter of fact, however, there are both immediate and ultimate advantages which make the firm an active partner instead of a mere source of industrial experience. Chief among these advantages are the following, which have to do respectively with personnel and research:

1. By employing co-operative students the firm is constantly and systematically infusing new blood into its organization. The morale of an entire working force is strengthened by the introduction of a few ambitious young employees who are known to be working their way up from the rank. Experience has shown, moreover, that a considerable number of these student employees remain with the firm upon graduation and assume key positions. Thus, whithout the expense of maintaining a training school of its own, and without paying more than the standard cost of productive labor, the firm is able to obtain selected employees, brought up in its own organization and trained by the university for future usefulness.

2. Through the co-operative relationship the firm is served by the university in many ways which would not otherwise be possible. The constant exchange of ideas resulting from the employment of students and from the visits of co-ordinators affords opportunity for the discussion of research problems which continually arise in industry. The student, as he

becomes more advanced in his studies and more familiar with the industry, is called upon to solve some of these problems. In doing so, he draws upon the resources of the university as a whole. Carrying this idea to its logical conclusion, as developments in some colleges illustrate, the university becomes a center for basic research in the larger problems which affect industry as a whole.

ADVANTAGES TO THE COLLEGE

The college which maintains a co-operative course might well be satisfied with the larger service it is able to render to the student and to the employing industry. There are advantages within the school itself, however, that are directly traceable to the co-operative system. These benefits alone provide ample justification for the extra effort which the administration of the course involves. Among the outstanding advantages are the following:

1. Since the students are subjected to the double test of academic fitness and ability to handle outside work, there is more prompt elimination of students who are not qualified to carry on the college course.
2. Owing to the contact which students have with industry descriptive technical matter may be eliminated from the course, affording correspondingly greater emphasis on fundamental principles.
3. By utilizing for educational purposes the modern and complete equipment of large industrial corporations, the university not only affords better instruction but saves the expense of school shops and of illustrative models.
4. The alternating periods of shop and college respectively permit a fuller use of the university plant, since many more students can be accommodated when only part of them are in college at one time.

5. Through its intimate relationship with industry the university finds not only a humanizing influence, but also a perpetual stimulus to research in the basic principles of science."(30)

Dean Schneider also was involved in the early development of evaluation instruments to measure the success of the new educational program. Even today some of this early efforts can be useful in discussing the successes and benefits of co-op programs.
The program is still running and is still very successful. Some other universities and colleges copied the new way of co-op education very fast and underwent also a steady growth that is continuing until now (see chpt. 3.4).

In the co-op education programs very early the administrative requirements led to the way of erecting special academic units within the colleges to fulfill the intentional and organizational needs of the program. Nearly each college or university with a co-op program today has a special office, following the ideas of Herman Schneider, who described the functions and purposes of these units as follows:

"(a) Plans for sequential training in practical work;
(b) Methods of acquainting the students with phases of engineering outside of their particular branch;
(c) Stages of development to be expected in the successive years of study and practical experience;
(d) Types of problems and reports to be looked for in various industries;
(e) Occupations and working conditions best suited."(30)

Fig. 9: Growth of Co-Operative Courses in American Universities

College Year	University of Akron: Co-op.	University of Akron: Regular	University of Akron: Firms	Antioch College: Co-op.	Antioch College: Regular	Antioch College: Firms	University of Cincinnati: Co-op.	University of Cincinnati: Regular	University of Cincinnati: Firms	Georgia School of Technology: Co-op.	Georgia School of Technology: Regular	Georgia School of Technology: Firms
1906–7							27	107	15			
1907–8							61	113	20			
1908–9							84	106	24			
1909–10							138	65	28			
1910–11							176	56	40			
1911–12							239	48	55			
1912–13							294	40	68	12	660	
1913–14							376	30	73	19	712	
1914–15	30	No Engineering Courses on Regular Basis.	10				424	34	75	8	724	
1915–16	43						441	36	82	17	724	
1916–17	53						473	27	86	18	843	
1917–18	52						428	25	85	39	945	
1918–19	132						†	†	†	60	1365	
1919–20	134						787	54	135	114	1425	25
1920–21	135						950		161	117	1551	23
1921–22	141		60	160	49	60	970		208	127	1629	30

College Year	University Harvard: Co-op.	University Harvard: Regular	University Harvard: Firms	Marquette University: Co-op.	Marquette University: Regular	Marquette University: Firms	New York University: Co-op.	New York University: Regular	New York University: Firms
1906–7									
1907–8									
1908–9									
1909–10									
1910–11	Optional For All Engineers.								
1911–12									
1912–13									
1913–14									
1914–15					No Engineering Courses on Regular Basis.		Industrial Engineers Only.	Other Engineers on Regular Basis.	
1915–16									
1916–17									
1917–18									
1918–19				175		11			
1919–20				215		16			
1920–21	31	*31	15	250		22			
1921–22	17	36	8	312		22	35		

College Year	North-eastern College: Co-op.	North-eastern College: Regular	North-eastern College: Firms	Massachusetts Institute of Technology: Co-op.	Massachusetts Institute of Technology: Regular	Massachusetts Institute of Technology: Firms	University of Pittsburgh: Co-op.	University of Pittsburgh: Regular	University of Pittsburgh: Firms
1906–7									
1907–8									
1908–9									
1909–10	8		4						
1910–11	30		8				132		7
1911–12	55		8				171		11
1912–13	70		10				181		16
1913–14	85		13	E. E. Course Ch. E.			249	No Engineering Courses on Regular Basis.	28
1914–15	107	No Engineering Courses on Regular Basis.	14				255		37
1915–16	143		18				231		39
1916–17	160		27				188		32
1917–18	139		37				172		31
1918–19	235		42				180		30
1919–20	407		58	57	3078	5	290		28
1920–21	592		92	96	3436	5	322		30
1921–22	800		133	208	3505	6	334		26

* Includes men on co-operation basis for only part of a year.
† Students Army Training Corps.

[30]

4.1.2 The Program of UC today

The professional practice program at the University of Cincinnati is designed to enrich a student's learning and sharpen his career choices through alternating study with employment. Student counseling and placement are performed by a professional staff. Students are placed off-campus for as many as seven quarters by alternating a study quarter with a work quarter during the second, third,and fourth years. The degree program lasts five years. Student employment compensation increases with the student's responsibilities.

H i s t o r y :

The University of Cincinnati, founded in 1819 with the establishment of Cincinnati College and the Medical College of Ohio, became a university in 1870 through an act of the City of Cincinnati. It is the nation's first municipally-sponsored, state-affiliated university and is the second largest municiple institution in the country. The College of Engineering began its cooperative program in 1906 under Dean Herman Schneider's leadership.

P r o g r a m   D e s c r i p t i o n :

The co-op program currently called the "professional practice program" is mandatory for students in the Colleges of Engineering and the College of Design, Architecture, and Art. It is optional for students in the College of Business Administration. Over 3000 students are enrolled in the program and nearly 1800 of these are engineering students. More than 1000 firms and agencies cooperate with the university by offering students work experience opportunities. Professional career counselors, organized in the Office of Professional Development which is independent of the three participating colleges, administer the program. The director serves on an executive board which governs the program whose members include the vice-provost for academic affairs and the deans of the three participating colleges. Students first enter the program through a one credit course - Professional Development I - taken in their first year. The course facilitates career planning through descriptions of career possibilities and encouragement of self-analysis. After completing the course, students are advised by a career development counselor on possibilities for their initial placement. Students can interview for several placements and choose among their offers. Their choices are based on the type of career desired combined within the student's engineering speciality. Generally, students in engineering are encouraged to stay with one company which may involve as many as seven placements, successively progressing into positions of greater responsibility. Students finish their co-op experience with a final course, Professional development II, which facilitates the job-seeking process.

Program Purposes:

The general purposes of the program are listed in the University of Cincinnati Bulletin:

"The professional practice program offers the student an opportunity for selected practical experience purposely intermingled with a gradually expanding academic background. Thus, students obtain first-hand knowledge of professional practices and opportunities. The professional practice assignments assist each student in developing an understanding of human relationships and in learning to work with others as a team. His individual growth during his practice experience is enhanced by the realization that, in addition to demonstrating his theoretical knowledge, he is developing the supplementary skills and attitudes possessed by professionals in his field. Participation in the program enables the student to make a more intelligent selection of graduate position. As a graduate, his professional practice experience makes him more valuable to an employer and increases his qualification for a more responsible career assignment." (22)

4.2 The Largest Program: Northeastern University Boston

Northeastern University has the largest cooperative program in the country with a total enrollment, including all freshman and seniors, of approximately 14,100 undergraduate students. A staff of 33 faculty coordinators, 15 assistants to the coordinators, and 9 cooperative education counselors is responsible for the placement and guidance of the students on the cooperative programs.

Approximately 70 percent of the cooperative assignments are located within commuting distance of Boston, with many of the remaining 30 percent centered in New York, Philadelphia, Baltimore and Washington. However, portions are located in the Midwest, the Far West and abroad. At the time of this study, the number of students actively engaged in the alternating work-study pattern was as follows:

Boston-Bouvé	776
Business Administration	1,854
Criminal Justice	940
Education	346
Engineering	1,420
Lincoln College	288
Liberal Arts (Science)	690
Liberal Arts (Non-Science)	384
Nursing	682
Pharmacy & Allied Health Professions	466*)
	7,846

COLLEGE OF ENGINEERING

Engineering, which encompasses the design of items and processes based on scientific phenomena, is in itself the practical application of laboratory theory for economical utilization by mankind. It is an acknowledged fact that there are many facets

---

*) contains also part-time and postgraduate students

of this profession that cannot be taught in the classroom. On this basis, some competent engineering educators have boldly predicted that within the next 10 to 15 years all engineering curricula will include some form of work-study program in order to supply the student with the "art" of engineering.

<u>Employment Conditions</u> - At the close of World War II, there was a shortage of engineers. Magnified by the Cold War and brought into focus by the rapid technological advancements in recent times, this greatly aided the cooperative education movement. Under the conditions of a short supply, employers were anxious to participate in the employment of students. In the first place, the opportunity to recruit potential engineering graduates through the cooperative program had a substantial appeal. Secondly, the students were able to fill many positions with employers that normally would have been filled by engineering graduates. In the absence of graduates the cooperative students represented the best alternative. These competitive conditions combined to provide excellent experiences for students at relatively high pay.

In early 1970's, however, the situation was rapidly altered by the changing conditions due to a reduced emphasis on space and defense expenditures. Suddenly engineers were out of work and cooperative assignments became difficult to find. Engineering employment is particularly sensitive to changes in the nation's economic, political, and social environment. At present, engineering placements are again on the upswing despite fluctuations in the national unemployment rate. (35)

The co-op program at Northeastern University is structured by the following calendar:

Five-Year Quarter-System Cooperative Program (with sixth-year option to continue to master's degree)[1]

CLASS SCHEDULE TO RECEIVE B.S. DEGREE IN AN ODD YEAR					CLASS SCHEDULE TO RECEIVE B.S. DEGREE IN AN EVEN YEAR			
Sept. | Oct. | Nov.	Dec. | Jan. | Feb.	Mar. | Apr. | May	June | July | Aug. | Sept.		Sept. | Oct. | Nov.	Dec. | Jan. | Feb.	Mar. | Apr. | May	June | July | Aug. | Sept.
Quarter 1	Quarter 2	Quarter 3	Vacation	FRESHMAN	Quarter 1	Quarter 2	Quarter 3	Vacation
Quarter 4	Work	Quarter 5	Work	*Division A*	Work	Quarter 4	Work	Quarter 5
				SOPHOMORE				
Work	Quarter 4	Work	Quarter 5	*Division B*	Quarter 4	Work	Quarter 5	Work
Work	Quarter 6	Work	Quarter 7	*Division A*	Quarter 6	Work	Quarter 7	Work
				MIDDLER				
Quarter 6	Work	Quarter 7	Work	*Division B*	Work	Quarter 6	Work	Quarter 7
Quarter 8	Work	Quarter 9	Work	*Division A*	Work	Quarter 8	Work	Quarter 9
				JUNIOR				
Work	Quarter 8	Work	Quarter 9	*Division B*	Quarter 8	Work	Quarter 9	Work
Work	Quarter 10	Quarter 11	Work	*Division A*	Quarter 10	Work	Quarter 11	Work
				SENIOR				
Quarter 10	Work	Quarter 11	Work	*Division B*	Work	Quarter 10	Quarter 11	Work
Quarter 12	Work	Quarter 13		GRADUATE	Quarter 12	Work	Quarter 13	
Sept. | Oct. | Nov.	Dec. | Jan. | Feb.	Mar. | Apr. | May	June | July | Aug. | Sept.		Sept. | Oct. | Nov.	Dec. | Jan. | Feb.	Mar. | Apr. | May	June | July | Aug. | Sept.

[1] This unique cooperative program, pioneered and currently in effect at Northeastern University in Boston, Mass., is in power systems engineering.

Each student has to sign the following agreement:
"I, the undersigned, agree to work for the company named on the reverse side of this card as my regular cooperative assignment, in accordance with the regulations of the Department of Cooperative Education as outlined in the CO-OP HANDBOOK.
I also agree to accept the rate of pay stated, this amount to be increased as my ability and other conditions may warrant.
I understand that this agreement becomes effective upon my acceptance of the position offered."(24)

The agreement covers two basic policies:

(1) The student must continue on the job assignment until released by the coordinator. Theoretically, this could extend over the entire length of the cooperative program.

(2) The student may not expect a change of assignment until he has completed a minimum of two quarters with the employer. Only under unusual circumstances will the coordinator consider a change in less than that time, and the change may not be granted even after the minimum period has expired.

Some training programs require the student to undertake a commitment of a minimum period of employment of more than two work quarters. When this occurs, the student must give careful consideration to the commitment before accepting the assignment.

The agreement is strictly between the student and the university. The employer is not an active participant in the agreement. The university believes that contracts with employers to retain students in their emplcy are neither necessary nor desirable. To promote mutual confidence and assure the maintenance of higher standards, employers are advised to discharge any student who, after a fair trial period, performs unsatisfactorily, is judged incompetent or incapable of performing tasks expected of him, is irregular in attendance or punctuality, or fails to cooperate in every reasonable way.

An employer cannot be expected to retain cooperative students any longer than is practical from a sound business standpoint. Moreover, it is not conducive to sound cooperative relations for students to expect priority considerations over other regular employees. It is believed than an employer who sincerely demonstrates an interest in training cooperative students may be trusted to judge when business conditions make it advisable to terminate the employment of cooperative students.

Regulations for co-op students:

TIME OFF.

A student must be on the job regularly and punctually. He has only the privileges allowed other regular employees of the company. He must not ask the employer for or take time off from work for any college requirements without first obtaining the consent of the Department of Cooperative Education.

Students will not be allowed to take academic work for credit through daytime classes during the regular work hours. In addition, ROTC summer camp requirements for cooperative students in that program must be completed during the summer following graduation and not during a cooperative work period.

ABSENCE FROM WORK.

The tasks performed by students on their cooperative jobs are part of a carefully planned and scheduled program of work. A student's absence from work immediately necessitates replanning and rescheduling of performances expected of him. Therefore, in case of sickness or other emergency necessitating a student's absence from work, the employer should be notified by telephone as early as possible. If an absence will cause the student to miss a full week or more, then his coordinator should also be notified.

LAYOFF.

Any student who is permanently or temporarily laid off must notify the Department of Cooperative Education at once.

DISCHARGE OR DESERTION.

A student who leaves his cooperative job without prior approval of the Department of Cooperative Education, or who so conducts himself on the job as to cause his discharge, will be subject to disciplinary action which could result in suspension from the university.

FAILURE ON JOB.

Any student who, although not discharged immediately by the employer, fails to perform in a satisfactory manner on a maximum of two cooperative assignments shall be brought before the proper academic committee for appropriate action.

OWN JOBS.

Under certain conditions, a student may be permitted to work on a job of his own finding. He must petition his coordinator for approval of such work before accepting the job. Petitions are obtained from the coordinator and, if approved, remain in effect for one work period. If conditions warrant the student's continuance on his own job beyond one work period, a new petition must be submitted for approval. The student is expected to conduct himself on this job in the same manner as on any cooperative assignment. All cooperative education rules and regulations apply. Approval of the petition is based on the following considerations:

(1) The job of the student's own finding must be the equivalent (in training potentialities and application to the student's field of study) of any job that the Department can provide for the student.

(2) Existing assignments with cooperative employers must be given priority.

(3) The employer must be informed that the student is attending Northeastern on the cooperative program and that he will be returning to school at the end of the work period.

EXPERIENTIAL PROGRAM.

One or more times during his participation in the cooperative program, a student may wish to engage in an activity other than paid employment, such as travel, independent study, or volunteer services. The Department of Cooperative Education recognizes the educational value of this type of experience and may allow the student to participate in the experiential program. Any student anticipating participation in the experiential program should discuss the possibility with his coordinator or the director.

He must petition his coordinator for approval of this activity before he makes any commitment. If approved, a petition remains in effect for one work period. Petition forms may be obtained from the coordinator concerned.

SOCIAL SECURITY AND UNEMPLOYMENT COMPENSATION.

Social security numbers are required of cooperative students before they may start work on cooperative jobs. Federal and state laws require that employers pay taxes based upon the amount of their payroll to provide funds for old age retirement annuities and unemployment compensation benefits. The administration of these laws necessitates the registration of all employees of employers subject to these laws. Practically all workers are now included. This registration is evidenced by a social security number. The social security number may be obtained in one of two ways:

(1) The number may be obtained without any delay be applying in person at the regional office of the U.S. Social Security Office.

(2) Application blanks may be obtained at any U.S. post office. These blanks must then be taken or sent to the local regional headquarters, and the social security card bearing the number will be issued immediately or mailed to the address given on the application.

There are two separate taxes, one for old age assistance, the other for unemployment compensation. The law requires contributions by the workers as well as by the employers. The employer is required to deduct the worker's share from his pay envelope or check. The amount deducted is ordinarily made known to the worker either on the check or on a slip accompanying the pay in the envelope. The deductions from the student's pay are for old age assistance; the employer pays all of the unemployment compensation tax. The Massachusetts Unemployment Compensation Law, Section 7, reads: "The term 'employment', except as used in the definition of 'payroll' in subsection 'n' of section one, shall not include: (1) "Services performed by an individual while registered for a prescribed course at any educational institution on a cooperative plan of education and industrial training. (2) Services performed during customary vacation periods by an individual who was registered for full attendance at and regularly attending an established school, college, or university, in the most recent school term and who intends to return thereto or to enter another school, college, or university as a student for the next regular term." Therefore, Northeastern students are not eligible to receive Unemployment Compensation Benefits. Other states have similar laws.

WORKING CERTIFICATES.

The laws of the Commonwealth of Massachusetts require that, on certain kinds of work, minors under 18 years of age may not be employed without first obtaining a working certificate. Employers are fined if this certificate is not posted in accordance with the law. Therefore, because the student is the only one who can procure this certificate, he should assume the responsibility of getting it immediately after he has been accepted for the job and present it to his employer when he starts work. Certificates are available at the office of the superintendent of schools of the student's residential community or, for graduates of Boston schools, at the Continuation School Headquarters.

HEALTH PROBLEMS.

A student may occasionally have a health problem which will have a significant effect on his placement on a cooperative assignment. It may be a physical defect which will hurt his placement possibilities, or it may be a condition requiring extensive or unusual medical or surgical treatment. In some cases, it will require removal from a particular cooperative job or a leave of absence for all or part of a work term. Regulations require that the student discuss the problem with his coordinator and fill out a petition requesting appropriate action. The coordinator may refer the student to the University

Health Department, where, after an exchange of information with the family physician, a judgment will be made with respect to the legitimacy of the request. In most cases, the student will be asked to sign a statement releasing the health information so that the Health Department may disclose the necessary facts to the coordinator. Also the coordinator is given permission, through the signed statement, to use the information with potential or existing employers to the best advantage of the student. Whenever surgical or medical treatment is elected, the student must petition in advance. When emergency conditions prevail, the petition must be filed with the coordinator as soon as possible after the emergency.

4.3 A Very Unique Program: La Guardia Community College NYC

LaGuardia Community College, the newest unit of the City University of New York (CUNY), was authorized by the Board of Higher Education (CUNY's "Board of trustees") in May, 1980, as the eighth community college in the 18-institution CUNY system. LaGuardia's creation was in large part stimulated by the Board's decision to adopt, effective in the fall of 1970, an open-admissions policy for all New York City high school graduates. Following closely a period of turmoil on several other CUNY campuses, the Board's actions, both in establishing open admissions and in creating an eighth community college, were intended as clear responses to pressures from several populations, particularly disadvantaged minorities, that had until then been largely excluded from public higher education in the City.

The college's location in Long Island City, in the Borough of Queens, was selected after a demographic survey commissioned by the Board revealed that the area manifested among the lowest average family income and educational attainment of the entire city, and that its population was clearly not being served by any other CUNY institution.[1] LaGuardia's early efforts - in the year before the college opened - at establishing positive relationships with the western Queens community were at first frustrating.

Local leaders tended to accord the college a lukewarm reception

---

1) A glance at LaGUARDIA'S STUDENTS (19):
- Over three-quarters belong to minority groups
- Median family income is about $ 8,000 per year
- Sixty-eight percent are women
- About $ 2,500 is earned each year through internships
- Each quarter, about 400 students are off-campus on cooperative education internships
- Well over a third are over age 25 when they first register

for reasons they readily expressed: LaGuardia's prospective constituents were largely blue-collar families (including white ethnics, blacks, and hispanics) with average family incomes under $8,000, and they were struggling for economic survival. Children of such families were expected to contribute substantially to the resources of the household -- at least until they married and moved out on their own. A college education might be a luxury for some time in the future; in the present, their children needed jobs, not more schooling.

It was immediately clear that LaGuardia's answer would have to go beyond educators' traditional advancement of their product as an investment in one's future. To be responsive to community needs, the college would have to provide a tangible link between education and work. The link that quickly emerged was cooperative education. The college proposed to the community that it would establish a comprehensive cooperative education program, involving every student in an alternating quarterly pattern of studying and working; that through its "co-op" program students would, in effect, be receiving on-the-job training for nine of their 24 months of college attendance; and that through their co-op internships, they would be able to satisfy, at least in part, their families' needs for contributed income, while providing themselves with significant steps toward upward socioeconomic mobility.

The community approved. In 1971, LaGuardia enrolled 566 students. By the fall of 1978, the college had grown to over 6,000 students.

LaGuardia Community College's fundamental mission has remained the same since its planning stages in 1970: to serve the multiplicity of needs of each segment of its diverse population; to give special emphasis to preparation of the individual for work and / or further study; to combine, using a year- round quarterly calendar, practical fieldwork experience with classroom instruction through a universal cooperative education program; and to assume a special responsibility for service to adults, the handicapped, veterans, non-English-speaking students and other populations generally excluded from the mainstream of higher education.

With only minor changes, that mission statement has served well and comfortably for seven years. Over the years emphasis has been added to the college's commitment to the city, to career education, and to non-traditional learners, and the above statement is expected to continue as an accurate description of the College's reasons for existence.

Just as cooperative education, later incorporated into a more comprehensive career education program, was initiated in response to the outspoken needs and demands of the local constituency, so too was LaGuardia's broad commitment to basic-skills instruction a response to community need. The open-admissions program brought to CUNY, and to LaGuardia students who in the 1960's would not have even considered attending college. With a combination of poor general high-school preparation, the absence of any technical or vocational training, and an ever-weakening market for unskilled labor, the open-admissions student often came to college for lack of any other choice. Consistently since 1973, the reading skills of 20 percent of LaGuardia's freshman classes have been below the 9th-grade level; in fact, fully 80 percent of freshmen require remediation in at least one (reading, writing, mathematics, or oral communication) basic-skills area.

Some of CUNY's older institutions were ambivalent towards the open-admissions program. Students were guaranteed admission, not retention. In the early years of the program, open doors often became revolving doors. At LaGuardia, however , there were never many "traditional," higher-skilled students; the college's community was the open-admissions community, and the institution's mission was to serve their needs, "appropriately and effectively."

LaGuardia has, from the beginning, devoted a substantial portion of its resources (including over 20 percent of its instructional budget, and almost 30 percent of its teaching lines) to remedial instruction. The basic skills program, originally limited to two courses in two departments, has grown in proportion to an awareness of the seriousness of the problem. Where there were once two courses, there are now fifteen, including a special six-course sequence for those students whose first language is not English.

Where there were once two departments operating independently of each other (and, largely, of the rest of the college), there is now a basic skills program, incorporating and integrating the efforts of five academic departments and a cadre of counseling specialists.

As LaGuardia slowly came to grips with the magnitude of its students' skills deficiencies, it began to grapple with a central dilemma facing community-college educators: how could it provide a meaningful, useful college experience to students who could not read their textbooks, write their term papers, express their ideas, or perform simple mathematical operations? The choices, it seemed, were either to become a credentialing agency, merely "processing" those who matriculated, or to turn away those who could not quickly measure up to the traditional definitions of " college student" and "college level." Neither alternative seemed appropriate to the needs of the college's population, and it rejected both extremes.

The college chose instead to acknowledge the difficulty of its task and slowly to build its programs and policies based on what its faculty knew as educators and what they were learning as teachers. Over the last five years, the major themes that bind together all of the college's activities have been expanded and strengthened. For example:

In basic skills:

+ All basic skills courses have established clearly-defined exit criteria
+ Faculty in content-area courses reinforce basic skills in their classrooms
+ Careful placement and registration procedures have been developed that insure that students enroll only in courses with levels of difficulty appropriate to their skills levels

In career education

+ Responding to suggestions of "co-op" employers (a broad cross-section of New York's diverse labor market), required courses were added to the curriculum which deal with such matters as basic communication strategies, interviewing skills, and resume-writing

+ In acknowledgement of students' difficulties in relating their coursework to their early internships, the college embarked on a systematic program of teaching, application, and reinforcement of basic concepts in each major (the "TAR" project), through which material taught initially in classes and in the co-op preparation course is applied on internships, using guided study workbooks, and reinforced in evening seminars held concurrently with work placements.

In services to adults

+ The college, in keeping with its stated mission to provide programs for adults and special populations, has expanded the offerings of its Division of Continuing Education, which now has classes for adult community groups at 15 extension sites, and which enrolls more than 7,000 students in non-credit courses on campus each year.

In all courses

+ Performance objectives have been written for every college course, and they are distributed to all registrants in the first few days of each quarter, along with an outline of the methods by which student performance will be evaluated.

4.4 The Harvey Mudd College Clinic Program

The Engineering Clinic, or experience portion of the curriculum, was begun in the early 1960's and is now a mature program solving problems unique to Harvey Mudd but which exemplify broader engineering and professional educational concerns. Harvey Mudd faculty members wanted to offer students a real world engineering experience with all the learnings inherent in "the real world." They recognized that faculty were often divorced from practice except occasional summer consulting.

Alternate solutions were explored - cooperative education, the practice school approach and clinical training models in other professions are examples of the alternatives considered. Harvey Mudd synthesized elements of these approaches to create "a primarily campus-based, team-centered, funded, open-ended, problem-solving experience" entitled the "Engineering Clinic." These experiences flow from projects generated by local, state-wide or national firms or agencies who look to Harvey Mudd for high quality work at limited expense.

Students must participate in the engineering clinic generally during their junior and senior years. Each semester's activity is graded and worth three credits. Fifth year masters students also participate in the clinic as project leaders, earning six units per semester. While student participation in the clinic is mandatory, students choose their particular project in consultation with the project director. Students report that their selection decisions are influenced by: 1) the substance of the project; and 2) the professor and team members potentially or actually involved in the work. Student choice seems to positively influence student motivation. Projects are recruited in various ways and selected with important learning criteria in mind. All projects are funded. Each client is charged a standard fee which covers direct and administrative costs. The students are not paid to work on the project.

A good project according to those involved is one which emphasizes the application of theory, involves engineering design work and necessitates a team approach. Projects tend to be longer than a semester; therefore, students often flow in and out. Some students never see the project from beginning to end. Projects involving substantial amounts of menial work are screened out. In general, the projects are rigorous and comparable to graduate level sophistication.

Student/faculty/client interactions have both formal and informal dimensions. Formally, the client presents a general problem to the clinic. Students, led by a fifth year student and with faculty supervision, develop a proposal which is shared and negotiated with the client. Once the proposal is accepted,

periodic team meetings with and without the faculty member take place. Progress is reviewed, plans are made and responsibilities are detailed. Sometimes students visit the client or vice-versa depending on the nature of the task and the client's location. The team is responsible for a project presentation to the entire Clinic in the college auditorium. The Clinic faculty and students currently participating in projects offer critiques of methodology, analysis and solutions. Students must formally prepare for these sessions and three members of the audience are responsible for written feedback on the presentation. Lastly, the team produces a written report for the client at project's end.

Informally, students use faculty members as resources, involving engineering and other faculty who can best contribute to their projects. Naturally, their supervising professor is their primary resource. He was chosen because of his competence for the particular project.

4.5 The Kansas State University Design Laboratory

As part of the senior year curriculum in mechanical engineering, all majors at Kansas State University are required to participate in an M.E. Design Laboratory. This industrially-based, experiential aspect of the curriculum is a two-credit, capstone laboratory course for M.E. Majors. It is intended to serve as a transitional vehicle which introduces students to the types of problems they will encounter "on the job" and affords them an opportunity to apply a cross section of their course work to real world problems.

The students, working in three to four person teams, solve actual engineering problems that are submitted by industrial clients. These industrial firms represent a diverse geographical group from Texas to Indiana and offer a broad cross-section of projects(e.g., from pipelines to grain dryers). In any one semester 6-8 teams of senior M.E. majors are working toward the presentation of both a written and an oral report to the client on a proposed solution.

Within any one semester, the process of organizing the M.E. Design Lab begins when the department receives pre-enrollment statistics. From these figures the number of projects needed for the upcoming course is determined based on three or four person teams and projects are solicited from industry. KSU has prepared a "participation agreement" which each client must sign. This brief two-page document formalizes the obligations of all parties in a contractual form.

Brief background statements on each project are prepared by the supervising professor and distributed to students. From this information the students preferentially rank each project. Using these preferences as input, professors then assign students to a project, thereby creating three to four person teams with one professor supervising a maximum of four projects. With the exception of two initial lectures on problem-solving, the remainder of the Lab course is given over exclusively to the solutions of their engineering design problem. After projects have been assigned a representative of the client firm will usually travel to the school to make a detail presentation to the design team, although some firms prefer that the students visit the plant site.

Although the format varies across faculty, students meet with their supervising professor on a weekly basis. At this time the week's progress is reviewed, and next week's goals are agreed upon. The students have the freedom to place a collect telephone call to the client once a week to gather information and get important questions answered. Twice during the term students are required to send written progress reports to the client and make oral presentations to their classmates. Feedback from the client is encouraged, but it is received infrequently.

All of the work in this two-credit laboratory is focused on the ultimate production of a written report which is bound into a highly professional document and presented to the client. A project team accompanied by its supervising professor travels to the client's home base to make an oral presentation and defend the proposed solution. This visit serves not only to present and discuss the written report but also gives the students an opportunity to tour the plant facilities and become more familiar with the client's environment. The written and oral reports form the basis for evaluating performance in the course. From this work and the interaction throughout the semester the professor assigns each student a letter grade.

4. 6 The Worcester Polytechnic Institute PLAN Program

In 1971 Worcester Polytechnic Institute embarked upon a most ambitious curricular plan which resulted in the total revamping of their learning environment. The WPI PLAN, as it has come to be known, is an attempt to provide engineering students with an education that is in keeping with the contemporary world. The PLAN was designed specifically to provide "a new and comprehensively different educational program, responsive to the needs of individual students and society while encouraging sensitivity to the ideas and values of civilization."

The two qualifying projects, the MQP and the IQP, represent the experiential dimension of the WPI PLAN. The Interactive Qualifying Project(IQP) focuses on the interactions of technology with society in human values. An IQP may range from studying the impact of an educational satellite to teaching guitar lessons to a juvenile delinquent. These projects are often times expensive and allow these future engineers to gain first-hand experience with a set of societal issues they might not normally encounter. The Major Qualifying Project(MQP) integrates formal academic studies in one's major field via an in-depth research project. Although each of these graduation requirements are project-oriented, it is obvious that their purposes are quite distinct.

With the introduction of the PLAN, a unique academic calendar was instituted consisting of four, seven-week terms with a two-week intercession between the second and third terms and an optional summer term. For any single term students register for a total of one unit of activity with a traditional three-credit semester course translating into one-third of a unit. Both the IQP and the MQP are designed to each require one unit of activity for a seven week term. Students may register exclusively for project work and thus spend fulltime for seven weeks on their project. Many students, however, opt for spreading a project over a number of terms and will register for fractional units of project activity, independent study and classes totaling one unit of activity per term. WPI alumni thus graduate with at least two units of project activity, two units in humanities, and a total of approximately sixteen units.

Project activity for both the IQP and the MQP takes place in a variety of formats. More often than not, projects are completed in two- or three-person student teams. Interactions with clients range from no involvement with a client to literally changing residence for a seven-week term and working as a full time employee. Client involvement can be broadly grouped into three alternatives. First, students may literally set out to accomplish the objectives which a client has outlined. In this case, students will be working much like an employee of the firm. Approximately 200 projects(24%) are this type. Second, students may work on an offcampus project which has student or faculty designed objectives. This may involve some interaction with a set of "clients" but the focus of responsibility resides on campus. Approximately 100 projects(13%) are this type. Third, projects may involve no off-campus experience. Such projects may be a laboratory experiment or a library research project. Approximately 500(63%) of the student projects are of this variety.

To expand the number of off-campus projects, WPI is establishing a set of project centers. One of the most exciting is the Washington,D.C. Project Center. This "branch campus" of WPI takes full advantage of the nation's capital and its resources to generate stimulating project activity. Other centers have been established at a nearby hospital and a local manufacturing firm. These WPI Centers will facilitate project coordination and build on project experience.

To assist students in designing and planning their projects, two voluntary "proposal courses" are offered, one for the IQP and one for the MQP. The objectives of these courses are to assist the students in generating a detailed research proposal for their own IQP and MQP.

Upon completion of the projects, a detailed report is written, much like a technical paper or engineer's report.

Students may complete the MQP and IQP anytime in their academic career and in any sequence. In actuality, students are encouraged to complete their IQP - the societal based problem - during their sophomore or junior year. The MQP normally requires a thorough grounding in the major field of study and therefore is usually completed in the final term of the junior year or in the senior year. On occasion students will get involved in a research project in their major field during their sophomore or junior years. This often times results in early completion of their MQP. Projects may receive one of three grades: acceptable with distinction; acceptable; or not acceptable. This grading system is also used for course work at WPI with the exception that no record is kept for work that is unacceptable.

4. 7 The West Virginia University PRIDE-Program

The PRIDE program, or Professional Reasoning Integrated with Design Experience, is a curriculum revision within the Department of Chemical Engineering at West Virginia University. The basic purpose of the program is to integrate theory and application in the learning process to better prepare students for employment in industry. However, unlike the other programs in this study, PRIDE does not utilize any direct client or industrial experience. The "real world" is brought to campus by simulated, open-ended problems, given to students as projects.

Like Guided Design, PRIDE involves small group work on open-ended, industry-like problems, created by the faculty. The program involvement increases from two credits per term in the sophomore year to six credits per term in the junior year, and finally to ten credits per term in the senior year. The format emphasizes project work during class-time, with student self-study of content outside of class, aided by faculty tutorial help. This progression of involvement includes the entire curriculum and is comparable to the increasing number of courses taken in the major.

The flow of the program begins with close guidance and extensive feedback on two projects per term in the sophomore year and ends with a year-long, very large and loosely defined problem in the senior year. Faculty input declines as student leadership increases with each project. Approximately 40% of actual class time is spent on projects and 60% on traditional course work. In the junior and senior years, "blocks" of time are obtained by scheduling certain content classes back-to-back, and then concentrating on a set of objectives (content or project) over the course of the day. This facilitates the integration of the project into the class learning activities.

During the sophomore year students are given very specific engineering problems. Professors carefully monitor a student's progress via group and individualized feedback. The sequence of student activities has been carefully designed and the student is given specific instructions for the next task. It is not until the final two months of the sophomore year that students are given a completely "open-ended" problem in which they must determine the constraints and work totally on their own. At this point, students work in four-person groups to tackle these problems.

In the junior year the faculty plays a smaller role in guiding the students through their design problems. Two related courses of six credit hours/semester are involved and students continue to work in small groups in solving open-ended design problems. Because each of these problems has no single right answer, student groups may eventually be working on quite different solutions. The commonality of activities that was evident in sophomore classes disappears. This obviously alters the role of the faculty member, as he must be prepared to deal with many more complexities as students probe problem solutions.

The senior year curriculum is expanded to ten credit hours per semester and includes four projects - one year-long five to six credit-team project; and three intensive 5-14 day projects or "major exams" which are completed individually. In this final year, Tuesdays and Thursdays are set aside for the students to work on their own with little assistance from the faculty in the design aspects of the problem solution. The faculty serve as expert resource people, perhaps even lecturing in their traditional role as content authority. The students are concurrently enrolled in two or three traditional courses. Oral reports and written "major exams" are an important part of the learning process. At the completion of each project, a "verbal" defense and explanation of the group's work is presented before at least two faculty. The faculty becomes more critically demanding of student professionalism as students gain problem-solving experience. Written exams in major content areas are given at least three times per semester. Also communication skills are examined in all reports and a staff person works with individuals to increase oral and written reporting capabilities. Thus, student progress in both the academic and experiential components is monitored.

From the curricular perspective, traditional subject areas are studied by utilizing programmed instruction books, standard texts, lectures, and study guides. Faculty team-up to both teach and evaluate courses, dividing these functions within the same course. In sum, the curriculum is classic in content but innovative in its process.

4.8 Three Different Programs at Massachusetts Institute of Technology

4.8.1 The ESIC - Program

In January, 1973, a segment of the Mechanical Engineering Department at the University of Massachusetts began a unique experiment in engineering education. The formal name of the innovation is Professional Practice-Directed Engineering Education(PPDEE) and the aim of its practicum, or experienced-based component, is Engineering Services for Industry and Community (ESIC). The goal of the total program is industry-oriented and prepares students to practice their profession by including the mastery of a fundamental knowledge base, as well as the development of the behaviors and the skills required in quality professional practice. As part of this preparation students work half-time on real problems obtained from local industrial firms and community organizations via ESIC. It is this aspect of PPDEE which demands our attention.

In January, 1973, the program officially enrolled its first three students. Since then, it has grown to twelve students, four part-time faculty, and includes approximately fifteen clients through ESIC. From its conception, limited growth, small size, and careful program management have characterized PPDEE. Students may enter the PPDEE any time between their sophomore and junior years. Thus, they come to the program with certain basic departmental and university requirements fulfilled. PPDEE is strictly an option within the Mechanical Engineering Department, not required of its students and/or in other departments. Students apply at the PPDEE director for admission and are extensively interviewed and then chosen for entrance by an informal faculty consensus. There is no firm criteria for admission, except perhaps dedication to a fifty-hour work week and a strong desire to practice engineering. Students backgrounds and abilities are diverse.

Once in the program two activities prevail. Students work approximately half-time on their ESIC problem. They are assigned industry based projects by the faculty, as much as possible on the basis of students' educational needs. A problem-oriented engineering record is maintained, detailing the goals of the project; the data base; the design or solution specification; PERT charts and other planning documents; current problem status; results to date; time and money records; and a complete log of project work.

The faculty role is to "coach" the student via the unique audit method of twice weekly reviews of student performance, the engineering record, and the academic work component. The faculty auditor is a constructive critic, incisive questioner, and demanding professional. He will make suggestions about project direction, but will not contribute the project solution nor lecture on solutions. While one faculty member is "chief" auditor for each student, faculty do sit in on each others audits and freely contribute to the process.

The student has total client responsibility, both technical and communicative. Most projects are done individually rather than in teams and average about three months in length. Projects include machine design; product design, testing, and evaluation; failure analysis; manufacturing process and equipment design; and value engineering.

The other half of a student's program is acquiring the required base of engineering science knowledge through self-study. Unlike many other programs, this is normally not done in traditional class settings. The student's study is based on the questions/issues/data raised in his or her project, and most students learn most of the required knowledge base this way. Students may take up to one outside (conventional) course per semester to help them with the knowledge base or to satisfy a special interest. However, the majority of learning is done on a self-taught basis, using texts, programmed instruction, and auditor suggestion.

A learning record, similar to the engineering record, is also kept by the student and is a regular part of the audit. It consists of knowledge objectives (areas of study, principles, processes, ideas studied), confirmation that these topics were mastered; reference notes or problems on topics studied; and a complete personal reading list. Further, the Computer-Monitored Instruction (CMI) system under development will test knowledge progress, diagnose needs, recommend learning resources and record student learning progress for the faculty with a visual display computer terminal.

Other mechanisms such as the professional review and "senior" examinations monitor the student's educational progress. The professional review is a personal, in-depth faculty-student discussion and evaluation of both the project and academic components. Grades are assigned after the professional review at the end of the semester, where project performance, engineering and program goals are synthesized and evaluated. "Senior" exams are two part: a written exam on the required knowledge base and an ability-to-practice exam, based on the final semester's project and presented before a panel of industry observers.

4.8.2 The UROP - Program at MIT

MIT, a larger and more prestigious university, has since its inception in 1871 been committed to preparing the young "in the fundamental principles of positive science, with their leading applications to the industrial arts." Despite the eminence of many of MIT's faculty, this tradition of attending to their undergraduates has pervaded the staff of the institute throughout its history. Nonetheless, the comparatively rigid curriculum of science and technological fields imposed restraints on many of the institute's students and caused resentments that called for new and more flexible approaches. A number of experimental ventures have been tried at MIT over the years, most of them dying on the vine, and there have been indications that some of its most creative students were turned off by what the institute had to offer. Many freshmen came to MIT with a formidable high school preparation that resulted in boredom rather than excitement.

Though the sixties provoked more visible student dissatisfaction at MIT, the institute's moves to reconsider its undergraduate offerings long preceded that period. The move for reform came into renewed focus after a major lecture in 1957 by Edwin H. Land, president of the Polaroid Corporation. In an address entitled "Generation of Greatness: The Idea of a University in an Age of Science," Land outlined a major revamping of the undergraduate experience that would allow the formation of small clusters of "research families" by undergraduate students and senior faculty. These families would remain through most of the undergraduate years and hopefully advance the students' original thinking and research sophistication.

Land's notions continued to percolate through the institute and provided further impetus to a series of ad hoc and continuing undergraduate education committees designed to enrich the seminar-research experience. These committees carried the firm support of high administrative circles. Out of these efforts emerged, among other projects, an impressive new Undergraduate Research Opportunities Program (UROP), which in a span of half a decade has materially affected undergraduate performance and which has tangentially given the institute's faculty a monitoring mechanism to gauge the educative process in the university as a whole.

Despite its comprehensive influence, MIT's Undergraduate Research Opportunities Program must surely stand as the antithesis of the bureaucratic academy. It doubles as a learning facilitating support office and an institutionally-based grant-making foundation for innovation, and its only claim to turf and academic clout is that it is and remains a faculty support function, intersecting but not threatening all disciplines and academic territories.

The Undergraduate Research Opportunities Program began at MIT in 1969 and is referred to almost always by its Acronym, Urop, pronounced "yourop." Under it, students have patented a number of inventions, including an X-ray processor and a heart valve. Moreover, they have on their own and in collaboration with faculty members published dozens of articles in scholarly journals.

UROP was supported by an annual appropriation of $100,000 initially provided by Edwin Land. It has since grown to include an annual budget of $800,000 - 1,000,000 that comes largely out of MIT's operational budget. Used often as seed money, UROP research funds extended to faculty-student collaborators have pulled additional funds from outside sources. And participation in this vibrant undergraduate program is impressive: More than half the institute's 4,433 undergraduates are engaged in the voluntary program at any one time. Virtually every student will have participated in at least one and as many as three or four projects by the time he or she gets a Bachelor's degree. UROP now collaborates with all of the institute's 24 departments, with faculty participation ranging from 83 percent in nutrition and food sciences to 6 percent in foreign literature and linguistics. (The reason for this disparity is largely the degree to which laboratory work is adaptable to a disciplinary field.)

The program is administered from modest offices in a barracks-like structure on the edge of campus. It is an ancient building with wooden staircases and a rich history, the place in which MIT researchers developed radar and later the atomic clock.

The entire UROP program is brilliantly headed by a young physicist, Margaret L.A. MacVicar, and a small, dedicated group of UROP "facilitators," none of whom has ever had extensive educational experience. This staff of six coordinates the program, helping students who have ideas for research to find interested professors and notifying students of on-going projects by professors who welcome the participation of undergraduates.

The office publishes an annual directory listing MIT's faculties members and the research interests of each. Twice a year, UROP distributes 10,000 copies of a 134-page directory of research opportunities and supplements its listings with weekly updating in 'Tech Talk', a university publication. 'Tech Talk' makes fascinating reading, particularly since it is written in refreshingly simple English.

In addition to matching students with professors at the institute, the program enables many students to join research projects in industrial laboratories and hospitals in Boston. More than 100 off-campus medical researchers have agreed to accept undergraduate collaborators.

Payment of Credit

A participant may also be paid hourly wages - on the average of $450 a semester, either directly out of program funds or from the cooperating professor's research grant. But a project cannot be applied toward academic credit if a student is paid.

Most students are required to join the program, and those who have research requirements may satisfy them through the program. Grading is generally on a pass/fail basis.

Many students decide to apply for neither wages nor academic credit despite an investment of time that may run upwards of 10 or 12 hours in a typical week during the year or longer that they remain with the projects.

As it is, proposals must be turned in for certain projects, and evaluations are supposed to be submitted every semester by each professor and undergraduate involved in the program.

4.8.3 The MIT Engineering Internship Program

- Introduction:

The coupling of academic study with work in industry or government has long been recognized by both academe and industry as an effective mode of education. Over the years MIT has developed an educational program that is acclaimed throughout the United States for its excellence. The Engineering Internship Program is modelled as follows:

- Student participation:

Students in the School of Engineering may participate in the program by registering in the appropriate departmental program.* They will typically spend three summers and one term in residence at a participating company or government agency, receiving academic credit toward a Bachelor's and Master's degree, while earning a salary to help defray their educational expenses. Students are selected by the participating companies in a series of competitive interviews held each spring on the MIT campus. Emphasis is placed on ensuring that students in the program are placed in rewarding "real-world" work assignments under the tutelage of experienced engineers. These assignments extend the learning experience into areas that are not available at MIT curriculum from a new perspective and thereby facilitate early career planning.

To help ensure the quality of the work experience from the viewpoint of both the student and company, a faculty representative is assigned to each company participating in the program. Extensive faculty participation is a key element of this program. Faculty coordinators from each engineering department at MIT and the faculty representative are all available to both students and practicing professionals to help in enriching the quality of the program.

---

*Programs have been established in the Departments of Aeronautics and Astronautics, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mech. Engng., Nuclear Engng., and Ocean Engng.

- Organization:

The program is under the direction of the associate dean, School of Engineering. There is a full-time program director who is responsible for the operating aspects of the program and contractual relations with participating companies. A faculty steering committee, comprised of the department coordinators and chaired by the associate dean, is responsible for academic aspects of the program. In addition, a faculty representative is assigned to each participating company to provide effective liaison between the firm, students, and MIT.

- Work assignments:

The program consists of three work assignments at the same industrial firm. There are two under-graduate work assignments of three months duration each - one after the student's second year at MIT and one after the third year. During the first term of their fourth year, students apply to the department for admission into the graduate program. For those students who are accepted to the graduate program, there is one additional work assignment of seven months duration after the fourth year.

Table 1 shows two typical work/study schedules based on three summers and one semester in plant. Work assignments can occur during the academic year by agreement between the company, student, and department. For those students who are not admitted to the department graduate program, the cooperative program will terminate at the end of the spring term of the fourth year at the S.B. level.

Table 1: Possible Work Assignment Patterns

	Year in School				
Term	1st	2nd	3rd	4th	5th
Fall	MIT	MIT	MIT	MIT	Industry
Spring	MIT	MIT	MIT	MIT	MIT
Summer	-	Indust.	Indust.	Indust.	MIT
			Or		
Fall	MIT	MIT	MIT	MIT	MIT
Spring	MIT	MIT	MIT	Indust.	MIT
Summer	-	Indust.	Indust.	Indust.	MIT

- Academic credit:

Students will receive 6 units of academic credit for each of the first two summer work assignments and 12 units of academic credit for the last work assignment, with additional credit for thesis work. Grades for these work assignments will be assigned on a pass/fail basis by the faculty representative, in consultation with staff members of the participating company. In addition, a written evaluation of the student's performance will be prepared by a company supervisor and made available to the student.

Each student is encouraged to keep a diary and will be required to prepare a report of his or her experiences for review by the faculty representative. Before students return to the campus to resume their academic studies, they will engage in a briefing session with their colleagues, company representatives, and faculty participants of the program to review their experiences.

- Tuition:

Students in the program will pay the normal registration fees for the academic year. No special fees will be paid for summer work assignments; however, students will be regarded as registered during the summer. Students on work assignment after the fourth year of registration at MIT and the fall term of the fifth year will pay a full academic year's tuition for the fifth year even though they will not be in residence at MIT during the fall term. However, registration fees will be waived for these students during the summer after the fifth academic year.

- Compensation:

Students are paid during their periods of residence at the participating companies. While salary levels are a matter of negotiation between student and company, it is expected that salaries will be consistent with those paid to permanent staff members of comparable experience levels and abilities in the participating companies. It is also expected that a company will fund each student's travel from MIT to the company at the beginning of each assignment and his/her travel back to MIT at the end of the assignment.

- Company fees:

The incremental expenses incurred in the conduct of such a program are covered partially by company fees which are negotiated between the company and the school via the program director. The general fee structure has been developed, which consists of a fixed annual fee of $3,000 plus a unit annual fee of 10 percent of the nine-month tuition for the current academic year for each student (regardless of year in school) on a work assignment with the company. Thus, for a company with 6 students, the fee for 1979-80 would be:

$$\$3,000 + 6(0.10)(5,300) = \$6,180$$

The $3,000 fixed annual fee includes an allowance to defray the anticipated costs for faculty travel between MIT and companies within the United States. The fee would be adjusted depending on the company's geographical location and the faculty travel costs, the fixed annual fee would be $1,000.

5. Benefits, Success and Problems of Programs

5.1 Expected Outcomes (22)

An experiential learning activity provides a number of opportunities and fringe benefits in addition to its programmed objectives. Each model offers different outcomes, but, in general, a well managed activity, especially when it contains an authentic involvement component, has an impact on the learner and the faculty. There is, for the student, an environment rich in excitement, high in motivation and challenge. The authenticity of the experience has a noticeable maturing effect and develops a strong sense of self-concept and confidence. The open-endedness and the obvious awareness that the problem requires a solution that neither the client nor the instructor is aware of, creates a demand for creative and innovative action. The magnitude, complexity, and challenge demand leadership, planning, and self-management, and an ability to accept failure and seek alternatives. There is a development of professional value systems and an engineering attitude that cannot be obtained in a classroom.

Experiential activity creates opportunities and a justification for the utilization of self-learning resources. There are inbuilt opportunities for students to study the literature for new information and to undertake self-study of techniques and background information not available in the required curriculum. It creates an environment of self-managed learning - the necessity for life-long learning. There is a broadening of awareness that encourages study in areas peripheral to the degree discipline.

In the development of programs where the experiential component dominates the degree program, there are program objectives for generalization and education of the complete man. An underlying conceptualization evolves that learning-to-learn and being able to apply what is learned is what education is really about.

The faculty who engage in experiential learning management find that the change in role from "instructor" to "supervisor-consultant" opens up new creative opportunities in educational innovation, professional counseling, management and consulting.

In a nutshell, experiential learning is a necessary, though not sufficient, component of the educational process. There are two phases in the educational process: inputting (learning information and techniques), and outputting (synthesis, analysis, and decision making). The formalized instructional processes take care of the inputting; experiential learning develops the outputting.

5.2 Evaluation of Cooperative-Education-Programs

5.2.1 Introductional Remarks

The following evaluative reports are mainly gathered from self-evaluative studies and reports of those institutions, who are running a program. Even if it looks difficult - in a first view - to evaluate the own program 'critically' it seems to be worthwhile to present and to discuss those self-evaluative results. But it is needy to unveil all used criteria and the sources of information. That type of self-evaluation also seems to be used more often within the USA than in Germany.
One reason may be that all educational institutions have to be accredited. The responsible boards, associations, or governmental agencies are using informations from this type very often during the accrediting process, for only statistical data are not always sufficient for a judgement about the quality of programs.
That most of these self-evaluative reports have a positive basic sound about the benefits and successes of the respective program must not be mentioned as a severe bias. We will make some additional critical remarks in the final chapter about this expectable fact.

5.2.2 Evaluation of the "Co-op"-Education Program at University of Cincinnati (22)

Alternating on-the-job employment with classroom and laboratory academic preparation makes Cincinnati unique among the programs investigated for this study. It is. however, typical of the co-op approach used in a large number of institutions. Teaching responsibility has been diffused because of these parallel activities. A philosophy of career development, in addition to academic development, undergirds this program. Therefore, new learning objectives have been developed which foster the student's development as a person in the role of professional engineer. Responsibility for insuring that these objectives are met rests with a career development counselor - a different and emerging pedagogical role as it is conceived at Cincinnati.

Given this distinctive characteristics, how do program participants - alumni,students, faculty and clients - view this program's strengths and weaknesses? Students and alums recognized the major strength as a comprehensive exposure to engineering and its possibilities for them as developing engineering. They learned much about engineering and about themselves - their skills, interests and ideals. Interpersonal skill development was also viewed as an important strength of the program, e.g., cooperation, communication, leadership.

Earning a living while studying was also mentioned as being especially important to some students. Site-visit team members also sensed that students valued the rhythm of study and work. These life and learning styles seemed to balance themselves to the student's satisfaction. Some locked forward to leaving work for academe just as they anticipated getting back to the job after weeks in the university setting.

The faculty (career development counselors and professors) noted that the program's strength lay in providing a truly comprehensive engineering education - personal growth and maturation, the opportunity to relate theory and practice and the chance to begin a career with a broad base of knowledge.

Strengths from the clients' viewpoints focused on the quality of both the students and the program's administration. One client valued the long history of good working relationships with both the professors and the counselors.

In addition to identifying strengths, program participants were asked about weaknesses. Clients didn't spot many problems - one suggested stronger business and computer orientations among students and another noted that he had an overload of students during the summer.

Career development faculty members noted that because of workload and varied treatment of companies and students the program was unevenly administered. Sometimes students weren't placed in demanding enough assignments and one faculty member sought more interaction, generally, between supervisors and faculty members. Another respondent noted that good students tend to go right into a career rather than pursue advanced work and still another sought a longitudinal study of the program to truly identify its impact on individual career management.

Generally, the feeling of confinement to a single company is one weakness emerging from student interviews. They felt a need for additional exposure and felt both limited and stereotyped because of work with one company in one engineering area. Another group of weaknesses pointed to refinements; in the supervisory rating procedure, in providing more information before the first placement, and in the availability of good job experience matched with student needs. One student mentioned that returning to the university in the summer, when it was not really in full swing, limited his education because of fewer offerings in arts and sciences, no student newspaper, and restricted medical service.

Suggested improvements and challenges for the future focus on overcoming weaknesses. Students would like to see the possibility of more than one placement. While shifts are possible, they are not encouraged. Career development counselors see the quality of their service caught in the current fiscal crunch. They also see challenges ahead in better involving the academic faculty in the program. The clients interviewed see no pressing areas for improvement.

Generally, the comments are testimony to a well-conceived and smooth-running program with a long and successful history which has built-in sources of quality control and refinement. This program admirably exemplifies the "co-op" notion for professional education as it has evolved over the years.

5.2.3 Evaluation of the "Co-op"-Education Program at Northeastern University Boston (33)

In an evaluation research study with 456 interviewed undergraduate students at NEU the following principle findings have been found:

"1. Cooperative education students, in contrast to those students not participating in the program, perceive greater personal changes since entering college, particularly in the area of career development.
2. There is a consistent and clear trend, inferred from the results of comparisons across classes, within the cooperative education group to perceive greater personal change as they progress from freshman to senior.
3. The most important agent of change for both groups was perceived to be general maturity, but almost as important for the cooperative sample, but not the control sample, was work experience. Work experience became increasingly important for the upperclass cooperative education student.
4. As freshmen, substantially more cooperative students were unsure of their career goals. As upperclass students, they did not differ from the non-cooperative students with regard to having made a career decision but they more frequently selected non-service careers.
5. Cooperative students put a high priority on career establishment. By contrast, the non-cooperative students put a high priority on personal well-being.
6. The attitudes of both samples of students toward people generally, minorities, women and society-as-a-whole were very similar. Essentially, they think positively of people and trust them, recognize the existence of discrimination against minorities and accept the need for concerted efforts to solve racial problems, believe that women should be treated equally and view our society as too materialistic.
7. Although the social and humanistic attitudes of the cooperative students are similar to their non-cooperative peers, they evidence more conservative, cautious, and prudent judgment. This was interpreted as a consequence

of their involvement in practical, adult work experience. This is especially the case in situations that might affect their own career prospects.

8. The overall evidence is that the cooperative work experience has a considerable impact upon student development during the college years, particularly in the area of career development."

In a broader view these findings can be summarized: "Participation by students in some form of a cooperative education program with its emphasis on integrating work and study broadens the nature and scope of factors which influence a student's personal growth and professional development. The role of practical experience provides the student with opportunities to analyze, evaluate, and adapt to a number of new situations. In addition, the student's off-campus experience brings him in contact with a variety of people from all walks of life which enhances his perspective and outlook about his self-image as well as a greater understanding of others and the world in which he functions. His ability to cope with the world of reality pursuant to these new real-life experiences reflects his development in terms of his emotional and intellectual maturity.

In summary, the proliferation of cooperative education into practically all professional fields today as well as its implementation into all levels of post-secondary educational programs definitely reflects the acceptance by more and more educators of the advantages of the cooperative plan. In fact, the consensus among most practitioners and other knowledgeable people in the field is that cooperative education is viable intellectually, administratively, economically, and above all, represents a sound alternative to traditional forms of education programs." (32)

5.2.4 Evaluation of the "Co-op"-Education Program at La Guardia Community College

Respective to the educational goals of LGCC's co-op education program in a self - evaluation study the following results could be stated:

"The results of this comprehensive self-study reveal that La Guardia has effectively provided to most of its student body nineteen specific career educational objectives, sets of which are subsumed by the college's three major career educational goals:

A. The Exploration of Appropriate Career Choice(s),
B. The Learning of Career Educational Concepts and Skills, and
C. The Reality-testing of Career Explorations, Concepts and Skills.

The various specific studies conducted of the perceptions of students, graduates and employers point to the effectiveness of the various program components of La Guardia's three major divisions (i.e., student services, instruction, cooperative education) that were developed to attain these goals.

While the results have provided us with gratification, they have also pointed to ways for us to further improve our programs so as to be even more successful in providing meaningful career education to all of our students." (17)

5.3 Evaluation of Other Programs:

The comparative study of L.Harrisburger(22), which compared the outcomes of 15 different programs including the 6 programs described in Chapter 4.4 - 4.8.2 programs within the field of experiential learning and co-op-ed. in engineering education has lead to the following conclusions:

"This study shows that models and outcomes vary with purposes, that costs vary with formats, and that there may be many "best ways" to structure experiential engineering education. This comparison should lead one to recognize which outcomes are related to which models and which activities within the programs produce particular outcomes. Extra student and faculty efforts characterize all programs. Thus, the critical questions which need to be asked then are: Experience for exactly what purposes? What kind of experience? How much experience? At what point should the experience component enter the curriculum? What client/institutional relationship best suits the situation?"

- <u>Assessment of Student Performance:</u>

In summary, the classical fundamentals of engineering education such as problem-solving, engineering judgment, and engineering fundamentals are regarded in each program as being very important student learning outcomes. The less traditional skills such as communication, planning, and interpersonal awareness are also consistently assigned high levels of importance. With only a few exceptions there is little difference across institutions.

- <u>The Experiential Curriculum:</u>

Recall that nearly all skills were rated as important with problem-solving, engineering judgment, and engineering fundamentals regarded as the most important. The quality ratings show that problem-solving receives very high and comparable marks in both traditional and experiential components. Engineering judgment receives a higher quality rating in the experiential programs across all institutions; whereas engineering fundamentals, also rated as crucially important, are best taught in the traditional program. Thus, the complementarity of experiential and traditional programs emerges as an important finding. Thus, although experiential programs do teach more of these skills with higher quality, important outcomes such as engineering fundamentals, technical skills, problem-solving may require much more course time to develop than other skills. These data do not support the conclusion that heavily experientially oriented programs are best, nor do they necessarily refute it. The data strongly support the contention that experiential programs do allow students to develop certain skills that are important and offer them a higher quality opportunity than do the traditional programs.

- Attitudes Toward the Profession:

Experiential education impacts on more than the development of professional skills and knowledge. Students' attitudes are affected; and these attitudes, in turn, shape the direction and enthusiasm with which students apply their talents. In broad terms this study assesses how experiential programs contribute to students' attitudes toward their profession.

In this context, students were asked three related questions;

1) Do you feel you have a more realistic impression of engineering and engineers because of your involvement in the (experiential) program?
2) Are your impressions of engineering and engineers more positive, more negative or about the same as before your entry into this program?
3) How has the experience component affected your commitment to an engineering career?

On each of the questions, responses indicate that the "real world" affected their attitudes. Taken together these responses suggest that experiential learning promotes realism, that positive impressions are generated and that career commitment is enhanced.

- Student Satisfaction:

This study probed student satisfaction to determine how satisfying experiential education was and to diagnose the strengths and weaknesses of an experiential system. Data were collected on five areas of student satisfaction: four focused on experiential learning and one on traditional learning. For experiential learning, students were asked to scale their satisfaction with the assessment process, their relationship with supervising professors, their relationship with clients, and their overall feeling about the experiential component of their program. Similarly, they were asked to scale their overall satisfaction with the traditional program. The data do support the contention that students find experiential learning a highly satisfying experience.

- Strengths and Weaknesses:

It is difficult to succinctly summarize the diversity of these six experiential programs. Yet, some general strengths and weaknesses emerge from the interviews of program participants. There is little doubt that experience-based education creates a powerful learning environment which results in new educational outcomes. Yet, in each program, weaknesses appear that dilute the full impact of this new learning system.

The most consistently mentioned strength of experiential learning is its educational impact on students. New qualities are cultivated and new skills are developed. Skills and attitudes which are important to practicing engineers, such as communication, planning, interpersonal awareness and organization, are developed through participation in these experiential programs. Problem-solving skills and engineering judgment also result. The skills most highly developed through experiential learning complement the strengths of the traditional curriculum. Taken together, the traditional and the experiential curricula provide the student with qualities deemed important in professional engineering practice. The program participants believe that the original purposes for constructing a "real world" learning experience are being accomplished. Experiential learning in these six models does make a difference.

A weakness cited across all programs concerns "the project". This concern encompasses many different attributes of experiential learning from project selection to project diversity. For projects to realize their maximum educational potential, they must require an application of theory, must be open-ended and should not be characterized by a unique answer. Participants frequently cite the need for a diverse pool of project topics which, in turn, can satisfy the diverse interests of students and their far-ranging professional needs. In addition, varying substantive areas of engineering need to be solicited so that students can have a breadth of exposure. Comments were frequently made that reflected the difficulty in finding a good match between the student and the project. For example, "The project wasn't challenging enough," or "I just couldn't get a project that fitted my exact interests." The importance of project selection defines what both the students and the faculty will gain from the activity.

The assessment process was another weakness pinpointed in several of the programs. New learning goals and a new learning environment may stretch traditional assessment procedures beyond their credibility. "How can interpersonal awareness, ethics, creative expression or self-confidence be measured?", "What criteria should be applied?" and "How will I know one when I see one?", are questions which exemplify the challenges faced by faculty members who are consciously breaking new ground. The assessment task is complicated by the team format in which the learning may be richer, but the assessment is far more difficult. Assessment in any educational system is inherently complicated; and as these faculty gain more experience, undoubtedly techniques and procedures will be improved.

Interestingly, none of the weaknesses cited by participants challenged the fundamental merits of the experiential approach. Rather, the weaknesses focused on refining and perfecting the existing programs. In general, program participants view the future from two perspectives. Those in the older established programs seek ways to refine their systems and retain vitality. Those in new programs seek ways of institutionalizing them into stable on-going segments of the total curriculum.

Experiential learning enhances a student's preparation for a practice-oriented engineering career. However, programs require sound conception, leadership, and management to fulfill their potential. Even if these requisites are met, as demonstrated by the programs in this study, experiential learning presents many pedagogical and management challenges.

We have described and compared six quite different approaches to experiential learning. It is evident that each of the programs is successful, not only in meeting the various learning objectives, but in providing a rich spectrum of experiences that are extremely satisfying and highly valued by both faculty and students. They all work!

Varied as the programs are, there is a remarkable similarity among the profiles of achieved learning outcomes. The differences in programs are reflected more in degrees of satisfaction of specific skills than in total omission or alternation of certain skills. The outcomes tend to vary more directly as a result of the variation of emphasis on particular goals and different activity mexes in the program. Each of the models provides opportunities to achieve a chosen inventory of learning outcomes at any level of success the faculty wishes to emphasize.

The study clearly shows that these six models develop a set of learning outcomes that are not generally achieved in traditional courses, such as communication skills. It also indicates there are learning skills that are better achieved by the traditional courses (engineering fundamentals). It seems logical to conclude that these experiential models promote a set of skills and attributes that are not as highly developed by a curriculum that includes only the traditional courses.

It is interesting to note that there is, in general, a high degree of student satisfaction and enthusiasm for the experiential learning activities. There also seems to be a relationship between level or degree of satisfaction and the amount of involvement in client projects. The two program models that required a continuous and total involvement in engineering activities with industrial clients throughout most of the tenure of the degree programs received the highest satisfaction profiles. A modest involvement occurring at the end of the degree program seems to leave the least impact on satisfaction and commitment. Thus the degree of immersion in the "real thinking" may be a strong factor in generating the self-satisfaction of involvement, accomplishment, and commitment.

The management of the experience is indeed a strong force in determining the quality of the outcomes for the student. The success of experiential learning, as would be expected, is supervision-dependent. In the co-op program, the quality of experience is directly related to how conscientious and experienced the employer is in both shaping the work activities for the student and in feeding back performance evaluations. In the faculty supervised programs, the outcomes are heavily dependent on the supervisory style and guidance of the faculty. The "chief engineer" role of the faculty is one that is both demanding and satisfying. It is evident that the faculty "load" is no more than that required of a conventional laboratory, although the amount of time and effort varies with individual faculty work styles and student needs. In general, in all the models, the value of the outcomes for the students reflect directly on the close counsel and guidance received from those supervising the experience. A colleague relationship develops that is not only valued by both, but is a requisite for learning." (22)

6. Final Remarks from a German Viewpoint

This paper has shown mostly positive results of practice-oriented programs that offer the students a chance to do practical work while still at the university and to get early experience in the working world that awaits them after graduation. The advantages of these programs are threefold: the student can (1) test his theoretical knowledge in a real working situation, (2) find out if he has chosen the right profession, and (3) see if the knowledge acquired at the university measures up to the expectations of industry.

If we compare the practice-oriented curricula with traditional programs, we find that they train students in the following special abilities:

- interpersonal competence
- communicative skills
- planning ability.

Furthermore this survey shows that those students enrolled in a practice-oriented program mature faster due to their early contact with the real business world.

But it must also be said that the programs show some weak points, which, however, must not be attributed to the programs as such, but rather to the way they are organized. For the students it is not easy to find an appropriate project to work on. For the professors it is difficult to find the proper objective criteria to grade the practical work phase of the students and to judge how much they have learnt during that time.

Even though this paper can only be a small contribution to a broad field of study, some additional remarks from a German viewpoint may be helpful in raising more detailed questions.

(1) The professional role of the German practice-oriented engineer (Fachhochschulingenieur, ing. grad.) whose main field of work is

closely related to production, cannot be considered as being similar to the American engineer's role. First tentative steps towards a more practical engineering education can be seen in the so-called 'technologist'-programs developed by some American institutions. Still the traditional type of engineering education with a full 4-year undergraduate academic program prevails, due to the pressure exerted by the accrediting institutions. Even if some institutions have added a stronger emphasis on practice to their traditional programs, the education of the classical, professional engineer still remains the major objective of the educational system. This fact implies that course and laboratory work are still considered as being the most important parts of a student's education and mandatory steps for receiving a degree in Engineering. There are, however, some stringently organized programs where the problems of practical work determine the academic process. (See the interesting difference between the programmatic objectives of Northeastern University and La Guardia Community College.)

(2) The results of this study show that there is no common understanding about the role of 'practice' within the field of higher education. This is very similar to the situation in Germany, where the discussion about the question "what is practice?" still prevails. Practice has several meanings:

- research activities of a professor;
- development and design activities of professors and students in cooperation with industry;
- employment of students as skilled or unskilled workers during their formal education;
- simulation of practice work within the university;
- concentration for both professors and students on problems closely related to practical matters;
- work in university workshops, labs,and other facilities.

If the understanding about the role and the function of practice during higher education is so diverted, how can one measure the outcome and the results of the different programs with the same evaluation criteria? Nevertheless most evaluative studies come to the conclusion that all the programs with an orientation towards practice achieve positive results. Astonishingly enough these results seem to be nearly the same no matter how widely the programs differ in intention, organization, and duration. This phenomenon leads to the conclusion, that either the methods used for evaluation are not descriminate enough, or the organization of the programs makes their aim so inspecific that every program that contains a certain amount of practical work must by necessity produce positive results. But that seems trivial, so that we maintain that both evaluation and organization must be refined for further work in this field.

(3) One of my main questions concerning the involvement of labour unions in these programs was not sufficiently answered. Even if students work full-time for an industrial firm or an office, the unions seem to ignore them, and the students, - oriented toward their future status as professionals, - don't feel inclined to join them. By the same token, the professors, even if they were organized in the respective union of university teachers, could not give me a clear answer about the role of unions in planning, programming, and organizing those programs containing a practical phase. This differs widely from the situation in Germany, where the unions are increasingly interested not only in the students as their future members, but also in the curricula of universities, especially if students work as regular employees in different branches of industry.

(4) Another question which is also discussed in Germany concerns the 'pedagogization of student employment'. Most programs strongly recommend a supervision of the students by their teachers during the practical work phase, yet it remains difficult to relate the industrial work to the university's curriculum, to influence the type of work given to students, and finally to grade the practical work for the students' academic record. Moreover, it must be mentioned that the most cooperating companies cannot and will not guarantee to always offer a certain number of jobs to students. In times of recession, for example, employers hesitate to hire students. This means that universities cannot by the same token guarantee to always offer practice-oriented programs, since the offers made by industry vary according to the economic situation.

Finally I wish to make a very personal statement based on the impressions I received during my stay at a number of institutions and my attendance at the Second World Conference on Cooperative Education in Boston. Obviously all supporters and participants in practice-oriented programs feel like members of one 'family' sworn in on a more practical orientation in modern higher education. But unfortunately this family is seen by other families as not belonging to the 'upper ten' (especially the so-called 'ivy-league'). This exclusion from the 'upper ten' produces a greater sensitivity, an esprit de corps, and a strong will to succeed in all supporters of the practice-oriented programs. Academic excellence is certainly not the major aim of these programs, yet it cannot be denied that they play an important part in today's higher education in the USA.

7. Epilogue

The study presented here is the result of a research trip I took across the USA financed by the Fulbright Commission. Since this exchange program intends to improve mutual understanding between nations, in this case Germany and the USA, I somehow hope that my topic: "Practice Orientation in Engineering Education" could also be of interest to an American scholar on a similar purpose here in Germany. We have developed comparable modes and programs and it would be interesting to hear the comments from "the other side of the ocean" concerning the organization, intentions and results of our programs.

I would be very glad, if this study would interest an American colleague to study the following analogous phenomena in Germany:

Praxissemester
Berufspraktika
Praktika
Projektstudium.

Unfortunately it seems that even if everbody demands a greater orientation towards practice, work in this area is seldom honoured. But it is an interesting field nevertheless.

Appendix: Bibliography

1. The American Society for Engineering Education, Engineering Education and a Lifetime of Learning, A Study by the Stanford-Ames Summer Faculty Workshop in Engineering Systems Design; Washington D.C. 1975.

2. The American Society for Engineering Education(ed.), Future Directions for Engineering Education, Systems Response to a Changing World; A Report by the Center for Policy Alternatives prepared for the School of Engineering of the M.I.T., Washington D.C. 1975.

3. Brown, S.J./ Whitten, C.J., Cooperative Education for Graduate Students, publ. by the Cooperative Education Research Center, Northeastern University, Boston MA. 1977.

4. Carnegie Council, Three Thousand Futures: The next Twenty Years for Higher Education. Final Report of the Carnegie Council on Policy Studies in Higher Education, San Francisco/ London 1980.

5. Carnegie Foundation, More than Survival. Prospects for Higher Education in a Period of Uncertainty, San Francisco 1975.

6. University of Cincinnati, Professional Practice Division, Student Handbook - Professional Practice Program in Cooperative Education, Cincinnati OH. 1979.

7. Cosgrove, S.L./ Gilbert, N./ Greenberg, D.B., Cooperative Graduate Engineering: The Value of Careful Planning, in: Engineering Education(Journal of ASEE), November 1976,pp. 150-153.

8. Cosgrove, S.L., Cooperative Engineering Education - its Impact on Academe, paper, presented at the First World Conference on Cooperative Education, London, May 1979.

9. Cosgrove, S.L., The Different Faces of Cooperative Education, paper, presented to the Cincinnati Torch Club, March 13, 1980.

10. Cummings, J./ Sussman, M.L., A Model for Integration of Cooperative Education and the Classroom in Data Processing, in: The Journal of Cooperative Education, 1978.

11. Curtius, C.F., Evaluation im Hochschulwesen - Modewort oder Methode von morgen?, in: DUZ/HD 1/ 81,pp. 17-21, Bonn - Bad Godesberg.

12. Curtius, C.F./ Grüger, A.M., Die Praxis der Hochschulplanung - Das Beispiel der University of California, in: DUZ/HD 18/78, Bonn - Bad Godesberg.

13. Doigan, P./ Wolfe, J.K., Western Europe/USA - Technical Education Systems - A Comparison, for the Office of Doctoral & International Recruiting, General Electric Co., Schenectady N.Y. June 1963 (reprint: January 1967).

14. Ehrlich, D.J., Employer Assessment of a Cooperative Education Program, in : The Journal of Cooperative Education 1978 (Number 2), pp. 74-87.

15. Elstermann, G., Notes towards a Systems Comparison of Higher Education in the United States and the Federal Republic of Germany, in: Journal of Cooperative Education, 1978.

16. Farrell, C./ Rossman, N., Philosophy, Freedom and Cooperative Education, in: Journal of Cooperative Education, 1978.

17. Feifer, I. and Ass., An Evaluation of La Guardia Community College's Career Educational Approach to the Integration of its Various Program Components, N.Y., November 1978.

18. Grant, W.V./ Lind, G.C., Digest of Education Statistics 1979, U.S. Government Printing Office, Washington D.C. 1979.

19. La Guardia Community College, Self-Study, Prepared for the Middle States Association of Colleges and Secondary Schools by the Self-Study Steering Committee, N.Y., April 1979.

20. La Guardia Community College, Cooperative Education at La Guardia: Learning Through Experience, N.Y. 1980.

21. McGuinness, L., Students Take Credit for Their Past - College Units Granted for Experience, in: The Los Angeles Times, Orange County, July 27, 1979. Part IV.

22. Harrisburger, L./ Heydinger, R./ Seeley, J./ Talburtt, M., Experiential Learning in Engineering Education, published by the American Society for Engineering Education, Washington D.C., May 1976.

23. Hecksteden, U., Bericht über eine Studienreise in die Vereinigten Staaten, in: ad acta 5/ 1976, München.

24. Knowles, A.S. and Associates, Handbook of Cooperative Education, Jossey - Bass Inc., San Francisco/ Washington/ London 1972.

25. Massachusetts Institute of Technology, The MIT Undergraduate Research Opportunities Program 1969-1976-UROP-What's it all About ?, Cambridge MA. 1979.

26. School of Engineering, Massachusetts Institute of Technology, Engineering Internship Program, Cambridge MA., September 1979.

27. Millonzi, J.C., Liberal Education and Cooperative Education-Are they Compatible?, in: Journal of Cooperative Education, 1978.

28. Müller-Solger,H., Amerikanische Hochschulen im Wandel - Weiterbildendes Studium in den USA, in: DUZ/HD 7/ 79, Bonn - Bad Godesberg.

29. National Commission for Cooperative Education, Undergraduate Programs of Cooperative Education in the United States and Canada, Sixth Edition, 1978. (prepared for the National Commission by The Cooperative Education Research Center, Northeastern University, Boston MA. 1978.)

30. Park, C.W., Ambassador to Industry - The Idea and Life of Herman Schneider, Bobbs-Merrill Co., Indianapolis/NY. 1943.

31. Reitano, J.R. and Associates, Work and Society - An Introduction to the Social Sciences, prepared by the Social Science Faculty, La Guardia Community College, CUNY; Kendall/Hunt, Dubuque, Iowa 1979.

32. Seaverns, C.F.(Jün.), A Manual for Coordinators of Cooperative Education, Center for Cooperative Education Northeastern University, Boston MA. 1974.

33. Wilson, J.W., Impact of Cooperative Education upon Personal Development and Growth of Values: Final Report to The Braitmayer Foundation, Northeastern University, Boston MA. 1974.

34. Winkler, H., Tendenzen und Entwicklungsperspektiven im amerikanischen Hochschulwesen 1980, in: Neue Aufgaben der Hochschulen, hrg. von Neusel, A./ Teichler, U., Reihe: Werkstattberichte, Bd.3, Kassel 1980, pp. 60-89.

35. Wooldridge, R.L., Analysis of Student Employment in a Cooperative Education Program, Northeastern University, Boston MA. 1978.