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New Engineering Curricula in Germany: an Attempt to Modernise and Globalise Engineering Education*

Klaus Detert
Faculty of Mechanical Engineering, University of Siegen, D-57068 Siegen, Federal Republic of Germany

The paper describes attempts to modernise engineering education in German universities by introducing new curricula directed towards globalisation. Also, it is expected that the introduction of English-style degrees will attract more foreign students to study in German Technical Universities and Universities for Applied Science (Fachhochschulen). The potential for these attempts to fail, because they do not properly address the real issue of modernisation, will be explained.

INTRODUCTION

In recent times many German Technical Universities and Fachhochschulen (University of Applied Science) have implemented new curricula in order to modernise academic engineering education according to guidelines developed as part of the updated German *Law on Academic Education,* a law that establishes a framework for the reformation of education in academic institutions [1]. Section 19 of the Law specifically addresses the trial introduction of new curricula with degrees similar to those in the Anglo-American system.

In 1998 the German Association of Engineers (VDI) also argued that modern academic engineering education in Germany required a new curricula and should introduce Anglo-American degrees, namely Bachelor and Master's degrees, in place of the German Dipl-Ing [2]. This recommendation came as a surprise since the VDI had only a year earlier expressed its reservation about the introduction of new courses that would lead to Bachelor and Master's degrees [3].

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THE OBJECTIVES OF THE NEW ENGINEERING CURRICULA IN ACADEMIA

The argument for the introduction of new curricula is based on the following:

- Throughout the educational process and formation of future professionals and world-citizens, modern academic education must address the challenges of globalisation, a feature of modern life that includes the global interrelation of politics, economy and human society. Due to the increasingly global nature of engineering practice, engineering education must in particular comply with this demand.
- Studying in Germany must become more attractive to foreign students. It has been observed that there is less interest from foreign students in studying in Germany than has formerly been the case. It is felt that the German education system is failing to meet the challenge of globalisation and is therefore losing in the highly competitive global education market. This could prove to be a severe handicap for German engineering education.

Politicians and educators alike are demanding that the German education system therefore adopt the Anglo-American tertiary system as, it is claimed, that would open the system up to globalisation and would encourage more foreign students to study in Germany.

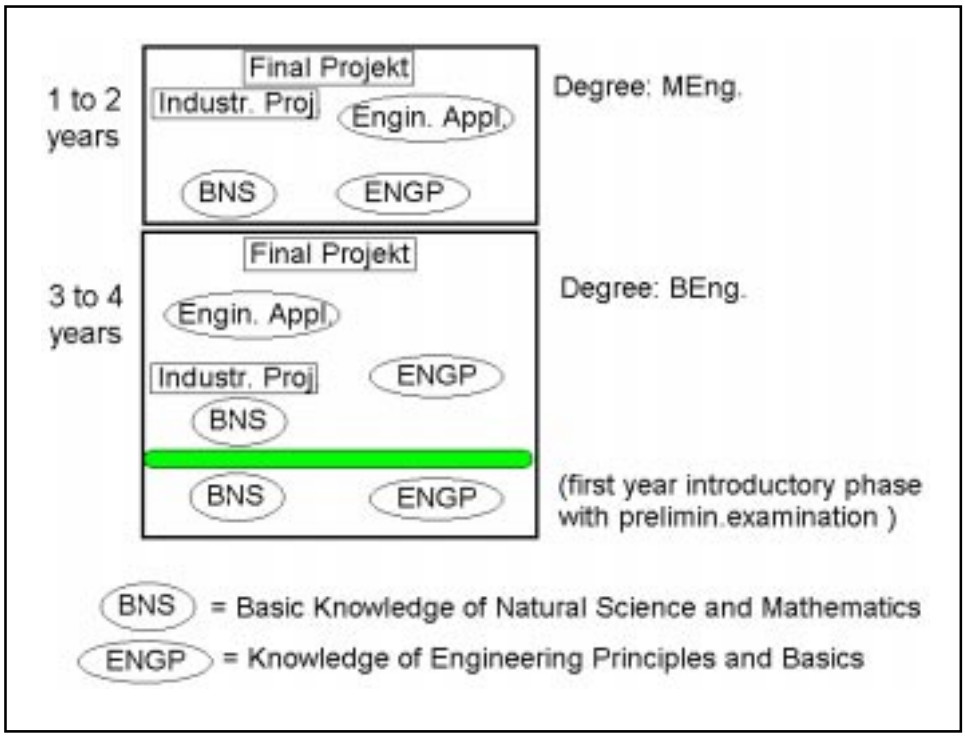

Figure 1: Structure of the new curricula in Germany with Bachelor and Master's degrees [2].

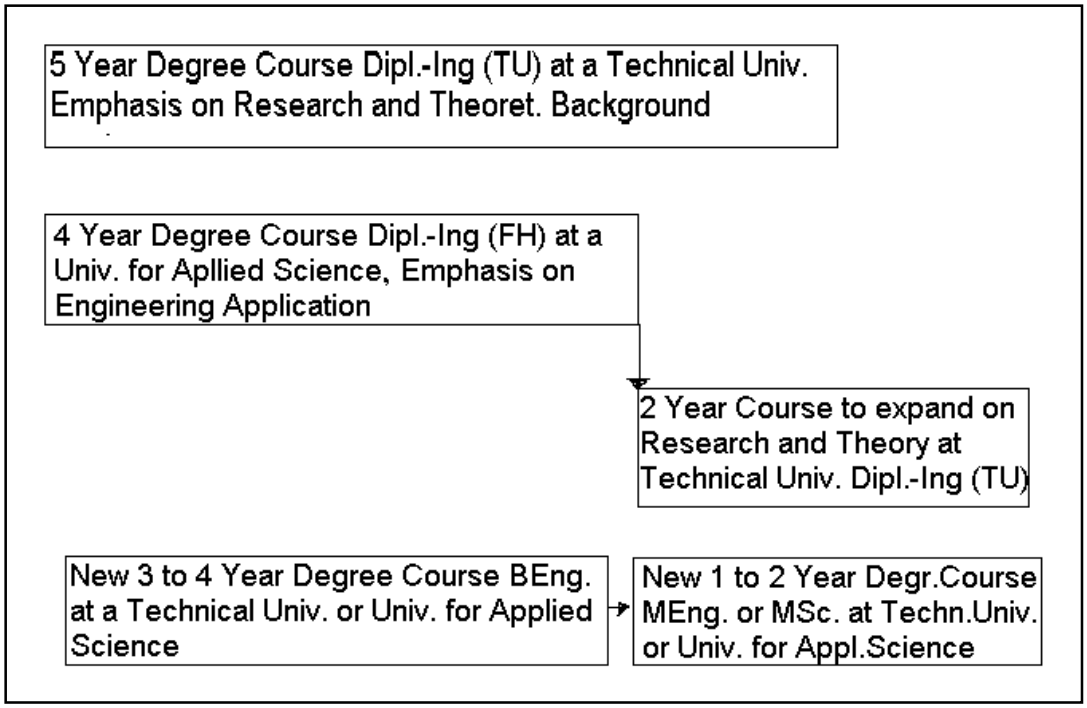

Figure 2: The system of engineering education in Germany.

GLOBALISATION AS ARGUMENT TO PROMOTE NEW CURRICULA IN ENGINEERING EDUCATION

Figure 1 depicts the VDI's recommendations for the re-organisation of the engineering curriculum [2]. It can be seen that the general structure of the curriculum and nomenclature for qualification are essentially those of the Anglo-American system. On successful completion of three to four years of study, students can graduate with a Bachelor of Engineering (BEng) degree, allowing them to commence their professional career in industry. A further one to two years of post-graduate study will allow students to graduate with a

Master's of Engineering (MEng) or Master's of Science (MSc) degree.

It should be observed that this recommendation is primarily concerned with the structure of curricula and that no reference is made to the requirement of the Anglo system that qualification as a professional engineer requires an accredited period of professional experience. The main difference between the old and the proposed engineering curricula is the replacement of a unified structure with two consecutive parts. The first part of the curricula, ending with a Bachelor degree, is less comprehensive than the current curricula, but it is sufficient for the graduate to commence their professional career; however, a graduate can strengthen their knowledge by opting for the postgraduate programme.

The proposal is that both types of German university offer these courses; the consequence would be that the Fachhochschulen will provide a more extensive academic programme than currently, and the technical universities will be able to release a proportion of their students into professional practice sooner. The introduction of the new curricula would obviously blur the current distinction between the objectives of the two forms of tertiary institution; Figure 2 indicates differences between the existing and proposed engineering curricula.

A central issue for the curricula in any engineering education must be continuous adaptation to the progress of technology; subject syllabi and the structure of curricula must therefore be continuously changed. The changes proposed above - the introduction of new curricula and subjects and the development of a new type of university - characterise such a progressive ethos, one that finds further fuel and justification by the supposedly *necessary* push for globalisation. With the competition to attract students and resources only likely to worsen in the future, the discovery of effective responses to these necessary changes will determine the survival of technical universities.

Since the Industrial Revolution, strong competition between states, enterprises and individuals for mere economic survival has been characteristic of existence for many. The progress of technology has played a dominant role in all of this, and for that reason there is always a demand for competent engineers who are able to create technical innovations. Much attention is therefore given to educating students to become competent engineers. The number of opportunities to accelerate the progress of technology through the global network of co-operation and competition in industry and the scientific community is probably unique to our time. Modern engineering education must take advantage of these opportunities, which can be characterised as follows:

- A worldwide expansion of industry

  For example, the so-called economic *tigers* of Southeast Asia.

- An increase in the number and reputation of NGOs

  NGOs are worldwide organisations that are not under the direct control of a national government. Today NGOs exert a deciding influence on the global progress of technology.

- An increase in mobility

  Modern air travel, made possible by the development of jumbo aeroplanes and electronic navigation, has considerably reduced the time needed for intercontinental travel and thereby contributes to the creation of international links and the worldwide transfer of technology.

- Improved electronic communication

  The opportunity to exchange information cheaply has been immensely enlarged through satellite communication and Internet technology.

The question has been raised as to whether the Anglo-American system of engineering education is any better than the German system in terms of adjusting to the progress of technology. It can be observed that several highly respected universities in the USA, Great Britain and other English speaking countries have demonstrated the ability to adjust their engineering education very effectively to the demands of the technical world, but it is possible to conclude that it is not the structure of their courses and curricula that allows them to do so. These universities have considerable flexibility to develop their own profile, unlike German institutions, which must strictly comply with governmental rules and regulations; they possess a management structure that is reminiscent of corporate structures and can draw upon financial resources that allow greater management flexibility than is true of the management of German universities. These non-German universities have greater liberty to hire well-known academic teachers, and to establish co-operative ventures with industrial enterprises. On the other hand, they must constantly compete to attract students and to receive grants for research and development projects in order to survive.

Before the German system adopts the Anglo system, it is also worth observing that the British Engineering Council is currently attempting to restructure the engineering courses in British technical universities, with the objective of offering two courses in parallel (Figure 3). After three years of successful study, students will graduate with a Bachelor degree (BEng) as an Incorporated Engineer. A new four year course will allow students to graduate with a Master's degree (MEng), and, after four years of qualified industrial experience, to receive the title of Chartered En-

gineer. This new system proposed for adoption in Britain closely resembles the current German system of engineering education, where technical universities and Fachhochschulen (Universities of Applied Science) offer courses that are distinguished in their objectives and requirements.

It is therefore questionable whether the introduction of an essentially Anglo-American system will be the solution that many German politicians, educators and managers in industry believe. If only for demographic reasons, a change in the German system of education is very urgently needed however. Within the next forty years, the German population will fall from about 80 to 68 million, and the population will age, with a drastic decrease in the number of younger people relative to the older population (Figure 4). Already this decrease has had an impact on the number of engineering students, and has raised concerns amongst engineering associations and industrial enterprises that there will not be enough well-educated personnel for an economy that depends on the export of modern technical products. In short, attracting enough students to study engineering is not simply a matter of survival for German engineering schools and technical universities, it is also a matter of survival for the German economy.

STUDENT EXCHANGE AS ARGUMENT TO PROMOTE NEW CURRICULA IN ENGINEERING EDUCATION

The issue of globalisation also has important implications for international competition between universities to attract foreign students. It has been claimed that German universities are now less attractive on the international education market, although statistics, which show a continuous increase in the number of foreign students choosing to study in Germany, do not support this claim [5]. Nevertheless, one could ask why German technical universities might be less attractive to foreign students. An aspect of globalisation in education is the establishment of common standards, so one can ask: *why should a student study engineering abroad when it is possible to study the same subject, to the same standard, at home, when studying abroad can require the student to learn engineering in a foreign language, with higher expenses and over a longer period, without the assurance that the degree obtained will be acknowledged at home?*

This question indicates mayor obstacles for many against studying abroad:

- A higher cost of living and admission fees
- Teaching in a foreign language with different technological terminology
- An unfamiliar system of education with a different curriculum and problems with recognition of qualifications gained or study undertaken abroad

Germany has the advantage that there have been no admission fees for students. Nonetheless, English speaking countries have the considerable advantage that English is pretty much the universal language in technology and engineering. Furthermore, the liberal German education system does not provide rigidly defined course structures, which can prove to be problematical for foreign students as they must put much

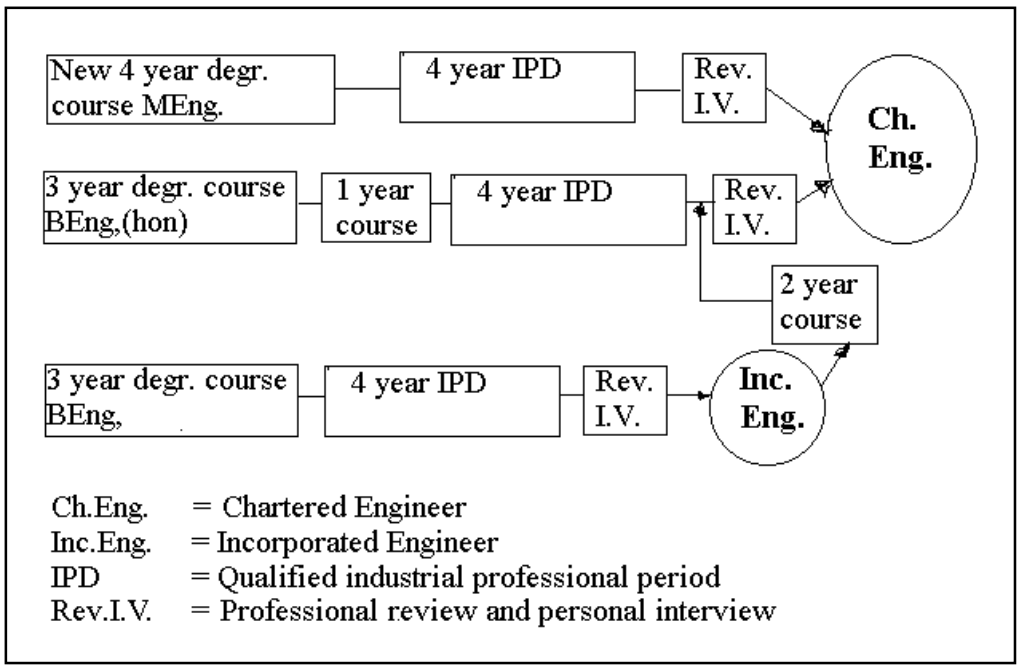

Figure 3: The system of academic engineering education in the United Kingdom (Sartor 97).

effort into planning and organising their own curriculum, a complex task for those who are familiar with the system, let alone for those who are new to it.

It is hoped by some that the introduction of a new Anglo-American curricula, comprising Bachelor and Master's degrees, will make acceptance of German degrees abroad far easier. However, this position neglects the fact that approval of degrees and curricula is an obligation of a country's national authorities, and that simply changing the names of degrees does not at all guarantee that German degrees will be accepted outside of Germany.

In spite of all of these obstacles, foreign students have continued to study engineering in German universities. Why? It seems that the special challenge to succeed in an unfamiliar environment and to learn to understand a different country and its culture has well balanced the obstacles in the past. The different engineering curriculum and well accepted Dipl-Ing degree has attracted, and continues to attract, students because they expect to receive a thorough grounding in engineering principles.

RECOMMENDATIONS FOR ADAPTING GERMAN ENGINEERING CURRICULA TO GLOBALISATION

The most important task in the reformation of German engineering education is to prepare German universities for global competition in the market for education. It is crucial therefore to allow German universities to have the flexibility to adapt their educational system and their engineering curricula to the demands of technology and society so that they can survive in the competition to attract students. An effective management structure is a prerequisite, as is the ability for an institution to develop its own profile according to available resources and co-operative agreements. Global co-operative agreements between universities, administrative authorities, industrial enterprises and engineering associations are necessary if there is to be a global engineering education. Co-operation with national engineering associations and international NGOs concerned with engineering education must be established in order to secure worldwide approval of universities' educational activities. Widely accepted objectives of engineering education are:

- imparting *basic knowledge in natural science and technology,* which is required for any engineering application;
- teaching *engineering application,* the application of knowledge to promote technical progress;
- providing *competence to perform engineering tasks,* which includes the ability to collaborate and communicate within a team of experts, and to accept responsibility for the management of an engineering project;
- developing *a responsible character*;
- encouraging participation in *the political dialogue*

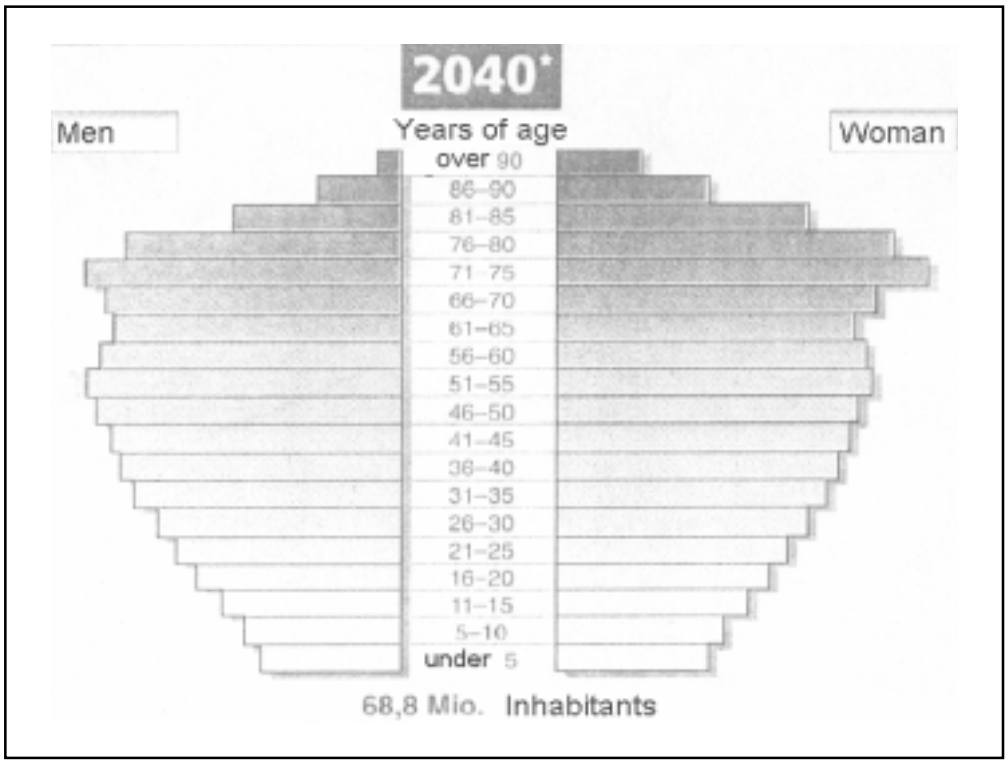

Figure 4: Predicted population growth in Germany.

to defend the position of technical progress in the global development of human society.

On the whole, no new curricula are required to meet these objectives, since many German universities have already developed their study programmes to achieve these ends. The implementation of new curricula has been used in the past as a means of overcoming resistance in organisations to change, and in some circumstances it may be well justified to introduce a new curricula that will attract students; however, the provision of technical competence must remain a priority in any new curriculum.

In 1995 the German Association of Engineers (VDI) proposed a structure for modern engineering education (Figure 5) [6]. The VDI has accepted the idea that it is impossible to include all mayor subjects of engineering application in a course of study, and that 60% of a course should comprise the basics of natural science and engineering principles. Only 20% should be devoted to engineering application, which will demonstrate how the basics are applied to modern technology. A further 20% should be devoted to interdisciplinary subjects. It is implicit to this recommendation that attempting to impart all new aspects of modern technology to students is pointless, since most of it will be superseded by the time graduates commence their professional career. Far more important for the graduate is the ability to solve engineering tasks, a competence that is based on an understanding and application of scientific and engineering principles, and which therefore transcends technology. On the other hand, young students should not be repelled by too much theory, since the majority of engineering students do not want to study theory but want to accomplish something that is practical and useful. An option is to teach more theoretical subjects as case studies, a practice that demonstrates the application of engineering theory, and stresses the interdisciplinary

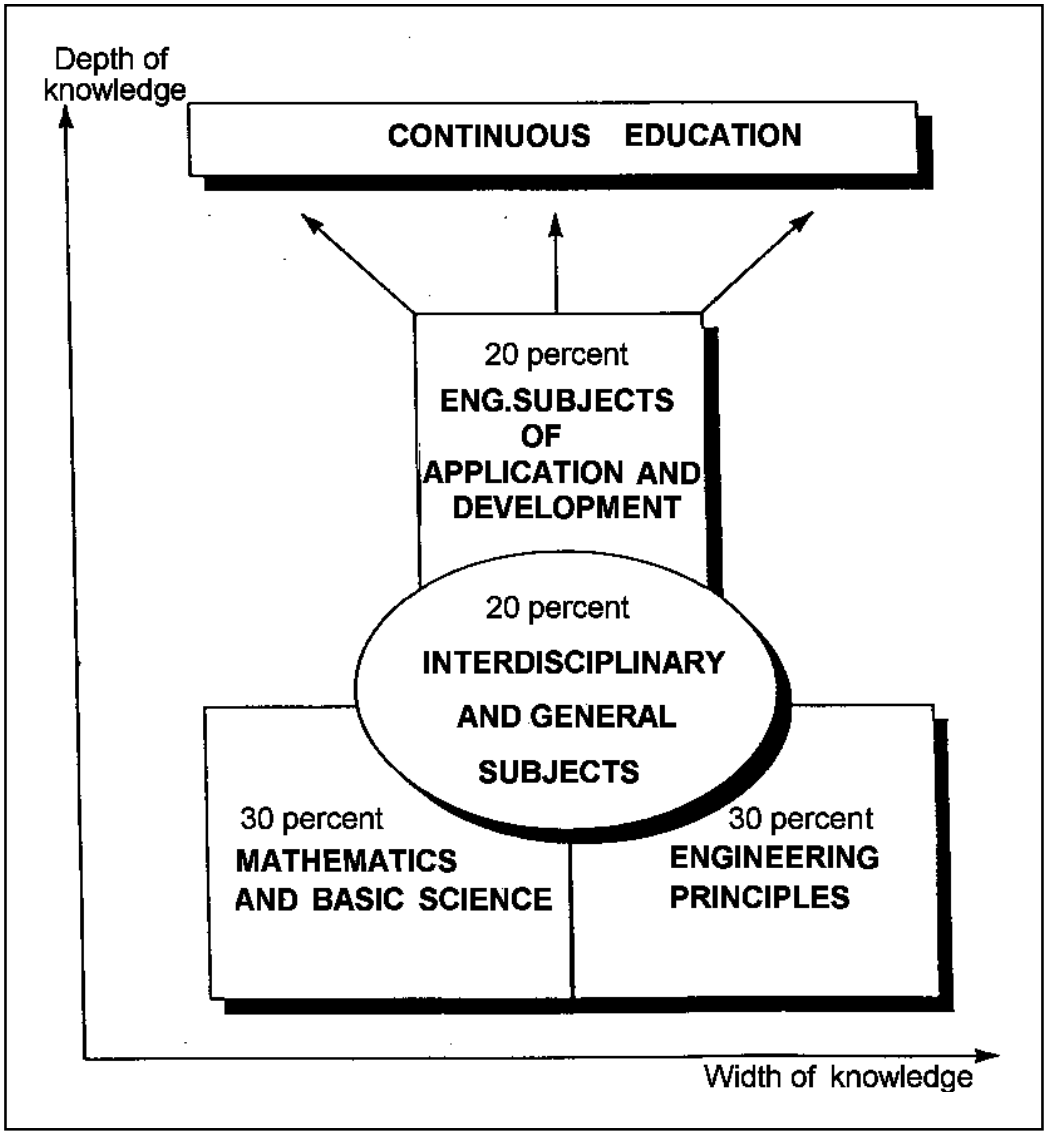

Figure 5: Programme of an engineering curriculum [6].

approach to the solution of engineering problems. Collaboration with industrial enterprises through project work will expose students to the real operating conditions of industry and will teach them to consider the relations of any new technical product with the whole environment:

- Economic: is it economically feasible to produce the product? Is it profitable?
- Social: what are the social consequences of producing the product? Will it maintain or even expand employment? Does it have consequences for the economic welfare of the community?
- Environmental: will production have an impact on the natural environment?

From these few observations it is possible to appreciate why modern engineering education must be interdisciplinary. A modern engineer must be aware that the profession operates within a global economic, social and ecological framework. This kind of thinking is more than globalisation.

RECOMMENDATIONS TO ATTRACT FOREIGN ENGINEERING STUDENTS TO GERMAN UNIVERSITIES

Attracting foreign students to a university does not only indicate success in the global competition for students, but also serves as a convincing measure of its global reputation and ability to offer a modern and interesting curriculum. Any effort that reduces the difficulties of foreign students to study in German universities is therefore worthwhile:

- Many German institutions offer grants to foreign students in order to relieve the burden of *higher costs* associated with studying abroad (they also offer grants to German students studying abroad). The German Service for Academic Exchange (DAAD), Bonn-Bad Godesberg, selects a large number of foreign applicants and financially supports their study period in Germany through funds from the government. The DAAD also administers grants offered by the EEC for student exchange.

  Foreign engineering students also have the opportunity to undertake their engineering projects in Germany since many German enterprises co-operate with foreign universities. IAESTE, for example, supports these student placements in industry with grants to cover the cost of living for the duration of the project.
- Most German universities have offices concerned with academic exchange (Auslandsamt). In many cases, German language courses are offered for foreign students. The Goethe-Institutes, established in many cities around the world, offer German language courses so that foreign students can acquire a basic knowledge of the German language before they arrive in Germany. It can also be highly recommended that the German engineering faculties increase bilingual teaching so that the technological terms are given in English and German; this will also allow German students to communicate better worldwide.
- Foreign students should have personal tutoring in order to understand the organisation and structure of the German educational system, and to assist them to integrate with their fellow students (through activities, for instance) and to understand the German way of life. It is recommended that professors teaching courses make contact with their foreign students in order to understand what difficulties they are having.

  It is also recommended that the characteristically liberal German course structure be modified and the number of optional subjects limited for foreign students in order that a module of the engineering curriculum can be successfully completed in a given period.
- Recognition of the achievements of a study programme undertaken abroad requires the special effort and collaboration of universities and governmental authorities. Universities in Germany are authorised to provide education by the German state administrations. Before universities can receive global recognition for their engineering education, for instance, they must convince the professional world that it is technical competence, and not simply political influence, that guides the teaching process. There is currently no independent committee in Germany to approve the quality of engineering education, and it is highly recommended that the German engineering associations' offers of assistance to help in the process of approval and acknowledgement of engineering curricula be taken up [7]. To install such a system will take some time to prepare.

  For the present, a feasible method of recognition of study undertaken by exchange students is the establishment of joint study programmes between German and foreign universities. Several such programmes have been established between well-known universities [8]. The programmes allow students to replace part of their course in the home institution with an equivalent module in the foreign partner university. In many cases the respective degrees of partner institutions are also recognised, so that the graduates who took part in

the exchange programme receive a degree from both institutions. This of course requires the approval of the national authorities in both countries. The German government is very open to such agreements as long as the foreign universities have a similar standard of academic education to the German university. It can be highly recommended that the scope of international collaboration and student exchange programmes between German and foreign universities be broadened.

While it is recommended that the part of such a programme that is equivalent to the Anglo-American engineering degree courses be defined, students with an engineering education from a globally recognised university have little difficulty acquiring acknowledgement for their study, even when there is no special reference to English degree courses.

All these measures to attract foreign students to German universities require much effort and some changes. Studying abroad will remain a demanding challenge for students, and one cannot expect great numbers of foreign students to participate in exchange programmes. Nonetheless, running such programmes is worthwhile for the personal development of students and for strengthening international co-operation between partner universities; it will also help to strengthen the position and reputation of universities in the competition for students in the education market, and will promote collaboration in research between professors in partner universities. And finally, it will strengthen the global links between professional engineers.

CONCLUSION

It is a global task to adapt engineering education to technological progress and the changing demands of human society, a task that must be fulfilled under the conditions of national and international competition between universities around the world. German universities require greater flexibility in order to develop their own profile and to modernise their engineering curricula, as well as to participate in co-operative agreements with other universities and international organisations in the field of engineering education. Rather than imposing rules about how to structure teaching, governmental organisations and national engineering associations should assist universities to develop an effective management to bring about the necessary changes in the structure and organisation of curricula.

While there is a common goal to develop competent and proficient engineers acting to promote technical progress to meet the future demands of industry and society, there is no unanimous agreement about how to achieve this. These demands of engineers are difficult to define, but their rough outline can be given as the ability to:

- react to the demands of customers and society by anticipating those demands and transforming them into technical innovations;
- create economic wealth through industrial production so that industrial enterprises, customers and society can profit by it;
- design sustainable technology for ecological protection of natural environments and resources;
- improve employment through more rational technology, where saving resources and energy during manufacturing are more in focus than reducing human labour;
- display ethical responsibility and a balanced approach to the different objectives of modern technology.

The development of technology that meets all of these in a balanced way is not only a matter of the welfare of human society, it is the most important challenge for the survival of mankind in a world with a rapidly growing population. Only the properly directed progress of technology can provide us with a sustainable future.

Engineers must keep in mind that all human venture has its limits and succumbs to the *will of God,* who, as creator, has designed the course of the world. It is therefore advisable that engineers ask how they can act in agreement with the will of God. The essence of this is that they will then have a basis for acting in a responsible and effective way.

REFERENCES

1. Viertes Gesetz zur Änderung des Hochschulrahmengesetzes August 1998. Bundesanzeiger Bonn, *Bundesgesetzblatt* 1, 54 (1998).
2. Thesen zur Weiterentwicklung der Ingenieurausbildung in Deutschland. VDI Düsseldorf (1998).
3. Stellungnahme des VDI zu den Abschlußgraden Mater und Bachelor in den Ingenieurwissenschaften. VDI Düsseldorf (1997).
4. SARTOR 97 Standard and Routes to Registration. Engineering Council, London (1997)
5. Universitätsbarometer Forschung & Lehre. Deutscher Hochschulverband (1998).
6. Ingenieurausbildung im Umbruch Empfehlung des VDI für eine zukunftsorientierte Ingenieurqualifikation Düsseldorf (1995).
7. Empfehlung des VDI zur Akkreditierung von Bachelor- und Masterstudiengängen im Ingenieurwesen.

VDI Düsseldorf (1998).

8. Carolus, T. and Detert, K., Study programmes for collaboration with foreign partner universities. *Global J. of Engng. Educ.,* 2, **2**, 139-142 (1998).

BIOGRAPHY

Klaus Detert was born in Berlin, Germany, in 1926. He studied at the Technical University of Berlin, Germany, and was awarded the degree of Diplom-Ingenieur in 1952, and the degree of Dr-Ing by the Institute of Physical Metallurgy, Technical University of Berlin, in 1954.

He has worked for Brown University, Providence RI, USA, as a research associate between 1954-1955; a scientist at Vacuumschmelze GmbH, Hanau Germany (affiliate of Siemens Corp) from 1955– 58; as chief engineer at the Institute of Physical Metallurgy, Technical University of Berlin, from 1958-63, where he was awarded Dr-Ing habil in Physical Metallurgy in 1962; research associate at R&D Centre Westinghouse Electric Corp, Pittsburgh Pa, USA from 1963–66; and Director of Materials Technology R&D Centre AEG Telefunken in Frankfurt/Main, Germany, from 1966–77. He was made Adjunct Professor in Materials Science at the Technical University in 1969, and full Professor in the Faculty of Mechanical Engineering, University of Siegen, in 1977, becoming Emeritus Professor in 1992.

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