

EDUCATION AND SOCIAL STANDING: GERMAN ENGINEERS, 1870-1930¹

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1.- The two Sources of the German Engineering Profession, 1750-1870.

“The two sources” refer: 1st to engineers in the public services, and 2nd to engineers in industry.

Engineering in the context of the public services is much older than industrial engineering. You can go back into ancient times, at least 6.000 years, when people started erecting cities and sanctuaries, walls, castles, dams, monuments, and other buildings. Engineers were trained by performing technical work, that is in a process of learning by doing. Additionally, since the 18th century, a part of the state engineers acquired their knowledge in technical schools². That school system started particularly in France and later on, was overtaken by other states in Continental Europe. The early engineering schools were specialized according to the different tasks of state technology. The school educated engineers worked in military, in mining, in civil engineering, building highways, canals, railways, bridges, harbours, and so on.

Concerning the case of Germany, we have to keep in mind that Germany in those times was more an idea than political reality. Germany consisted of

1 Authoritative overviews are: GISPEN, Kees (1989) *New Profession, Old Order, Engineers and German Society, 1815-1914*, Cambridge, Cambridge University Press; LUNDGREEN, Peter; GRELON, André (ed.) (1994) *Ingenieure in Deutschland, 1770-1990*, Frankfurt a. M., New York, Campus; KAISER, Walter; KÖNIG, Wolfgang (ed.) (2006) *Geschichte des Ingenieurs, Ein Beruf in sechs Jahrtausenden*, München, Wien, Hanser.

2 SCHOLL, Lars Ulrich (1978) *Ingenieure in der Frühindustrialisierung, Staatliche und private Techniker im Königreich Hannover und an der Ruhr (1815-1873)*, Göttingen, Vandenhoeck & Ruprecht.

dozens large, medium, and small independent lands. These lands were also responsible for technical education. And beyond that, they were responsible for all cultural affairs what is also the case today. Today's Federal State is partially responsible for research, beginnings are in the late 19th century, but it is not responsible for education. One advantage of that system is its competitive character. Today, the great disadvantage is that the German Federal State is more or less rich whereas most of the German lands are more or less poor. This results in many complaints that the German system of education suffers from underfinancing. And there is a broad discussion whether and how the division of responsibilities between the Federal State and the lands should be revised.

The second source of the German engineering profession was the craft system which originated in the Middle Ages. Over a long period of time, very prominent engineers arose from the craft system. Also civil engineering in the 18th and 19th century was organized according to the craft system. Beginners learned with an experienced civil engineer before becoming more and more independent. In early industrialization, also mechanical engineers started as craft workers in the workshop³. That means, that within industrial engineering a system of self-recruitment was at place.

In the beginning of German industrialization, state bureaucrats became convinced that this system of self-recruitment would not be sufficient anymore. In the 1820's and 1830's, in order to overcome the old system, each large and medium German land established technical schools at the level of trade schools. Most of today's prominent German Institutes of Technology (Technische Universitäten) were founded in these decades. The large number of German lands resulted in a considerable number of new engineering schools. With only few exceptions, until the 1960's, the number of these schools was sufficient for training engineers for the public services and for industry. Then, new engineering institutes and departments were founded.

The new schools' issue was that they should foster industrialization. They should contribute to the process of catching up with Britain. The crucial research question is whether the new engineering schools achieved this goal or not. Today's state of research is that the schools, with a few exceptions, did

3 LUNDGREEN, Peter (1975) *Techniker in Preußen während der frühen Industrialisierung. Ausbildung und Berufsfeld einer entstehenden sozialen Gruppe*, Berlin, Colloquium.

not contribute much to industrialization⁴. The most important argument refers to the graduates' careers. Most school leavers did not enter industrial firms but the public services. Industrial firms continued recruiting their engineers from their own craft workers. This kind of recruitment, however, changed in the process of industrialization, particularly after the founding of the German Kaiserreich in 1870. Since then, engineering institutes became more and more important for the recruitment of industry's technical personnel.

2.- German engineers in the Kaiserreich and in the Weimar Republic, 1870-1930.

2.1.- Emancipation.

In German society, engineers regarded themselves as being discriminated. They compared themselves with older professions which possessed a higher social standing, particularly with the juridical profession which dominated the public service. And they compared themselves with other academic disciplines like the humanities which were in higher esteem. Within the academic world, a fundamental dichotomy existed between the universities on the one hand and the Technische Hochschulen (the institutes of technology) on the other hand. The engineers were trained at the Technische Hochschulen, all the other important professions were trained at the universities. The university had a longer tradition. It possessed particular rights, among them the right to confer doctorate degrees. It was this right which became a main symbol of emancipation in the struggles between the university and the Technische Hochschule.

These differences were the background of the so-called emancipation movement of the Technische Hochschulen⁵. The Technische Hochschulen wanted to bridge the social gulf between them and the universities. They generally demanded for equal rights. The emancipation movement of the

4 KÖNIG, Wolfgang (1998) "Zwischen Verwaltungsstaat und Industriegesellschaft, Die Gründung höherer technischer Bildungsstätten in Deutschland in den ersten Jahrzehnten des 19. Jahrhunderts", *Berichte zur Wissenschaftsgeschichte*, vol. 21, num. 1, 115-122.

5 MANEGOLD, Karl-Heinz (1970) *Universität, Technische Hochschule und Industrie, Ein Beitrag zur Emanzipation der Technik im 19. Jahrhundert unter besonderer Berücksichtigung der Bestrebungen Felix Kleins*, Berlin, Duncker & Humblot.

Technische Hochschulen was an important element of the struggles about the interpretation of *Bildung* (the English term 'education' does not completely cover the meaning of the German word). One party emphasized the value of humanistic, the other the value of realistic *Bildung*.

Concerning the emancipation movement of the Technische Hochschulen and its results, I do not want to go into details. In the long run, it was successful. One milestone was that around 1900, also the Technische Hochschulen received the right to confer doctorate degrees. And in the early Weimar Republic, around 1920, they formally and completely got equal rights with the universities. Nevertheless, until the 1960's, the Technische Hochschulen remained independent institutions separated from the universities. Only after 1960, new hybrid universities were established which contained for instance humanity departments and as well engineering departments. Today, there are only some remains left from this former dichotomy between the universities and the Technische Hochschulen.

2.2.- Differentiation and Specialization.

Up to the mid-19th century, two concepts of engineering education competed to each other: 1st a concept of universal technical education, and 2nd a concept of special education. By the concept of universal education a virtue was made of necessity. The young engineering schools did not have the means to establish curricula for the different fields of engineering. This changed in the second half of the 19th century. From then, an extreme process of specialization took place which resulted in a huge number of disciplines, chairs, and study courses. The disciplines covered more general methodological disciplines like thermodynamics, branches like automotive technology, and vocational fields like design and production. However, until today, there is no consensus on the common grounds of the engineering sciences.

One particularity of that German system was that in late 19th and early 20th century engineering design and the education of designers was central⁶. The Technische Hochschulen possessed a large number of design professorships

6 KÖNIG, Wolfgang (1999) *Künstler und Strichezieher, Konstruktions- und Technikkulturen im deutschen, britischen, amerikanischen und französischen Maschinenbau zwischen 1850 und 1930*, Frankfurt a. M., Suhrkamp.

and most of the graduates started as designers in industry. Only during the 20th century, this strong position of design became qualified. The Technische Hochschulen additionally established study courses for production, marketing, management, research and development, and so on.

2.3.- Higher and Intermediate Learning.

One of the emancipation strategies of the Technische Hochschulen was to adjust themselves to the university norms. The engineering sciences oriented themselves at physics and mathematics and the kind of theoretical approaches which were at use in these disciplines. That was also the case in other countries but in Germany this adjustment started very early and went very far.

This strategy concerned a fundamental problem of engineering in which the tension between theory and practice is inherent. On the one hand, in engineering, becoming more theoretical means losing practicability, and on the other hand, becoming more practical means losing the ability to generalize. This tension is the reason why in engineering there is no linear way from practice to theory. Instead, the question is what in a given situation is the best mixture between theory and practice.

In late 19th century, engineering sciences' theorization, maybe overtheorization, resulted in struggles and quarrels between professors who were more theory-oriented and others who were more practice-oriented⁷. Later on, compromises were found what, however, did not solve the fundamental problem.

In any case, since mid-19th century, engineering education became more theoretical. Criticism against this, first of all, came from industry. Industrialists complained that engineering graduates would not suit industrial requirements. As a consequence new intermediate technical schools were founded, firstly by local actors, later on by the German lands⁸. Among the pioneers were private persons, cities, and industrialists. The result was a two-tier-system of engineering education consisting of institutes at the

7 KÖNIG, Wolfgang (2014) *Der Gelehrte und der Manager, Franz Reuleaux (1829-1905) und Alois Riedler (1850-1936) in Technik, Wissenschaft und Gesellschaft*, Stuttgart, Steiner.

8 GRÜNER, Gustav (1967) *Die Entwicklung der höheren technischen Fachschulen im deutschen Sprachgebiet, Ein Beitrag zur historischen und zur angewandten Berufspädagogik*, Braunschweig Westermann.

university level on the one hand, and of intermediate schools under a lot of different names on the other hand. Today, these former intermediate schools name themselves Hochschulen für angewandte Wissenschaften (in English “universities of applied sciences”). This means that the typically German two-tier-system of engineering education which is still in existence originated in the 19th century.

2.4.- Definitions and Numbers.

There is no doubt that around 1900, the German engineering profession was very heterogeneous. In those times, within the engineering associations the crucial and much discussed question was who should belong to the engineering profession and who should be excluded. Dealing with this question, it is helpful to distinguish four main groups:

- engineers, trained at the Technische Hochschulen,
- engineers, trained at the technical intermediate schools,
- shop culture engineers, trained in the workshop,
- and ‘technicians’ who in the last end were excluded from the engineering community.

The heterogeneity of the engineering profession was a source of a lot of conflicts, in particular, after the turn of the century. I will not discuss those conflicts in detail but report the results. For example, one result was that school education became the norm for entering the engineering profession. Shop culture engineers dominated until the 1880’s. Since then, their share diminished rapidly until they became a very small minority. Notwithstanding the above, until the German lands’ engineering laws in the 1970’s, it was possible to become a member of the engineering community without visiting an engineering school.

A second result was that after 1900, an influential group of academic engineers tried to exclusively use the term ‘engineer’ for graduates of the Technische Hochschulen. Leavers of the intermediate schools should be called technicians. At the end, however, these attempts failed due to the opposition of industrialists and managers. The representatives of industry highly valued practical experience and industrial performance and were not willing

to diminish the social standing of the intermediate schools' engineers. Most of the supporters of the technical intermediate schools were organized in the Verein Deutscher Ingenieure (VDI) (Association of German Engineers)⁹. Among the VDI's membership the academic engineers were only a minority. All in all, the controversies resulted in the two-tier-system of German engineering.

It goes without saying that because of the heterogeneous and controversial membership of the engineering community, exact data for the number of engineers cannot be given. However, there are estimations of contemporaries as well as of historians. My evaluation of the given data is: during early industrialization, the number of engineers in Germany was low. Since the 1880's it increased rapidly, reaching more than 100.000 before World War I, and more than 200.000 in the 1930's. More engineers came from the technical intermediate schools than from the Technische Hochschulen. Before the First World War, the ratio was about 5:1, today, the ratio is on a par.

2.5.- Engineers and Politics¹⁰.

The German Kaiserreich was a constitutional monarchy, Weimar a democratic republic. In the two political systems political parties played an ever-increasing role. However, considerable parts of society, among them the engineers, were not in accordance with the new system of constitution, democracy, and political parties. In particular, the engineers' engagement in political parties was extremely poor. Instead, many engineers sympathized with technocratic models in which political affairs were governed by experts including engineers¹¹. The German technocratic movement was, however, much smaller and less influential than in the US. In the 1930's, many German engineers supported National Socialism without playing a leading role in the

9 LUDWIG, Karl-Heinz; KÖNIG, Wolfgang (ed.) (1981) *Technik, Ingenieure und Gesellschaft, Geschichte des Vereins Deutscher Ingenieure 1856-1981*, Düsseldorf, VDI Verlag.

10 JARAUSCH, Konrad H. (1990) *The Unfree Professions, German Lawyers, Teachers, and Engineers, 1900-1950*, New York, Oxford, Oxford University Press; SANDER, Tobias (2009) *Die doppelte Defensive, Soziale Lage, Mentalitäten und Politik der Ingenieure in Deutschland 1890-1933*, Wiesbaden, VS Verlag für Sozialwissenschaften.

11 WILLEKE, Stefan (1995) *Die Technokratiebewegung in Nordamerika und Deutschland zwischen den Weltkriegen, Eine vergleichende Analyse*, Frankfurt a. M., Lang.

regime¹². Firstly, in the Federal Republic, the engineering community became integrated into the political institutions.

3.- Homogenization and Expansion, 1930-2000.

As I displayed, the German engineering profession developed in a historical process lasting from the 18th until the 20th century. The most important foundations were laid in the beginning of the 20th century, after, some refinements took place. Among them were the engineering laws of the 1970's. The engineering laws definitely brought the era of shop culture engineers to an end. From now on, engineers had to graduate in an engineering school. This is what I cover with the term «homogenization».

Since the 1960's, the system of engineering education expanded by establishing new universities, engineering schools, and engineering departments. Herewith politics reacted to the growing demand for engineers during the economic boom of the 1950's and 1960's (the German «economic miracle»/«Wirtschaftswunder»). Until today, the number of engineers augmented to circa 500.000. This is what I cover with the term «expansion».

4.- Conclusion: The German Engineering Culture.

During the 20th century, international differences in engineering education and in the engineering profession diminished and similarities increased. Nevertheless, particular national engineering cultures also today can be distinguished. Concerning the German engineering culture and its development, I would emphasize five particularities:

- 1st – The German system of engineering education is nearly completely run by the state. Private schools can be neglected.
- 2nd – That system produced large numbers of engineers early on, per capita of the population larger than in other countries. At least since late 19th century, these engineers contributed considerably to German industrial

12 LUDWIG, Karl-Heinz (1974) *Technik und Ingenieure im Dritten Reich*, Düsseldorf, Droste.

- development. However, generally spoken, it is difficult to evaluate the role of education for industrialization and industrial performance in an exact way.
- 3rd – Over a long time, there was a separation, maybe a dichotomy, between the university system and the system of engineering education at the Technische Hochschulen. Differences still exist but they are by far not as important as they have been in history.
- 4th – The German system of engineering became a two-tier-system consisting of the Technische Hochschulen and the technical intermediate schools, respectively today's Technische Universitäten and Hochschulen für angewandte Wissenschaften. The two kinds of engineering schools compete to each other but also supplement each other.
- 5th – In education and also in industrial work, engineering design was central. Around 1900, the large majority of engineers worked as designers. Also today, designers are a very important group within the engineering community. Contrary, in the US, production engineers played a much greater role than in Germany¹³. The German engineering design culture contributed considerably to the strength of the machine-building industry by adapting machines and facilities to the customers' wishes.

13 CALVERT, Monte (1967) *The Mechanical Engineer in America, 1830-1910: Professional Cultures in Conflict*, Baltimore, Johns Hopkins University Press.