The Education of the Engineer for Innovative and Entrepreneurial Activity

Supplement

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Errata to Proceedings of the 1982 SEFI Conference
INNOVATION CENTRES

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ABSTRACT

The paper discusses the development of Innovation Centres in the United States of America and their objectives, together with some of their achievements. It goes on to discuss the founding of similar Centres in Canada, Australia, Scandinavia, Ireland and the United Kingdom. Some suggestions are also made as to the future development of Innovation Centres in Europe, preferably with some EEC funding.

INTRODUCTION

The concept of Innovation Centres arose in the United States of America at a time when the American Government felt that two of the factors which had made a major contribution to the high standard of living in America were perhaps on the wane. These two factors were the entrepreneurial spirit of the American people and the innovativeness of its people and the small firms which they developed.

However, once signs appeared that these basic qualities were diminishing, with a consequent erosion of living standards, various remedies were suggested, one of which was the development of Innovation Centres. This paper traces the development of these Centres not only in the USA but also in Canada, Australia, Ireland, Great Britain and some developments in Scandinavia.

EARLY DEVELOPMENTS IN THE UNITED STATES

The story of Innovation Centres goes back as far as 1968 when Congress authorised the National Science Foundation to undertake applied research. There were several responses to this change in the charter of the Foundation, two of which were the Establish of RANN (Research Applied to National Needs) in 1971 and RDI (Experimental R & D Initiatives Programme) in 1972. A major objective of RDI was to identify and stimulate technological innovation. The Innovation Centre concept stemmed from this in 1973 with an experimental design by R. Colton and A. Ezra. The Innovation Centre idea was one of seven such RDI experiments developed in 1973. Following on from this idea in 1973, things moved very rapidly indeed and provide a good lesson for other countries wishing to develop similar Centres. The
experiment was established and funds were made available by June 1973. Also in that month three Centres were selected from the twelve initial applications and a sum of $3 million was awarded over a five-year period. Mr. Colton was appointed the Program Manager. The three first Innovation Centres were located at:
- Massachusetts Institute of Technology in Cambridge;
- Carnegie-Mellon University in Pittsburgh;
- University of Oregon in Eugene.

MAJOR OBJECTIVES

The National Science Foundation experiment in Innovation Centres was designed specifically to study the feasibility of:

'a limited duration federal cost-sharing with the universities to develop a Center (sic) which would educate potential technological entrepreneurs and innovators'.

This emphasis on the relationship between the entrepreneur and innovator is extremely interesting as it would seem that we in the United Kingdom have acknowledged the need for innovation whilst seriously neglecting the role of the entrepreneur and it may be that the United Kingdom is not alone in failing to fully recognise and appreciate the important role of the entrepreneur. A small company close to the Centre in which the writer works gave a very useful case study in this relationship where an entrepreneur joined forces with two innovators who were Infrared astronomers and in eleven years the team became world leaders in infrared technology. Starting from a spare bedroom they have now opened a factory on Route 128 as well as having launched a joint venture in Japan and set up manufacturing facilities in Europe. It had been hoped that the founder of this enterprise could have been present to give a paper on his company but the large response to the request for papers rendered this impossible.

In the American experiment it was considered that there were three essentials before innovation could take place:
1. The presence and associated actions of the entrepreneur/innovator must be assured.
2. Better understanding must exist between the innovator and private venture capital source.
3. There must be greater emphasis in engineering and business schools on curriculum related to innovation and entrepreneurship.
HAS THE EXPERIMENT BEEN A SUCCESS?

In an interim report on the experiment before the five-year period had elapsed Colton (1977) commented:

'(The Centers have) participated in the creation of over 30 new ventures, of which 23 have achieved sales in excess of $30 million, have resulted in approximately 1,000 new jobs, and have generated in excess of $6 million in tax revenues; exposed over 2,000 students to instruction and/or experience in the entrepreneurial, invention and innovation processes; and assisted in the evaluation of over 2,000 ideas for new products'.

A more recent report by Colton (1981) states in the conclusion the factors that led to the success of Innovation Centres:

'Perhaps the most important conclusion derived from the NSF's six years of experimentation on university/industry Centers (sic) is that successful Centers are built primarily upon strong leadership - both internal to the Center and external from the Federal agency directing the effort. As such, there should be a minimum of Federal contact and control. The characteristics of the university/industry participants necessary to achieve a long-term, self-sustaining relationship can be identified and achieved. Hence, the normal conflicts that arise when the needs and views of industry and the university intersect can be anticipated and alleviated before they become significant. Thus, it appears that the university/industry Centers cannot only be established but can flourish'.

PRESENT SITUATION IN THE USA

A recent private communication from Mr. Colton states that the following are currently active Innovation Centres:

- MIT Innovation Center, Cambridge, MA;
- Worcester Polytechnic Institute, Worcester, MA;
- Polytechnic Institute of New York, Farmingdale, NY;
- New Mexico Technical Innovation Center, Albuquerque, NM;
- University of Utah, Salt Lake City, UT;
- ITRAD/Oklahoma State University Innovation Center, Durant, OK;
- C.I.E.D. University of California/Santa Cruz, CA;
- Industrial Research Extension Center, University of Arkansas, Little Rock, AR;
- Center for Entrepreneurial Development, Pittsburgh, PA;
- Small Business Development Center, University of Wisconsin, Madison, WI*.

* Not funded by the National Science Foundation.
Colton comments about the future of Innovation Centres in the United States:

'By 1983, it is expected that 40 operating Centers will be in existence. It is expected that each of these Centers will primarily be involved with about 6 to 12 businesses of varying sizes initiating and conducting R & D projects leading to new commercial products and services for the participating businesses, or will be assisting in the development and growth of about six to twelve new technology oriented businesses annually.'

OUTLINE OF A TYPICAL CENTRE

Colton has suggested that a Centre has a one half to full-time Director with a permanent staff of two or three associates with four to six half-time assistants engaged at any one time on approximately twelve R & D projects with an equal number of graduate and undergraduate students. He also states that six to twelve private companies are usually associated with the Centre as co-sponsors of projects of interest to both the University and the sponsor. Projects will cover both basic and applied research in various disciplines and technologies with the hope of their leading to new products, processes or services for the sponsoring company. The costs during the first year of operation when the Centre is principally concerned with planning and organisation is approximately $75 thousand with an annual budget for a typical Centre of $200 thousand to $500 thousand. Initially, the Centres are heavily subsidised by the Government for approximately 80% of all costs but are expected to become substantially self-supporting within a five-year period (less than 25% Government support).

INNOVATION CENTRES IN CANADA

The Quebec Industrial Innovation Center was established as a non-profit corporation wholly controlled by the École Polytechnique. It is administered by a Board of Directors consisting mainly of individuals with industrial experience. The role of this board is to operate the Centre by delegating operational responsibility to a coordinating Director and to the Directors of three groups which are:

1. The Invention Evaluation Group;
2. The Technology Venture Group;

An academic programme is administered quite separately by the Dean of Academic Studies.

The Ontario Industrial Innovation Center was set up to stimulate and improve the quality of invention, innovation and enterprise formation in Ontario. The Centre is being formed as a wholly owned subsidiary of the University of Waterloo and its task is to enhance
the capability of Canadians to develop innovative ideas throughout the whole range of activities from conception to success in the market place. Sound development of both the entrepreneur and the enterprise is accomplished by providing education to upgrade skills and direct assistance to clients in developing inventions and innovations.

AN AUSTRALIAN INITIATIVE

The Royal Melbourne Institute of Technology has established a Centre for Innovation Development (CID) to promote innovation in Australia. The primary activity for the achievement of this objective will be the development and implementation of proposals for selected innovations. The proposals will be developed in an environment which provides for the interactive consideration of the market, commercial, production, technical and design factors. Inventions will be licensed by the CID to selected Australian companies. It is anticipated that 10-15 proposals will be developed annually, once the CID is fully established. It is also anticipated that the proposals selected would normally be in the area of high technology.

INNOVATION CENTRE IN SCANDINAVIA

The Chalmers University of Technology is promoting the development and transfer of university based knowledge and ideas into new or existing industries and its basic activities are to give service to innovators and entrepreneurs and spin-off companies to bridge the important phases in the innovation process. They will also carry out education in innovation and entrepreneurship.

The Technical University of Denmark has a special unit fully integrated with the University and known as the Institute for Product Development which is a special unit working on development of products on contract with industry and other organisations acting as an independent non-profit Centre.

Whilst much work is taking place within the Scandinavian Universities it could fairly be classed as Research and Development rather than in the area of Innovation Centre.

WORK BEING CARRIED OUT IN IRELAND

An Innovation Centre for small industry has been set up in Limerick and is the first of its kind in Europe. This is progressing along the lines of the American Centres but with its own characteristics and the writer believes it to be the most advanced Centre outside North America.
INNOVATION CENTRES IN THE UNITED KINGDOM

A number of experiments has been undertaken in the United Kingdom amongst which may be included:

- Centre for Industrial Innovation, University of Strathclyde Glasgow, which is a self-financing department of the University of Strathclyde. It employs a number of professional, technician and support staff and has the added resources of a comprehensive workshop, laboratory and small drawing office. A major advantage is that the Centre may enlist the technological back up of 700 academic staff from the University. It was formed in 1968 to undertake research projects initiated by academic staff, to undertake research contracts and, where appropriate, the transfer of successful research to industry together with some undergraduate and post-graduate teaching.

- Merseyside Innovation Centre, Liverpool, is an independent company sponsored by the University of Liverpool, Liverpool Polytechnic and Merseyside County Council to foster close liaison between the research activities of the University and the Polytechnic and the economic development objectives of the County Council. It is funded by the Merseyside County Council and the Inner City Partnership.

- Hull Innovation Centre has been established by the City Council and is operated as part of the Department of Industrial Development. It is funded with the aid of a 75% grant from the Inner City Partnership Fund and 25% from the City Council. There are no plans at present for active student involvement.

- Tyne and Wear Innovation Centre is controlled by an independent company, the Tyne and Wear Innovation and Development Co Ltd. The Centre is funded similarly to the Hull Innovation Centre and was not operational as of October 1981 but a number of projects were earmarked for development.

- Whitechapel Technology Centre is one of the first of its kind to be established and is specifically created to develop small companies supplying technologically innovative processes or services. It is housed in a new four-storey building with nine large units on the ground, first and third floors and 14 'genesis' - or start up - units will be available on the second floor. It is funded by the Greater London Council.

LESSONS FOR EUROPE

In view of the number of Innovation Centres becoming operational in many countries it is hoped that the EEC could take an initiative and support similar Centres in European countries. The Centres could be attached to a university or universities in which there exists both a strong School of Engineering and a strong School of Business. There should be a number of high technology organisations in the immediate environment, since all too often valuable projects
are shelved in the R & D departments of large companies, due not to any inherent fault, but rather to the fact that the new products may not be in line with Company policy. Innovation Centres could assist in the development of such products and also provide a core of mutually supportive inventors as well as providing courses in invention, innovation and entrepreneurship for undergraduates and post-graduate students.

SUGGESTED FURTHER READING


ACKNOWLEDGEMENTS

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EXPERIENCES OF THE COURSE ACTIVITIES AT THE UNIVERSITY OF OULU

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ABSTRACT

This paper describes the course activities started in 1978 at the University of Oulu in Northern Finland. The long courses (8-9 months) given to graduate engineers and small entrepreneurs attempt to combine job creation for academic people with active enhancement of small and medium sized industry in the area. Based on the experiences gained from the courses some ideas are discussed for developing the continuing engineering education in Universities which serve developing regions suffering from long-term unemployment problems.

RÉSUMÉ

Cet exposé a pour but de présenter les activités des cours de perfectionnement dispensés à l'Université d'Oulu en Finlande du Nord. Les cours longs (durée de 8-9 mois) destinés aux ingénieurs diplômés et aux petits entrepreneurs ont une double tâche: créer des emplois pour les diplômés de l'Université d'une part, et stimuler les petites et moyennes entreprises de la région d'autre part. Basé sur les expériences des cours dispensés depuis 1978 certaines idées sont discutées pour développer la formation des ingénieurs à l'Université en vue d'aider les régions en voie de développement à faire face aux problèmes généraux du chômage.

ZUSAMMENFASSUNG

The University of Oulu, located in Northern Finland, is a major University serving Northern Finland with less than 1 million inhabitants.

The University has some 7000 students and a teaching staff of about 700 people. The University has 5 faculties, namely the faculties of Technology, Natural Science, Humanities, Medicine and Education. In general, the emphasis of the University is on science and technology.

The University has, since its foundation in 1958, served the regional needs of Northern Finland. During quarter century its impact on the development of Northern Finland has been decisive, mainly through the dissemination of academically skilled people, some 70% of which have gone to work in Northern Finland.

During recent years, however, a strong demand has been placed on the University for a broader and more direct influence on the development of the area and, particularly, its industry. This demand has been intensified by the increasing unemployment rate of academic people and the population of Northern Finland in general.

At the same time, the emphasis on industrial development has shifted towards small and medium sized enterprises which are seen to have a large potential for dynamic growth and job creation. In Northern Finland the industry base is still quite small and the entrepreneurial tradition in the industrial field, although historically strong in agriculture, in the form of small family operated farms, is just emerging.

This background has lead to a new emphasis on entrepreneurship in the area. Consequently, teaching entrepreneurship and related subjects at the University has become a central issue, placing new demands on the development of the University of Oulu in general.

In the following sections the course activities of the University forming an experimental attempt to meet these objectives are described. Later their impact on engineering education is discussed and some ideas in this field are given.

2. COURSE ACTIVITIES AT THE UNIVERSITY OF OULU

Background. Course activities at the University of Oulu were started in 1978. The immediate cause was the sudden increase in the unemployment rate of academic people in Finland which also effected newly graduated engineers in many areas of technology.

Courses given by the course organization. The organization established for planning and carrying out the actual courses has 11 full-time people. In addition, every course has a full-time director assisted by a 10 member board which represents all the interest groups of the particular course. In total, some 1000 people participate in the activities and the size of the annual budget, financed almost totally
by the Finnish Labor Department, is some U.S. $ 3 million.

In 1982/1983 13 long courses (8-9 months) will be given in the fields of public management, export marketing, project export, technical development, domestic energy and industrial design. These courses are given mainly for students with difficulties in finding employment after graduation. In addition to this 6 courses are given to small entrepreneurs in separate locations in Northern Finland. Also an experimental course in entrepreneurial activities for small farmers will be started.

Most of the courses are based on learning by doing with problems taken mainly from small and medium sized firms in Northern Finland.

Objectives of the course activities. Since their start in 1978 the course activities have attempted to meet the following objectives:

1. To help employ unemployed engineers or academic people who have graduate from the University.
2. To advance small and medium sized industry in Northern Finland.
3. To create new jobs in Northern Finland.

To experimental activities in Oulu are directed towards finding an overall solution to meet these different objectives simultaneously.

3. EXPERIENCES OF THE COURSE ACTIVITIES

The preliminary experiences accumulated since 1978 can be summarized by the following.

The integration of the enhancement of the employment situation of engineers and the active improvement of the employment situation can be combined by a University under certain conditions. These conditions are:

- active support and interest by the University administration;
- availability of people interested in the work (entrepreneurs within the University);
- a small relatively independent organization within the University for planning and carrying out the activities;
- sufficient funding to finance the individual courses and long-term activities.

The course activities have emphasized the following points central to achieving success:

- interested course directors with suitable personal qualities;
- extensive personal contacts with the surrounding industrial base;
- co-operation from local organizations operating in the same field;
- sufficient financing to carry out the activities.
The lack of work experience and positive attitude towards active personal development of the graduated engineers has required intensive effort during the courses. Particularly, the gap in experience between the engineers and small business owners has demanded a lot of attention. This is only partly caused by the differences in age and life experience. In part, however, the gap is created by the deficiencies in present engineering education. Some of the effects of the experiences gained from the courses on engineering education are discussed in the following section.

4. EFFECT ON ENGINEERING EDUCATION

First, some comments on why so few engineers (or academic people in general) become entrepreneurs are given as a background of the analysis.

An immediate answer is the almost total lack of courses in subjects relevant to becoming a successful entrepreneur. Therefore, entrepreneurial activity is not considered as a viable professional alternative by the engineers graduating from the University except for very few individuals.

The experience of the author in basic engineering education since 1970 and in the experimental course activities since 1978 has lead to some general conclusions about present engineering education.

In general, engineering education has been confined mainly to technology. This means that there has been an almost total lack of emphasis on courses essential to entrepreneurial students on the economic and human aspects of engineering. Examples of these courses are:

1. Economics.
2. Systematic work.
3. Creative work.
4. Training in basic human skills (team work, human communications, personal development).

New courses in these fields are being added to the curriculum at many Universities including the University of Oulu. Of course, the problem of being able to fit the technological, economic and human knowledge required by an engineer into the limited number of years available for basic engineering education forms a fundamental constraint.

More basically, however, the deep hidden attitudes built into the present engineering education programs do not encourage entrepreneurial activities. Basically, academic attitudes encourage rapid uninterrupted advancement in a 'teaching tube' not interrupted by problems or failures.

This aim is best achieved by the student through rapid and efficient memorizing of the information given by the teaching establishment. For example, general knowledge and, particularly, the skills needed for systematic and creative co-operation with other people are almost entirely neglected.
Entrepreneurial activities, in contrast, require an entirely different attitude. Being able to make mistakes and withstand difficulty or even temporary defeat is essential to becoming a successful entrepreneur.

Based on this analysis, having creative and systematic co-operation as a basis for engineering education, instead of the mere addition of a few courses to the curriculum, would mean a fundamental change in the overall principles of a University. This change can also be viewed as balancing the curriculum to give adequate weight to the creative and emotional activities controlled by the right hemisphere of the brain.

5. OUTLINES FOR DEVELOPING ENGINEERING EDUCATION

This change of course, can only take place gradually over a period of time. In the following, some ideas are presented on how the engineering education could be changed towards a creative and active direction.

The following constraints must be kept in mind to keep the solution feasible:
1. Limitations given by the time available for the basic engineering education are made more stringent by the rapid advancement of science and technology.
2. The impossibility of changing the curriculum and the basic attitudes in a University in a short time.
3. The board professional field of the engineers. For example, there is always a demand for highly specialized technology-oriented engineers although the demand for creative and entrepreneurial generalist engineers is greatly increasing.
4. The relatively small percentage of engineering students personally interested in entrepreneurial careers.
5. The additional funding needed to carry out the new forms of teaching and practical long-term work in a systematic way.

Based on the experiences the following solution for Universities serving developing regions which experience continuing unemployment problems could be considered:
1. A small flexible organization would be formed for carrying out the basic experimental work in the form of separate courses.
2. The experiences of the organization would gradually be utilized to develop the basic engineering education.
3. The long-term goal would be to create a continuing engineering education system.

The resulting continuing education would consist of two phases:
1. Basic education curriculum including enough courses suitable for the individual interested in entrepreneurial activities as a career alternative. These would consist of e.g.:
   - economics;
   - management training;
   - development work;
- systems engineering;
- creativity;
- personal development.

2. A continuing education program for giving more assistance to an entrepreneur during the critical periods of his career. It would include a long course before becoming an entrepreneur and a systematic education program during the initial phase of starting a company. For example: at the University of Oulu, a course is planned for early 1983 for assisting the students and staff members starting a new business in cooperation of the newly established industrial park.

The resulting continuing education activities would have much in common with the co-operative programs and the Small Business Institute programs of many Universities in the U.S.A.

Of course, financing this type of continuing education through University budgets is difficult. However, because of the benefits for the surrounding society (creating new jobs, starting new firms, expansion of existing firms, enhancing the technological level of the firms) the chances of obtaining outside financing are quite good. The possible sources would be government financing for the enhancement of employment, small and medium sized industry, and private sector financing through innovation centers of foundations.

In the present prevailing unemployment situation e.g. in most of the OECD countries obtaining this type of outside financing for developing engineering education depends mainly on the innovativeness and entrepreneurship of the Universities.
ACADEMIC - INDUSTRIAL LIAISON
AN INTRODUCTION

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ABSTRACT

Improved relationships between industry and the academic world are often seen as a key to enhancing industrial performance. Universities should be able to benefit from support for research programmes and opportunities to make their teaching more relevant and interesting. Industry should be able to benefit from new ideas and developments as well as the opportunity to recruit able young people. It is perhaps surprising therefore that liaison activities and joint ventures are not as widespread or universally successful as might be expected.

It is possible to find examples of successful relationships at a formal institutional level and at the personal level, but failures and disappointments are also very common.

This paper attempts to identify the principal forms of academic industrial liaison together with some guidelines for successful relationships and pitfalls to be avoided. Activities which may prove particularly beneficial in the development of innovative and entrepreneurial ventures are highlighted.

1. INTRODUCTION

Collaboration between Industry and the academic world takes on many different forms in the various European countries. This Paper attempts to describe the major areas of collaboration and highlight some features of successful ventures. It is to be hoped that this introduction, together with the following contributions, will prompt a broad ranging debate which can assist the Working Group "Innovation" in framing its recommendations and guidelines for academic/industry liaison.

The prospect of collaboration between Companies and Universities has an immediate attraction for those not directly involved in its execution! Industry appears to need new ideas and able recruits whilst Universities need funds for new research projects and should be seeking ways to make their teaching more relevant and up-to-date. It is important therefore, to try and identify some of the reasons why collaborative ventures are not always as popular or successful as we might wish.
2. OBSTACLES TO COLLABORATION

Structural barriers between Government, Civil Service, Education and Industry undoubtedly exist in some countries, but they are far less important than the inherent differences in objectives and interests between the academic engineer and the industry based engineer. The incomplete understanding which each has of the other only serves to exacerbate the difficulties.

The academic is usually concerned to develop his understanding of the physical world using analytical techniques based upon the application of scientific principles. He is required to simplify and generalise in order to teach complex subjects in a limited time. He is constantly aware of the danger of teaching detail which may become obsolete though attention to detail is vital for successful industrial applications. Usually the academic is a specialist and must remain in the forefront of new knowledge in order to maintain his professional credibility. By its very nature however, specialisation may conflict with the ability to adopt a broad ranging, multi-disciplinary approach to engineering tasks.

The industry based engineer on the other hand generally lives in a highly competitive, technical and business environment. He is inclined to seek quick and reliable solutions to urgent problems and must have a wide range of technical "tools" at his disposal. He is often strictly accountable for his decisions and his personal position may well be put at risk if he engages in too many speculative ventures or misses too many deadlines in pursuit of the elegant or innovative solution.

It is hardly surprising then, that representatives of the two "sides" sometimes find it difficult to establish common professional ground. Every Industrialist knows that the Academics are too theoretical whilst every Academic knows that engineers in industry are often too old fashioned and unimaginative.

In spite of the obstacles, many collaborative ventures do flourish and it is hoped that a clear understanding of successful initiatives will lead to a virtuous circle of co-operation and the breaking down of barriers. A common thread running through almost all successful collaboration is the establishment of good personal relationships as a basis for mutual respect, confidence and eventually professional sympathy. Some areas of joint activity which have proved fruitful are as follows:

3. INDUSTRIALLY ORIENTED STUDENT PROJECT WORK

The word "project" is used to cover a wide range of activities. In this context it is defined as a self-contained professional engineering assignment which the student is required to carry out largely independently. It may take place in the University or in Industry but has a clearly stated objective which is of potential benefit to a host industry.

Perhaps the most important general benefit of the project appr-
Each is motivation and involvement. Efficient teaching of science and engineering principles must inevitably involve the presentation of heavily refined and structured information – there is not time to allow every student to re-discover every principle! Unfortunately, this approach can seem rather sterile to some students and may inhibit those very qualities of flair and imagination which are vital to the innovator.

As well as motivating students, projects can provide an excellent vehicle for reinforcement of teaching by requiring the application of principles away from the normal textbook example. Nothing is more convincing than use of newly discovered tools to solve a real problem.

The successful innovator must be able to acquire, by his own effort and initiative the knowledge and skills which are necessary to break new ground. Project work can provide an excellent opportunity for the development of such abilities. Good supervisors can also encourage the student to develop his own problem-solving style - a mixture of approach, technique and imagination best suited to his own personality.

Finally, project experience should give the student an early and probably, unpleasant taste of the difficulties of managing time and forecasting schedules.

All of these potential benefits accrue to individual students but it is also possible for a well managed series of projects to serve a broader purpose in developing teaching. The best results can be obtained when real projects are carried out in a wide range of industries. Companies and topics can then be selected so that work is carried out in the most successful and innovative environments and the results of such work can be co-ordinated and introduced into teaching programmes.

Projects are of course, widely used in engineering education though unfortunately not always with care and attention they require. Poorly conceived or supervised projects can be a serious drain on students valuable time and in the worst cases may teach bad habits and give a dull and uninteresting impression of industrial life.

Some important criteria for collaboration in this area include:

a. Clear definition of objectives and recommended patterns of investigations and clear understanding of educational goals
b. Regular formal reviews of progress to avoid "dead-ends"
c. Selection of enthusiastic and competent supervisors both in Industry and University.
d. Identification of "real" rather than contrived exercises preferably industry-based.
e. Verbal and written presentation of results.

4. COLLABORATIVE RESEARCH

Collaborative research programmes tend to benefit the engineering teacher rather more than individual undergraduate students,
though of course, the students benefit indirectly.

The principle advantage to the University is of course, the provision of funds. Support for research programmes is notoriously difficult to obtain and if the terms are right, industrial support is usually welcomed. In some areas of technology the most advanced work is being done in industry rather than in the universities and in these cases collaboration can provide extremely valuable up-dating for university staff.

The opportunity to pursue research interests through well funded programmes must be good for the morale of engineering teachers and help them to provide lively and topical teaching well laced with modern practical applications gleaned from industrial colleagues. Additionally, industrial research contracts can often impose upon teachers some of the disciplines and constraints which their pupils will soon encounter — an experience which must be healthy if at times uncomfortable!

Small and medium sized companies can often benefit from the sophisticated equipment which universities tend to possess, particularly for measurement and analysis. Larger companies may well be prepared to support the longer term speculative venture. Frequently post-graduate students invest enormous efforts in such activities and the best research laboratories are powerful sources of new ideas and approaches — a fact which is too often overlooked by industry.

Enthusiastic post-graduate students can also provide a vital link in the chain of bringing innovations from the concept and prototype stage through development to production. In Germany in particular, the tradition of new technology moving with the man from university into industry seems to be quite strong, an example which others could well follow. Indeed, it is apparently not uncommon for German manufacturers to place some of their latest products in the leading academic institutions for research and further development. Perhaps the greatest difficulties associated with joint research programmes are questions of confidentiality, rights and time-scales. The need for commercial confidentiality is in direct conflict with the academic desire to publish, whilst disputes over the ownership of ideas can quickly sour relationships. Failure to meet deadlines can also be a source of friction despite the difficulty of accurately predicting the course of research progress. It is essential that these issues are clearly discussed and policies agreed before programmes get under way.

Some important criteria for collaborative research are:

a. Strong industrial commitment which can survive management changes.

b. Clear benefits to the university and individual academics

c. Clear written agreement on major policy issues before commencement of project.

d. Reasonable proximity of Company and University to ensure frequent visits and interchanges.

e. Projects to form part of the continuing relationship so that personal relationships and mutual confidence can be developed.
5. INDUSTRIAL TEACHERS

The use of industry based engineers to teach specialist courses in Universities has long been a successful practice in many countries and the post of visiting industrial professor is a useful vehicle for such contributions. The reactions of both sides to this form of collaboration are almost universally warm.

It is perhaps particularly fruitful for successful young engineers who have established themselves in the profession, to spend some time in a university. As a result of their work experience they will almost certainly have ideas which they would like to develop without the day to day pressures of an industrial post. The opportunity to fulfill such ambitions while maintaining a place on the industrial ladder should release a great deal of talent for innovative and entrepreneurial ventures. Again, the opportunity for under-graduates to work with relatively young professional engineers must be beneficial and schemes which involve regular turnover of visiting engineers ensure flow of new blood through the universities and help to build the essential personal links. An example of the possible success of this type of assignment is the way in which the very successful Cincinnati T3 Robot was conceived and developed.

There are some administrative difficulties to be overcome from a teaching point of view, particularly in the area of assessment and examining where newcomers to an educational establishment may find it difficult to calibrate themselves! From the industrial standpoint there is of course, reluctance to lose the most competent young men from the main stream of the company's activity, albeit for a short and defined period. Some features of successful industrial teaching programmes are:

a. Tangible benefits to industry through access to relevant research and potential recruits.
b. Security for the industrial teacher to ensure that his position in the industrial hierarchy is not prejudiced.
c. Adequate administrative preparation by the university to ensure that the visitor is swiftly and effectively integrated into the institution.
d. Provision for a full contribution to university life by the visitor, including under-graduate teaching, research and most importantly, continuing education.

6. CONTINUING EDUCATION

Rapid technological development means that commercially successful innovations are more likely to be dependent on sophisticated engineering applications. It becomes progressively more difficult for even recently trained engineers to keep up to date and although there is a mass of literature available, time to read and assimilate it is much more difficult to find.

It is unlikely that individual institutions can support research
across the wide range of technologies, but academics are generally aware of the latest developments in their fields and therefore well placed to provide continuing education in some form. Activities of this kind have not traditionally formed a significant part of University work, but this state of affairs must be urgently reviewed and it is unreasonable to expect innovation and new technology to be developed by engineers who are lagging behind.

Continuing education in the so-called Management subjects has grown dramatically over recent decades. The requirement must now be for improved post-experience, technical education and the Universities should be taking a lead in this respect.

Some features of successful ventures include:

- Accurate identification of industrial needs.
- Professional presentation of Courses.
- Careful matching of Course style to participants
- Ample opportunity for interaction between Course members.

7. FUTURE DEVELOPMENTS

I have attempted to show that, in spite of the very real obstacles there are many successful examples of fruitful liaison between industry and the academic world. Clearly there are no infallible recipes and new developments must reflect the needs of collaborating institutions and of personalities within them. It is nevertheless important to be as aware as possible of the diversity of successful ventures and I hope that the following contributions and subsequent discussions will spark off new ideas and new initiatives. I would however, like to conclude with three personal observations:

a. Academics must take the initiative.
It is generally far easier for the academic to visit industry than the industrialist to penetrate the universities. I have almost invariably found a warm and encouraging reception in Companies, but it is vital to appear in person rather than at the end of a telephone.

b. Development of personal relationships.
Time spent in developing good informal contacts between academics and industrialists is invaluable. During a recent visit to Japan the most striking feature of the industrial-academic scene was the variety and depth of personal contact between people from industry and the academic world.

c. Continuing education.
If we are to meet the international industrial competition it is vital that the existing stock of engineers, as well as new recruits, be adequately trained and universities and companies should be developing substantial programmes to meet this need.
ABSTRACT

The technically qualified person is an important agent for innovation and change and education is a key factor in equipping him to fulfil that role.

The paper describes recent initiatives at Manchester and Cambridge which seek to meet this educational requirement.

The Manchester experience includes involvement in a 'new enterprise program' sponsored by the U.K. Manpower Services Commission and the 'Greater Manchester Enterprise' sponsored locally.

At the Manchester Business School an entrepreneurship project forms an integral part of the M.B.A. programme.

At Cambridge a new course in manufacturing engineering has provided the opportunity to bring an entrepreneurial dimension into undergraduate teaching via a product-based business proposal project. More broadly the infrastructure building up around the course is designed to produce an engineer with a solid industrial and business outlook. A post-graduate programme is tackling innovation and change in an established manufacturing operation.

RÉSUMÉ

L'Homme qui possède une qualification technique est un agent important de l'innovation et du changement. La formation est un élément clé pour l'équiper dans ce rôle.

Cette communication décrit des initiatives récentes à Manchester et à Cambridge (GB) qui essaient de répondre à ce besoin de formation.

L'Expérience à Manchester comprend la participation à un 'New Enterprise Programme' soutenu par l'organisme public la 'Manpower Services Commission'; elle comprend également la 'Greater Manchester Enterprise', soutenue par la ville. À la Manchester Business School un projet de création d'entreprises fait partie intégrale du programme M.B.A.

A Cambridge un nouveau cours de production a donné l'occasion d'apporter une dimension d'entrepreneur au programme étudiant, ceci grâce à une proposition de création d'entreprises de production. L'Infrastructures du cours a été conçu de façon à former un ingénieur possédant des connaissances industrielles et commerciales très solides.
ZUSAMMENFASSUNG

Der technisch qualifizierte Mensch ist ein wichtiger Innovations- und Änderungsfaktor. Die Erziehung ist ein Schlüssel für die Ausübung dieser Rolle.

Dieser Artikel beschreibt gegenwärtige Initiativen in Manchester und Cambridge (GB), dieses Erziehungsziel zu erreichen.

Manchester ermöglicht die Teilnahme an einem 'New Enterprise Programme', das durch die staatliche Manpower Services Commission unterstützt wird. Manchester ermöglicht ebenfalls die Teilnahme an den von der Stadt unterstützten 'Greater Manchester Enterprise'. An der Manchester Business School gehört ein Unternehmer-Projekt zum M.B.A. Programm.


INTRODUCTION

Innovation implies change. In most industrial settings this is not brought about easily. It certainly does not come naturally for most people and when organised into groups they have their own criteria. The changes resulting from technology have been far reaching and will continue to be so. There is thus an inevitability about change and about resistance to it. It is the country, industry or company that can resolve this conflict that will reap the benefits of the opportunity presented by technological innovation.

Western Europe in the 1980's finds itself at last recognising the need for change in this area but is now concerned that it does not have the means, in money and manpower, or the time to do so.

Though finance, in particular so called 'venture capital', is not the subject of this conference it plays a vital role in both innovation and entrepreneurship and we neglect it at our peril. Too often funding is inadequate and the timescale too short. For the High Technology sector, if not for others, there needs to be good collaboration between the academics, the industrialists and the financial backers. The university may be the source of the innovative idea and its development and industry may provide the entrepreneur and give him support but unless the bank enables the project to be adequately financed it will fail. The human resource is also a key ingredient and the availability of the person who can handle and direct technological innovation is of special concern. Regrettably in Western Europe such people are few in number and it is a major challenge to the educational establishments to produce them in sufficient quantity and quality and to industry and the banks to give them room to operate and genuine support. This paper gives some
examples of how this educational demand is being met. In every case
the educational activity includes a strong 'learning by doing' ele­
ment and as much industrial/business reality as is possible. The
links between university and industry are of crucial importance in
both of these areas and specific efforts have been made to establish
a framework within which they can operate.

Time and timing can decide the success or failure of a strategy.
In most companies the short term business horizon means that the
longer term requirements of technological innovation are always un­
der threat. It is in essence the same mismatch of time that so often
besets academic/industrial collaboration. There is little doubt that
industry needs a long term 'technology' strategy and that this could
afford a real opportunity for industry and thus society to benefit
from the research activities of the universities.

The importance of timing is seen in the fact that at the very
moment when these needs are being recognised we are the least able
to take the long term view - how much easier it would have been in
the business climate of the 1950's and 1960's. Nonetheless initia­
tives are being taken as this conference and many of its papers in­
dicate. The task then is to identify the more important agents for
change and provide them with adequate support. The programmes de­
scribed in this paper at the Manchester Business School and Cambridge
University Engineering Department are concerned with producing the
technological innovator and entrepreneur based on the belief that
the human resource is a key agent for innovation and change. It is
recognised that not all students involved in these programmes will
be suitable for this demanding role so the aim is to give them the
opportunity to gain some experience in a learning environment and
encourage a natural response once they have tasted something of in­
novation and entrepreneurship.

The Manchester Initiative. Job creation is an important motive, par­
ticularly for governments, for the development of the small business
sector. The U.K. Manpower Services Commission (MSC) sponsored a New
Enterprise Programme (NEP) to encourage new business formation.
The first of these programmes was set up at Manchester in 1977.
Short term evaluation of their success in terms of simple parameters
such as employment can be misleading but along one dimension at
least substantial results can be claimed. The success of the early
Manchester Business School programmes led directly to the establish­
ment of MSC-supported NEP's in several other centres, and opened up
the field of new enterprise development in the U.K. in a new way.

Some 18 NEP's have been run in four centres around the country.
The results of the first seven of these, one year after course com­
pletion, are now available. 76% of participants completing a program­
me initiated a business and its average scale at that time was an
employment level of 8 people.

In addition 42 less complex Small Business Courses have been run
at various centres, of which figures are available for the first 18.
70% of trainees completing the courses started a business within one
year, with the year-end average employment of 4 people including the trainee.

This means that taken together the New Enterprise Programmes and the Small Business Courses have assisted 536 otherwise unemployed people to create more than 500 new businesses, providing employment in their first year alone for 2,857 people. Moreover, the somewhat limited evidence available indicates continuing growth beyond year one, above average survival rates and acceptable early levels of profitability. (Ref. 1).

A more recent venture, launched in Autumn 1980, was supported on a regional basis under the heading Greater Manchester Enterprise. This was designed to encourage people who would choose to set up firms within a local region. At the end of the total programme, held at the Manchester Business School, an informal assessment was made of the prospects of success for each business being planned by the 17 participants. Two were considered unlikely to make it and four were considered possible, with a potential employment level within two years of 30 to 45 people. The remaining eleven were all considered likely to succeed, and their expected employment was between 273 and 300 people within two years. One or two in particular have the potential to employ between 50 and 500 people each within 5 to 10 years. (Ref. 2).

The two programmes discussed above take people who already have a desire to set up their own company. Educational support is provided over a period of 18 weeks in the case of the NEP's. This takes the form of lectures and field work and results in the drawing up of detailed proposals for the setting up and running of the new company. Co-operation with industry and bankers is an important element in the preparation of the business proposal. In addition to providing the necessary skills and knowledge for those who are already motivated to set up their own business Manchester Business School has also sought to expose its M.B.A. students, many of whom have science and engineering backgrounds, to enterprise opportunities. This has been by means of an entrepreneurship project which takes them through the process of setting up a new business.

A typical project would involve the students in activities such as analysis of market trends, evolution of the business environment in a chosen area, the development of ideas, evolution of alternatives and of great importance the method of implementation including financial and manpower requirements. In some cases it is possible to associate this type of project within activities on the NEP hence gaining synergy from the location of post-graduate and post-experienced people in the same institution.

Cambridge University Engineering Department. Whilst at Manchester the work has been a post-graduate and/or post-experience activity, at Cambridge it has been with undergraduates, albeit they have stayed on for a fourth year beyond the normal three-year degree course. In early 1977 the University Grants Committee in the U.K. proposed that a small number of four-year courses be set up to provide very
high quality and broadly-based engineers for the manufacturing in-
dustry. Some 8 universities were selected and finance was made avail-
able to recruit the specialist staff required.

Two important features of the Cambridge course have been its close
involvement with industry and its entrepreneurship dimension. A sig-
nificant element in the success of this approach has been the fact
that prior to starting the course proper, i.e. the Production
Engineering Tripos, the students have completed the first 2 years
of the standard Cambridge Engineering Degree Course, which has a
strong analytical emphasis.

The first year of the new Tripos includes management and finance
topics as well as engineering and these are integrated together
around a major 'New Business Proposal' project (R & D). Each team
works within an entrepreneurial scenario in which they are three
friends with specified family and financial commitments who decide
that they want to set up their own business. The team are self-
selected and they choose a product from a selected list. The project
is phased to cover Marketing, Design, Manufacturing and Finance.
Each phase is assessed by staff and people from industry and the
banks via an oral presentation and a written report.

In the final year of the Tripos teaching modules are provided on
'Marketing and Innovation' and 'Business Policy and Strategy' with
the help of the Cranfield Management School. This is in addition
to engineering teaching which focuses on major industrial sectors.
Half of this year of the course is spent on tutored industrial as-
signments generally of 2 weeks duration. The combination of theory
and practice in this way has proved most valuable as a teaching
method. The links with industry by actual participation of the
students has given a reality to their engineering and business under-
standing and for those who have begun to show an interest in entre-
preneurship an opportunity to be involved in new enterprise compa-
nies, as well as those which are more established. An important de-
velopment has been the appointment by industry of industrial fellows
to provide additional staff support. To date Ford, British Aerospace
and IBM have appointed fellows and a Teaching Company Programme with
Plessey (Ref. 4) providing a fourth person.

This infrastructure building up around the course helps to ensure
a realistic industrial and business content. The innovation and
entrepreneur dimension is specifically included. The programme at
the Plessey Company for example involves innovation and the imple-
mentation of consequent changes in a manufacturing plant. Some five
graduates are engaged on this activity and it has also been a source
of industrial assignments for the Tripos undergraduates.

Whilst the course is too new for an in-depth assessment to be made
the results this far are encouraging. The standard achieved on the
'New Business Proposal' project has been high and the industrial
assignments have produced in the students a real professional com-
petence and confidence.

Of the 11 students to complete the course in 1981 two set up their
own business and of the 18 this year five have given it serious con-
sideration and four of these are using their final 8 week industrial assignment to develop their product and prepare a business plan.

The Implications. The above are just two examples of educational initiatives which either directly or indirectly seek to prepare people and particularly the technologist for innovation and/or entrepreneurship. They accept the importance of matching scientific and technological potential to market needs with particular emphasis on the issues of management and implementation of specific projects. They show the importance placed by the academics concerned on a close working relationship with both industry and the banks. This has implications for the level of response required by the educational establishments from these sectors and the consequence of such demands must be recognised.

There is also a recognition behind these programmes that the educational input can be an important factor in promoting the entrepreneur and contributing to his or her chance of success.

REFERENCES

SMALL GROUP DISCUSSION ON INNOVATION

Discussion paper by chairman/convenor
J. Eekels
The Netherlands

Twentyfive theses concerning innovation

1. Innovate or perish
2. Innovation can refer to
   - products (businesses)
   - manufacturing processes
   - marketing strategies
   - organization
   - management style
3. Innovation has to be defined as the development of a successful new business around a new product rather than as a new product.
4. Innovation requires from the innovating company
   - motivation
   - capability
   The capability should cover at least three areas, viz,
   - technology
   - marketing
   - management
   The managerial armour comprises
   - methodology of innovation
   - organization for innovation
   - psychology around innovation
5. New business development is a design process of a multidisciplinary character. It encompasses lower level design processes such as product design, process design, marketing design, organizational design etc.
6. The multidisciplinary new business development projects should interdisciplinary be managed.
7. The industrial innovation process is an iterative process comprising amongst others:
   - product strategy formulation
   - idea-finding
   - strict product and business-development
   - realization of the business
The structure of this process can be depicted as follows:

objectives

Corporate Strategy

strategies - ideafinding - strict product-development - realization

The structure of the innovative process

8. The ideafinding process can most effectively be subdivided into
   . the generation of idea finding regions
   and
   . the generation of product ideas project

9. The innovation process, being a design process, continuously
calls for decisions in order to select from alternative courses
of action. Decisions are only possible, if one has available:
   . factual information concerning these courses of action
   . strategic (policy) information
   . operational decision criteria
   . a method to conduct the decision process

10. Decision in the innovative process can be based on
    . intuitive arguments and common sense or
    . scientific (or semi-scientific) decision procedures
The company should strive after a healthy mixture of these two
kinds.

11. The most effective way to prevent anything from happening is
to insist on rigorous scientific decision procedures.

12. The most probable way to failures is to rely completely on
intuitive arguments for decisions.

13. Sometimes a quick intuitive decision is much better than a slow
scientifically argued decision.

14. Often a quick intuitive decision is much poorer than a slower
scientifically argued decision. There is no general rule to
select between theses 13 and 14.

15. There is no cheap way to successful innovation.

16. There is no shortcut to successful innovation. Innovation
projects should be taken up rigorously, yet they take time.

17. A sound new business can only be developed on the basis of a
sound present business. Neglecting innovation or neglecting
the present business, both will turn out fatal for the industrial enterprise.

18. New business development should go hand in hand with organization-development. The establishment of the product planning function in the company can be very helpful in this respect.

19. According to the V.D.I. the following tasks can be effectively assigned to the product planning function:
   - product strategy-formulation
   - idea finding and idea selection
   - coordination of new business development
   - product surveillance, once the new product is on the market.

20. The R.O.I. (return on investment) criteria is of no use with idea selection.

21. The R.O.I. criteria is a most useful instrument to steer the new business development-process.

22. Planning for innovation never comes true. Yet it is a very powerful instrument for the management of innovation.

23. Young people should be assigned prominent tasks in the corporation's innovation process. Yet one should take care not to neglect the know-how and experience accumulated in older employees.

24. It is preferable to emphasize the structure of the output of the innovative process rather than emphasizing the procedures within the process.

25. External consultants offer prove to be of immense value for the company's innovative process.
1. INTRODUCTORY CONSIDERATIONS

The influence of innovation on the activity of Engineering Schools in the Countries which are represented within SEFI - namely, the highly industrialized European Countries - is very strong: perhaps, even more so than in other fields, such as Medicine, Physics, etc.

In this paper, after some general considerations aimed at analyzing the contents and the various features of this influence, particular attention will be paid to the Italian situation in order to highlight some of its aspects.

From the point of view of the activities intended to produce innovation, the field of Engineering can be schematically subdivided into three sectors:

- a first sector, where advanced scientific research presses on ancient cultural frontiers and gives rise to innovative processes which have an extraordinary fallout in the social, economical and political context: New-Energies-Engineering (from Controlled Thermonuclear Fusion, to Photovoltaic Energy Conversion, etc.), Bio-Engineering, Planning Engineering, System Analysis, etc., belong to this sector;

- a second sector, characterized by research carried on in very dynamic and rapidly developing industrial fields, where innovation is mainly aimed at the progressive optimization of devices and technologies which are substantially already known: one can think of Electronic Engineering, Aerospatial Engineering, Chemical Engineering, Nuclear Engineering and so on;

- finally, a third sector in which scientific research is progressively exhausting in a technical and scientific finishing-work that has the character of development more than of a true scientific research: it's enough to think of many fields of Mechanical Engineering, Structural Engineering, Hydraulic Engineering and so on.

The Engineering Schools fully fit into this context of research development and contribute to all three sectors, even if in different ways.

In particular, it is evident that the research characterizing the first sector is typical of the university activity. Very often it is a matter of study and research crossing over the cultural bounda-
ries of traditional Engineering, trespassing onto many different fields: from the Mathematical-Physical field, to the Biological one, to the Economical one and so on. From this point of view, people working on these frontiers are often considered almost like 'strangers' with respect to the central core of the engineers professional activity. However, they play an essential role for a proper development of the university activity, for many reasons:

- first of all, it is often just from these areas, which are at present frontier-areas, that new important fields of Engineering and Technology could develop in the near future (typical was the example of Electronics in the last two decades);
- secondly, these activities enrich the cultural framework of Engineering with new subjects;
- finally, they oblige to reconsider old concepts and models from new standpoints.

The cultural contribution of the University to the second of the previously cited sectors is as clear as the preceding one, even if for partially different reasons: indeed in this case, a part from specific contributions to research (which sometimes is not perfectly suitable to the peculiar characteristics of the university activity), the typically academic contributions appear. We refer to that fundamental work of logical organization of the developing disciplines, of cultural systematization which is indispensable to both the transmission of knowledge and its future elaboration.

Strictly related to this kind of activity is the work, carried out in the Engineering Schools, in connection with the third of the above cited sectors. In this case, also the cultural systematization work has been mainly performed, at least as far as its guidelines are concerned, and therefore, it is a modest incentive for the original elaboration.

However, these kinds of original elaboration, even though modest, together with a deep study of the existing theories and models, reveal themselves as a fundamental tool for the development of the knowledge: they are aspects of an operation of 'cultural maintenance' without which the cultural 'tool' could not be transmitted efficiently to those who will have to use it after us.

In this field of activities, studies are appearing which begin to lay the foundations of an 'historical awareness' of technological development, by studying and mastering theories and techniques which - even if obsolete - enable to better understanding the present status of our knowledge.

To summarize, one would feel tempted to conclude that, perhaps, the cultural level of an Engineering School could be measured just by its capacity to harmonize each of the various above mentioned activities, by showing on one hand attention and consideration for research engaged on new frontiers (by assuring them an adequate cultural and academic space), and on the other hand by stimulating that cultural maintenance operation which can be carried out only by the University.
2. THE ITALIAN SITUATION

The situation of Italian University, although a phase of remarkable transformation has started, due to the recent reform, fits rather easily in the attempt of analysis above presented.

The fields of Mechanical Engineering and Civil Engineering (where an entrepreneurial activity playing a role comparable to that of other industrialized Countries is present) show a consolidated cultural structure and the education also has found a well established line of exposition, at least in its general aspects. The incoming innovations are easily inserted in the existing context and do not produce significant changes in the guidelines of exposition of the various disciplines.

From this standpoint, typical was the way of utilization in these fields of computers which, on one hand have obviously made it possible to solve problems which have been considered as extremely difficult up until now, while on the other hand they have often limited themselves to making use of well established theories and models without substantially the guidelines of exposition of the various disciplines.

In these fields, besides the critical reflection on the existing cultural framework, a first significant awareness (at an educational level) of new socio-economical needs is growing: typical are the cases of the Universities of Udine and Cosenza, where two new kinds of Engineering have been introduced:

- Engineering for Soil-Defence and Territorial Planning;
- Engineering of the Industrial Technologies.

The situation is different in other fields, where to an industrial situation continuously developing under the push of incessant innovations, a cultural framework corresponds which only recently has set up the first significant attempts of general systematization. This is the case, for instance, of Electronics and Computer Science, that were presented up until few years ago as just a collection of applications not yet ordered by a definite line of logical development. In these fields a process of logical organization of the various disciplines is developing, also under the push of the growing diffusion of System Analysis, the knowledge of which starts to be considered as compulsory for Electronic Engineers.

Even more different is the case of urbanistic planning, where recently remarkable changes have occurred. The cultural core of this discipline was born in the context of Architecture, but, from the sixties, in connection with the development of System Analysis and of the techniques for the data elaboration, the tendency is emerging to substitute the old, fundamental concept of 'planning as a design of the future desired forms' with the new concept of 'planning as a guide and control of the changes', for a given collectivity. This tendency, which produces at a practical level noticeable innovations in the legislation and in the Policy of the Central and Local Governments, implies several new hints from the educational point of view. Many new subjects reveal themselves necessary for the forma-
tion of Town-Planners: from Management, Operational Research and System Analysis, until Economics, Sociology, Ecology and so on.

Finally, as far as the 'frontier-fields' of Engineering are concerned, the situation is remarkably different in comparison with the above described ones. Research in the New Energies fields (from Controlled Thermonuclear Fusion, to Photovoltaic Conversion), in Biomedical Engineering and so on are not negligible in the Italian Engineering Schools (from Milan, to Padua, to Naples, etc.), even if it is not uniformly diffused in the Country. From the educational point of view, the status of these fields is at an embryonic level: few are the existing courses (even if several Italian Universities are planning to include some of them in their curriculae). To give an idea of the situation, it's enough to say that only Padua and Naples have introduced a course on the Controlled Thermonuclear Fusion.

The introduction of PHD Courses due to the previously cited, recent reform, begins to give an increasing cultural and academic space to these fields.
ANPASSUNG DER INGENIEURAUSBILDUNG AN INNOVATIONSPROZESSE UND DEN FORTSCHRITT IN WISSENSCHAFT UND TECHNIK

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Interuniversitärer Arbeitskreis Curriculum-Entwicklung Bauwesen
Maria Rain, Sipperhog, Austria


- Allgemeine Architektur, Entwerfen von Hochbauten;
- Konstruktiver Hochbau;
- Städtebau, Raumplanung und Raumordnung;
- Bauökonomie (Baubetrieb und Bauwirtschaft);
- Innenarchitektur, Innenraumgestaltung;
- Garten- und Landschaftsarchitektur;
- Denkmalschutz, Baupflege, Konservierung, Restaurierung;
- Bauen in den Tropen und in Entwicklungsländern;
- Haustechnik, Energietechnik Bauwesen.
Der innovatorische Charakter der Lehrplan-Fortschreibung ergibt sich aus der Ausweitung der Studien-Fachrichtungen, z.B. auf Bauen in den Tropen und in Entwicklungsländern, Energietechnik im Bauwesen.

Aber auch die einzelnen Lehrveranstaltungen sind der Weiterentwicklung der Wissenschaft angepasst. Als wichtige Beispiele werden angeführt:

AA Mathematik 4 - EDV -
Überblick EDV-Anwendung
1.4.1. Mathematik.
1.4.2. Baustatik, Festigkeitslehre, Tragwerkslehre.
1.4.4. Vermessungswesen, Massenermittlung, Trassierung.
1.4.5. Kostenplanung, Kostenoptimierung.
1.4.6. Bauzeitplanung, Bauzeitoptimierung, Netzplantechnik.
1.4.7. Ausschreibung, Abrechnung, Kalkulation, Rechnungswesen.
1.4.8. Statistik, sozioökonomische mathematische Modelle und Simulationen.
1.4.10. Rechnergestütztes Entwerfen, Funktionsoptimierung.
1.4.11. Rechnergestütztes Zeichnen.

AF Mathematik 5 - EDV -
EDV-Anwendungs-Seminar Mathematik, Baustatik, Festigkeitslehre, Tragwerkslehre.

AF Mathematik 6 - EDV -

AF Mathematik 7 - EDV -

AF Mathematik 8 - EDV -
EDV-Anwendungs-Seminar Statistik, sozioökonomische Modelle und Simulationen, Flächennutzungsinformationen, rechnergestützte Entwicklungsplanung, rechnergestütztes Entwerfen, Funktionsoptimierung, rechnergestütztes Zeichnen.

AF Bauphysik 2
2.2.1. Wärmeschutzverordnungen, Energiesparverordnungen.
2.2.2. Wärmeschutzoptimierung im Energiesparenden Bauen.
2.2.3. Baulicher Wärmeschutz (aktiv und passiv).
2.2.4. Fallstudien Wärmeschutz, Energiesparendes Bauen.
AF Bauphysik 8
2.8.1. Strahlungsquellen, Grenzwerte für Gefährdung durch Strahlung.
2.8.2. Baulicher Strahlenschutz (besonders in Isotopenlabors, Röntgenräumen, Materialprüflabors).
2.8.3. Strahlenschutzbauwerke, A-B-C-Schutzbauwerke (Zivilschutzanlagen).
2.8.4. Strahlenschutz im Reaktorbau (in Kernkraftwerken).
2.8.5. Schutz gegen elektrische und elektromagnetische Felder.
2.8.6. Fallstudien Strahlenschutz.

AA Baukonstruktionslehre 3
Sonderkonstruktionen.
6.3.1. Fertigbausysteme (Tafelbauarten, Gerippe-Montage-Bauarten, Raumzellenbauarten).
6.3.2. Weitgespannte Tragwerke, Raumtragwerke.
6.3.3. Leichttragwerke (Stahleichtbau, Seilnetze, Kunststoffschalen, dünne Betonschalen, pneumatische Konstruktionen, Zelte, Fliegende Bauten).

AF Baukonstruktionslehre 4
Baukonstruktionen für die Tropen und Entwicklungsländer.
6.4.1. Erdbebensichere Tragwerke.
6.4.2. Low-Cost-Baukonstruktionen, z.B. Lehmbau, bewehrter Lehmbau, Bambuskonstruktionen, einfache Ausfachungen, einfache Dachdeckungen, einfache Bodenbeläge).
6.4.3. Erdüberdeckte Dachdecken.
6.4.4. Einfache Haustechnik (Low-Cost-Selbstbau-Herd, Wasser und Abwasser, Sanitärbereich, Biogasanlagen, Eltanlagen).
6.4.5. Solaranlagen für Warmwasserbereitung und Kühlung.

AF Haustechnik 2
Energietechnik, Energiesparen.
7.2.1. Grundlagen der Energietechnik.
7.2.2. Solartechnik: Kollektoren, Energiedächer, Energiewände, wärmepumpentechnik, Speicher.
7.2.3. Bivalente Heizungsanlagen.
7.2.4. Niedertemperaturheizungen (Fussbodenheizungen).
7.2.5. Wärmerückgewinnungsanlagen.
7.2.6. Baukonstruktionen mit stark erhöhtem Wärmeschutz.
7.2.7. Regeltechnik, Gebäudeautomation.
7.2.8. Passive Sonnenenergienutzung, Solararchitektur.
7.2.9. Optimierung Baukosten - Heizkosten.

AF Städtebau 4
Umweltschutz und Umweltvorsorge.
9.4.1. Umwelt - Mensch - Gesellschaft (Entwicklungen, Belastungen, Tendenzen, Prognosen).
9.4.2. Begriff und System menschlicher Umwelt, Ökosysteme, Humanökologie.
9.4.3. Landschafts- und Naturhaushalt (u.a. Boden, Wasser, Vegeta-
9.4.4. Raumordnung, Landesentwicklung, Bauleitplanungen und Fachplanungen aus der Sicht der Umweltpolitik.

9.4.5. Belastung der Umwelt, Immissionen (Teilbereiche des Umweltschutzes und der Umweltvorsorge).

9.4.6. Ökologisch-gestalterische Beiträge zu Gesamt- und Fachplanungen.


9.4.8. Umweltpolitik, Umwelcharta.

9.4.9. Umweltrecht.

AF Baubetriebslehre 3
Baurationalisierung.

10.3.1. Grundlagen und Arbeitsmittel der Baurationalisierung, Gesetzliche Grundlagen, Baurationalisierung als Sonderleistung.

10.3.2. Rationalisierung der Planung: Optimierung Bebauungsplan und Erschliessung, Baumassen- und Grundrißoptimierung, Tragswerksoptimierung, Optimierung Ausbau und Haustechnik.

10.3.3. Rationalisierung der Bauzeitplanung und Baukostenplanung, Methoden der Netzplantechnik.


10.3.5. Rationalisierung der Bauausführung: Baustelleneinrichtung, Maschineneinsatz, Bauablauf, Taktverfahren, Entflechtung des konstruktiven Details.


10.3.7. Formblätter, Checklistentechnik, EDV-Software.


Die Standard-Lehrpläne und Standard-Lehrinhalte der IACEB sollen keinen verbindlichen, sondern einen empfehlenden Einfluss auf die Gestaltung autonomer Lehrpläne und Lehrinhalte haben. Durch multimediale Lehrmaterialien, die auf den Standards basieren und die in Autorengemeinschaften der in der IACEB mitwirkenden Fachleute bearbeitet werden, kann aber ein erheblicher Einfluss der Standards auf die Architekturausbildung erwartet werden, besonders auch deshalb, weil diese Lehrmaterialien gleichzeitig für den deutschen, englischen, französischen und spanischen Sprachraum inhaltsgleich bearbeitet werden.

Im IACEB kooperieren z.Zt. weltweit mehr als 400 Universitäten und Hochschulen mit Lehrangeboten zu Fachbereichen des Bauwesens. Es darf erwartet werden, dass von diesem Arbeitskreis entscheidende Impulse für eine Qualitätssteigerung der Ingenieurausbildung und die ständige Anpassung an Innovationsprozesse und an die Fortschritte
BERATUNG HANDWERKLER UND KLEININDUSTRIELLER UNTERNEHMEN DURCH DOZENTEN DER FACHHOCHSCHULE MÜNSTER

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ABSTRACT

This paper contains a discussion on subjects like: consultant, consulting engineer, technical college/university, staff, innovation, firm, subsidy, assistance, research & development, government.

Technologisches Know-how wird in zunehmenden Masse entscheidend für die Zukunft der Unternehmen und die Sicherung der Arbeitsplätze im nationalen und internationalen Wettbewerb. Die Entwicklung neuer bzw. die Weiterentwicklung vorhandener Produkte und Technologien stellt kleine und mittelständische (bis etwa 500 Personen) Unternehmen vor immer schwerer lösbare Probleme. Im Vergleich zu großen Unternehmen haben sie weder Mittel, noch Einrichtungen und geschultes Personal um Innovationen bis zur Produktionsreife durchzuziehen. Gleichzeitig besteht an Hochschulen ein immenses Potential an Wissen und Kenntnissen und auch die Bereitschaft zur Weitergabe dieses Potentials. Auch die technischen Einrichtungen wie Messgeräte, Rechner usw. sind im Allgemeinen vorhanden. Eine Zusammenarbeit zwischen kleinen Industriebetrieben bietet sich also regelrecht an. Trotzdem wurde sie nicht oder kaum praktiziert!


Im einzelnen werden drei Hauptaufgaben gesehen:
2. Beratung bei neuen Technologien. Hier geht es um die technischen Möglichkeiten bei Innovationen und Neuprodukten.

Es sollte nicht unerwähnt bleiben, dass insbesondere für länger als 8 Stunden dauernde Intensivberatungen auch freiberufliche Berater, Ingenieurbüros sowie einschlägige Fachinstitute unter den o.g. Voraussetzungen in Anspruch genommen werden können.

Wie immer stellt sich bei neuen Produkten und auch bei auftretenden Schwierigkeiten das Problem der Vertraulichkeit. Das Problem wurde so gelöst, dass alle Tatsachen und auch der Umstand der Beratung selbst vertraulich behandelt werden.

ERRATA TO THE PROCEEDINGS OF THE 1982 SEFI-CONFERENCE

Page 207: title - please read

FACHAUSBILDUNG UND ALLGEMEINBILDUNG
EIN WANDEL IN BERUF UND AUSBILDUNG DES INGENIEURS

Dietrich von Queis
Hochschule der Bundeswehr Hamburg
BRD

Page 392: caption Fig 5 - please read

The Loughborough Locstitch Machine (Pickering Limited, 1971)