

Engineering Education in Germany – A critical contribution –

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Abstract

A short review will be given on the development of engineering education in Germany during the last decades. It will be analysed what are the facts and influences that make attempts difficult to modernize and to harmonize curricula in engineering education in a European framework.

1. Introduction

Engineering education in the European Union is to be standardized. This is the main result of conferences held by European ministers responsible for higher education [1], [2]. While there is common agreement on the necessity of this aim at German universities, there are diverging strategies of how to achieve it.

One of the reasons for the ongoing dispute is the historically grown structure of the educational system in Germany. Any attempt of understanding what difficulties have to be overcome must, therefore, start with an analysis of the way decisions are found on adapting or changing the educational system.

2. Educational politics in Germany

Germany has never been a monolithic political unit. Even two hundred years ago,

there existed not yet a German nation in the sense that there was one community having a common culture, a common language and being governed by a common law that was developed by a common national assembly.

Indeed, there was only a collection of states, each having its own laws, its own financial responsibilities and its own political ambitions. However, a common language, and a common historical and cultural background were the brackets that brought together a good part of these political units during the last half of the nineteenth century. As a consequence a central government was installed.

Nevertheless, individual states succeeded in keeping strong influence on the educational system. Moreover, universities kept amazing independence on what and how to teach.

This tradition survived until today. It is the responsibility of the states (the Bundesländer) to finance and to define their educational systems. A federal law, the Hochschulrahmengesetz (HRG, Framework act for higher education) [3], is only giving common obligatory guidelines.

An amendment of that federal law, however, that was enacted in 1999, and that was again changed in 2002, is influencing more and more educational politics of the states.

Nevertheless, it is still in the responsibility of the states to harmonize educational systems. Therefore, it is not the government

of the Federal Republic of Germany alone that is the negotiating party on the European stage. There are sixteen more governments of the German states that also want to play a role in that game.

Education in Germany is offered by the government authorities to the public for free. It goes without saying that this causes enormous costs. That explains why some politicians think more and more about saving money by shortening the average duration of study courses or even by demanding fees for higher education. Therefore, increasing pressure is put on universities and Fachhochschulen (polytechnics) to take measures for supporting or even to force a short duration of studies.

This is done by enacting amendments of the state laws concerning higher education. These must be in accordance to the federal framework act for higher education. However, concrete regulations are predominantly given in the state laws. These differ from state to state. Harmonization of laws within the Federal Republic of Germany is not yet achieved completely.

3. Institutions for Higher Engineering Education

The predominant conception of higher education in Germany was characterized by W. v. Humboldt [3] in the beginning of the nineteenth century.

He introduced a trinomial system of education beginning with elementary school that was obligatory for all, secondary school for selected pupils and university for the educated elite. Nevertheless, following his ideas science had to be a liberal process that should be accessible for all.

In order to guarantee an optimum development of knowledge, he formulated the request for liberty in research and education. The importance of this idea is emphasized by the fact that it is guaranteed

by the constitution of the Federal Republic of Germany.

It is that idea of liberality that defined the conception of universities in Germany until the first half of the twentieth century. Universities were seen as institutions for scientific research and of scientific education being free of concrete dedication. While the last aspect is disappearing, universities are still interpreted as institutions of scientific research. They are the only institutions having the right to issue the doctorate.

Due to the request of liberty in research and education, professors of German universities insist on their (at least theoretical) independence of defining curricula. Indeed, new curricula and changes in existing curricula are suggested by professors, not by the authorities, though they have to be acknowledged by the responsible ministries.

In contradistinction to engineering education at a university (germ.: Universität or Technische Universität), a type of education is given at a polytechnic (germ.: Fachhochschule) that is oriented at practical and technical purposes. In former times, polytechnics used to be schools for people who had completed a training of apprentices. Teachers were well-deserved master craftsmen. This has changed during the last four or five decades. A sound theoretical education with strong relations to practical aspects has found acceptance in these schools. Nowadays, lecturers in the Fachhochschulen must have a doctoral degree from a university and they must have had a successful career in industry. This is why German Fachhochschulen prefer to translate the German term "Fachhochschule" by the English term "university of applied sciences" rather than "polytechnic".

In Germany, Fachhochschulen are regarded as institutions offering scientifically based vocational training on university level. They are not allowed to issue the doctorate.

4. Curricula at German Universities and Fachhochschulen

Due to the differing tasks universities and polytechnics have, curricula in electrical and electronics engineering and in information engineering differ considerably in these institutions.

Higher education in Fachhochschulen aims at preparing engineers for direct service in the process of industrial production. Therefore, theoretical background knowledge is taught at a level that suffices to comprehend important interdependencies in the necessary subjects. Greatest importance is attached to the ability of students to come efficiently to a practical result.

Therefore, curricula at polytechnics start with a good mixture of theoretical subjects and of basic material in the first year. In the second year, more specialised subjects are taught besides some few applications of the learned theory. The rest of the study courses is dedicated to specialised subjects and to a thesis. Regular duration of these curricula takes between three and four years. The degree earned used to be "Diplom (FH)" where the appendix "FH" characterises that it was given by a Fachhochschule.

In contradistinction to the situation at Fachhochschulen and following Humboldt's ideas, German universities aim at educating engineering scientists.

Therefore, a broad and rigorous education is normally given during the first two years in theoretical subjects comprising mathematics, physics, basic electrical engineering and others. Especially mathematics is a subject that must be learned consecutively. (That does not mean that mathematics should be taught without any relation to its applications)! Furthermore, physics can only be taught in a scientific way using mathematics.

The effectiveness in learning these difficult materials is optimised by curricula

that are designed strongly hierarchically. Therefore, specialised engineering education begins at German universities only in the third year and after a rigorous examination of the learning success of the theoretical material. This examination is called "Vordiplom" (prediploma).

Again, specialised subjects are taught in a scientific way after the Vordiplom at universities. A deep comprehension is considered to be extremely important. Furthermore, in that second part of the curriculum, students are instructed to learn how to learn in a self-contained way. After a thesis that in most cases is part of an ongoing research work of the institution, the Diplom degree is given. Note that in that title no addendum "FH" is indicated.

Engineering education takes at German universities a regular time between four and five years. However, since students are also encouraged to learn more than is provided in the curricula, it takes often more than that time.

Industrial employers in Germany appreciate the different types of higher education offered by Universität or Technische Universität on one side and Fachhochschule on the other side.

Most engineers are employed to design, maintain or to sell products. For these purposes, engineers from a Fachhochschule (FH) are employed.

Fewer engineers are employed to develop completely novel products. For these purposes, employers prefer engineers from a university.

4. The Bologna declaration and its influence on engineering education

In the Bologna declaration [1], European ministers responsible for higher education request the "Adoption of a system essentially based on two main cycles, undergraduate and graduate. Access to the second cycle shall require successful

completion of first cycle studies, lasting a minimum of three years. The degree awarded after the first cycle shall also be relevant to the European labour market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries”.

Due to many similarities with engineering education in the United Kingdom or in the US, it should not be too difficult to adapt the Fachhochschul-type of education to that scheme, though the existing Diplom (FH) is more than a normal bachelor-degree.

The situation is completely different with the engineering education at German universities. A two-years addition of graduate courses could hardly complete a scientific education.

There are four years of experience with that problem at the university of Ulm, Germany with that problem, where a two-years Master Course program on “Communications Technology” is offered to students having an above-average bachelor degree. Though (or even because) many of the students in this course program have already worked in industry, their theoretical education is frequently not sound enough for a full scientific program.

Adaptation of the university-type engineering education to the Bologna scheme is thus a difficult problem. In order to overcome that problem, part of the material that is normally found in a scientific engineering curriculum has been cancelled to gain more time for teaching a good scientific basis. More and more use is made from modern media during lectures and problem solving sessions. This increases the learning intensity (and makes studying more difficult).

The present author is a strong believer in that a three plus two years curriculum for engineering education is only second choice for a scientifically based education. A consecutive curriculum (as it exists in German Diplom-curricula) has a higher

quality standard. This might be different in other subjects like laws, for instance.

Nevertheless, German state governments seem to give preference to the three-plus-two scheme. It might be permitted to question this decision. (The over-simplifying answer that most Nobel-prizes are given to US-researchers that have learned following a three-plus-two scheme does not take into account that much more money is flowing into research in the US).

5. Conclusion

It might thus be stated that

- There exist two types of engineering education in Germany : scientifically based vocational training on university level in Fachhochschulen and scientific education in universities.
- While an adaptation to the Bologna scheme seems to be not too difficult for the Fachhochschul-curricula, severe problems arise when adapting scientific education at universities.
- Each state in Germany and each university or Fachhochschule has its own way to convert the Bologna decisions.
- Harmonization of curricula for engineering education in Germany in a European context is difficult and might worsen scientific engineering education.

References

- [1] <http://www.murst.it/convegni/bologna99/dichiarazione/english.htm>
- [2] http://www.hrk.de/vbsmodule/texte/std_text.asp?str_CallFile=texte/archiv/Entschliessungen/Plen193_3.htm#1
- [3] http://www.bmbf.de/gesetz_3823.html
- [4] P. Max: Wilhelm von Humboldts Vorstellungen zur Neuordnung des öffentlichen Schulwesens und deren Beurteilung im deutschsprachigen Raum während des 20. Jahrhunderts. Haag + Herchen, Frankfurt, Germany, 1996, ISBN: 3-86137-501