Title

Engineering a Link Between Universities and Vocational Schools? The Divergent Role of Professional Associations and Business Interests in the Formation of Systems for Technical Education in Germany and the USA

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Engineering a link between vocational schools and universities?

The divergent role of professional associations and business interests in the formation of systems for Technical Education in Germany and the USA

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Abstract

Germany and the USA both industrialized between 1860 and 1925, but they developed different systems for industrial and technical education. The Germans developed a more comprehensive, system, with three distinct levels; lower, middle and higher education. The higher engineering schools were separate from the traditional universities but granted equal status. Industrial education
in Germany was primarily part of a mobilization for *technik*, industrial growth, social unity and nationalism. Engineering education was used to establish a link between vocational schools and academic education. The American field of technical education around 1925 consisted largely of engineering colleges, which to a large extent was integrated in the traditional university system. Engineering colleges had multiplied as in no other country, and the training of artisans, foremen and technicians had been neglected. There was a clear social distinction between engineering schools and institutions for vocational education, the latter being partly associated in the public mind with rehabilitation of criminals and school dropouts. Engineering educators contributed to this mindset by distancing themselves from vocational schools and institutions for manual training.

I account for the different outcomes and ideologies by emphasizing differences in organizational resources and worldviews among four groups; teachers and academics, engineers in professional associations, politicians/civil servants and business managers. The educational revolution and the academization process in engineering started earlier in Germany, and the rise of large corporations increased the influence of practitioners and industrialists in the education system. Engineering in the United States was originally a practical and shop-based profession. Academic entrepreneurs and teachers had the initiative in education, and they were more firmly in control also after the industrial revolution.

1.0 Introduction

The "convergence" thesis, according to which all nation-states are on the same developmental path towards a universal industrial society, have been an important theoretical underpinning in sociology and political science in the post-war era. The clearest exposition of this thesis was Kerr et al. (1960) and Harbison and Myers (1959). They argued that the "logic of industrialism" would create a new uniform type of human being – the so-called "industrial man" - and that the forces making for uniformity among different societies and human beings would only become stronger as nations became more industrialized. The more undeveloped nation-states were supposedly "behind" on a set of variables a priori defined as part of a modernization index, which was partly based on statistics on human capital development, particularly technical and scientific manpower. The systems of education that provided firms with manpower would also eventually converge since "industrialism requires an educational system functionally related to the skills and professions imperative to its technology" (Kerr et al 1960/1996). [1]

It was taken for granted that nation-states with more engineers and scientists were also more developed, and comparisons among nation-states was used only in an illustrative manner to sustain this convergence assumption. Recent developments, such as the debate about the relative economic decline in Britain, the revised data on economic development in Russia and eastern Europe, and historical-comparative studies among European nations, have cast major doubt on the convergence hypothesis and the associated human capital theory. Comparisons are now used in a more exploratory way and other kinds of relationships are highlighted than those brought to our attention by the human capital theory. There has been a change in perspective from focusing on quantitative outputs and formal education systems towards qualitative and historical factors, such as educational philosophies and skills formation practices. It is not any longer assumed that contrasts among nations are of a temporary nature. Contemporary political scientists and sociologists more commonly assume that capitalism may be organized in several ways. An influential group of scholars even see it as their key issue to identify the major factors behind the development of particular kinds of business systems (Maurice et al. 1980, Maurice 1986, Whitley 1992, Whitley and Kristensen 1996). The major question from such a perspective is not how many graduates, but in what way national models of work organization and skill formation correspond with education systems and professional configurations. Other scholars have put more emphasis on the historical role of the state, and political-cultural variables (Fligstein 1990, Fligstein and Freeland 1995, Burrage et al. 1990, Steinmo and Thelen1992). Important issues have been state regulation, industrial elites and the relative timing of the educational and industrial revolutions. Curricular traditions and educational philosophies may also be important (Calori et al. 1997).

Each perspective has favored certain kinds of explanation for the various structural outcomes. The “industrial man” perspective looks to technology and business interests as the forces for change in educational systems. The business system argument puts a major emphasis on institutions for skill formation and industrial relations

[1] There have been made several attempts to estimate this factor. Some estimates have been primarily based on quantitative data, such as numbers of engineers and scientific graduates (Evan 1969, Mintzes and Tash 1983), whereas others have been based on more qualitative data (Musgrave 1967, Landes 1986, Gospel 1991).

systems. The state and its relationship to formal education system may also be important, as the historical institutionalists and some culturalists may argue.

The major question in this paper is why the German states developed a more comprehensive and multiple-layered system for technical education than the United States. The conventional story tells us that educational systems respond in predictable ways, and that what needs to be "controlled for" is variations in technical and economic development. If this were the case, then it would suffice to collect comparable technological and economic data. My suspicion is that the story is more dynamic and complicated, and I will therefore focus on the emerging world-views and strategies not only among industrialists, but also among other relevant actors, such as teachers and academic and professional entrepreneurs. I ask what factors were most important in each case: educational philosophies and institutional arrangements within the education system, industrial structures and business interests, or professional and government strategies?

Why do I focus on Germany and the United States? These countries represent alternative international models for economic development, work organization and education. The more recently industrialized countries in Asia and other European countries have emulated both systems. Arguably there has been a trend away from the traditional German model towards the American model in Germany and Europe. Germany and the United States industrialized at the same time, but the German education system was developed earlier. Indeed, Ringer (1992:36) has argued that the first educational revolution in the world occurred in Germany. Whereas the educational revolution preceded industrialization in the German states, the educational revolution took place along with rapid industrialization in the United States. Both economies were large and their engineering-dominated industries were involved in international competition early on. Their internal markets and technologies, and their positions in the international marketplace and technologies were not identical, but similar enough to justify a comparison. Germany and the USA clearly took the lead in engineering education and research from 1910 on, both in numbers of patents and engineers. The engineers took very prominent positions in industry during the first decades of the Twentieth Century, a position that German engineers have continued to hold until the present. It may be useful to focus more on the contrasts between the German and American cases and between Europe and the USA than has been the case until now when it has been more common to compare European nation states such as Germany, Sweden, France and Great Britain (Müller, Ringer and Simon 1987, Ahlström 1982, Landes 1969/1986, Torstendahl 1982, 1993). [2]

The systems did not develop independently of each other, however. Germany was looked upon as a kind of "second mother-country," in the U.S. because of the German University (Rheingold 1987). The "scientific" curriculum in German technical education was a model for American educators from around 1860. Likewise, as the American machinery industries demonstrated their competitive strength, the interest for the "practical" features of American engineering schools spurred a movement for a more practical education in German engineering (Gispen 1989: 115-21). Industrialists as well as teachers and academic entrepreneurs advocated a

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[2] One of the reasons for suggesting a comparison between Europe and the USA is my suspicion that engineering education in general was more easily integrated in universities in the United States than in Europe, where the traditional universities were more critical of industrial pursuits and the new professions. Independent technical universities and technical institutes has for this reason been more common in Europe.

direct emulation of laboratory instruction and other practical teaching methods in American engineering schools. A comparison of the formation of systems for industrial education may therefore also give a better understanding of the processes of emulation and cross-societal fertilization among rapidly industrializing nations.

The focus on qualitative and quantitative differences in technical education follows from my theoretical perspective. If I had focused exclusively on academic engineering education and avoided the more ambiguous term technical education, then the similarities between Germany and the USA would have been more apparent. The expansion in the number of engineering graduates in these two countries was more rapid than in most other advanced industrial nations (except the Soviet Union if we still count it in this group). According to the "industrial man"-argument referred to above one may attribute these similarities to the expansion of technology and industry in each case. This presumes that the development of education systems follows a "logic of industrialism", however. Alternatively, there may be more than one kind of logic. In this case, we may need to know more about contrasts in institutional environments and the division of labor and world-vies among relevant actors. It may be necessary to collect data on particularities in a few strategic cases, on the basis of which we can generate a typology of existing and possible models for capitalism and education in the present world economy (Kitschelt et al. 1999, Crouch and Streeck 1999).

1.2. Outline of the problem and the argument

The term "engineering education" as used in the United States around 1925 had no direct equivalent in continental Europe, where "technical education" was used as a more inclusive term for the training of all ranks of specialists in industrial and building technology (Wickenden 1930:751). "Technical education" was in Germany, as in most European countries used to describe a wide variety of training and education institutions qualifying for jobs and specialties at several levels of the industrial hierarchy. Three quite distinct categories of technical education developed, commonly called "higher", "middle", and "lower" (Wickenden 1930:751, Ahlstrøm 1992, Lundgreen 1994). The American system also had a lower and higher level, commonly called "vocational" and "professional", while it was difficult to recognize a middle level. The vocational level was not in any systematic way connected to the higher level, as in the German system, and there was

The most impressive fact about the German system was "its comprehensiveness; it is applied to every occupation in which it is better for a workman to have it than be without it" (Dawson 1919:103). A vocational orientation penetrated the school and corporation from the lowest to the highest levels, and there was also a great deal of horizontal specialization at each level. A non-academic practical type of engineer competed with the traditional academic engineer for the same type of jobs at the upper hierarchical levels. In contrast to in the U.S. both types of engineers originated in a school culture.

There were three types of technical education around 1910. The top category was higher technical education. It was the exclusive province of Germany's eleven *Technical Hochsculen* requiring the *Abitur* (high school diploma) from a nine-year high school and typically providing an eight-semester curriculum. At the lower end was lower technical training, based on *Volksschule* and made up of part-time vocational schools for blue-collar workers and foremen. The non-academic engineer graduated from a separate set of schools that had filled the gap between vocational and academic schools from 1890 on. *Abitur w*as nor required for these schools, and an extended period of prior practical experience was an absolute prerequisite for admission (Gispen 1989:216, DATSCH AB1 1910, 158-161). Employers had articulated a preference for the more practical and specialized non-academic engineers, and as the teachers from these schools also participated in both the engineering association and the cooperative education institutions the influence of the middle-level technical schools in the German occupational and institutional structure was steadily increasing.

The American engineering education system developed later and the universities took a more active role. The "self-made" engineer-entrepreneur/mechanic therefore was able to establish a much stronger position in industry and the conflict was more between a "shop" and "school" tradition than between various types of educated engineers (Calvert 1967, Layton 1971/1986, Noble 1977, Meiksins 1988). On-the-job-trained and self-made engineer-entrepreneurs were much more powerful in the industry and the profession than in Germany early in this Century. Whereas industrialization generated a divide between non-educated and university-educated engineers as well as manual technical workers in the USA, the non-academic engineers educated at the middle level provided a link between manual an academic labor in Germany.

Both the practical and academic types of engineers were organized in the same professional association in Germany. This meant that manual, administrative and conceptual tasks were not separated into different techno-cultures and careers to the same degree as in the USA (Wickenden 1930: 751, Chamberlain 1908:8). The Germans used the term '*technik*' to refer to manufacture and the knowledge and skills relevant to it. This concept does not have any equivalent in English, where distinctions like *Arts and Science* tend to accord engineering and technology a "junior, dependent and subordinate status under the aegis of science" (Snow 1961, Lawrence 1980:96). The balance of power between the humanistic and scientific cultures was reversed in Germany, where the engineers used the language of *Kultur* in their struggle for legitimacy. In his research on engineers during the *Weimar republic* and the *Third Reich* Herf found that German engineers and technologists put a great deal of emphasis on cultural politics:

> The contributors to the journals of the engineering associations and the lecturers at the technical universities fashioned a tradition, a shared set of texts, basic terms, and common metaphors with which they hoped to lift technology from the alien world of *Zivilisation* to the familiar world of *Kultur* (Herf 1984:157).

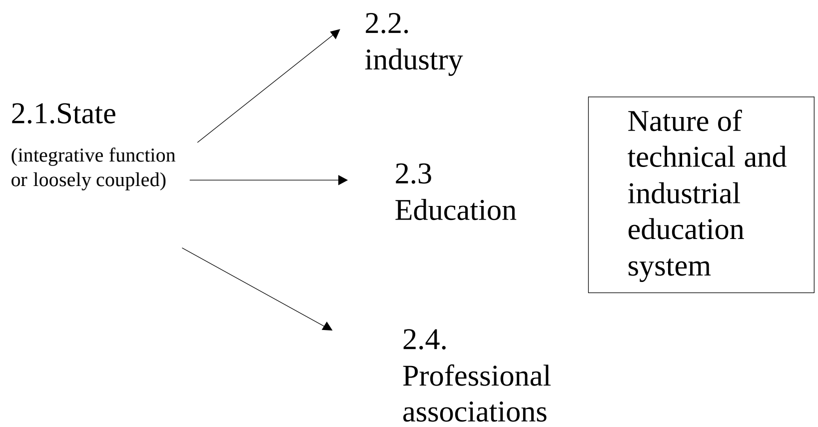
This relates to the more recent observations made by organization theorists and historians of a strong common identity among skilled workers, foremen, and technical workers in Germany; a feeling of belonging to a technical culture that is relatively independent of science and *industry.* The Germans still tend to dignify and even glamorize the engineer as a technical practitioner and a force for social unity and nationalism (Sorge and Warner 1986:189, Locke 1989:267, Lawrence 1980:97, 1992:89). *Technik,* then, may symbolize a common language and cultural 'tool-kit' that has made it possible for people in various functional specialties and hierarchical positions to communicate and develop common understandings and identities (Swidler 1986). It has been pointed out that the notion of *management* and the discourse and metaphors attached to the managerial dimension may have played an equivalent role in American society (Lawrence 1996:21).

Engineering education in the USA, on the other hand, was based on the idea of a sharper distinction between technology and art; the implication was that engineering (and management) was a collection of abstract principles and techniques that could be applied in industry. Engineering was conceived of as a profession linked to a field of *expert knowledge.* The terms engineering, vocational and industrial education were not linked to a common technical dimension and an industrial purpose, as they were in Germany. Vocational and engineering education were opposed positions, in the sense that the engineering profession feared that they would be degraded in status if they were associated with vocational training. Progressive reformers in the USA were able to fill the concept of vocational education with a *pedagogical* and social meaning; the purpose was to improve motivation, recruitment and career prospects for *manual jobs*. Manual training, accordingly, was associated in the public mind with the rehabilitation of criminals (Fisher 1967:78-79). The meaning and purpose attached to this concept in Germany on the other hand was linked to the notion of industrialization and "Kultur". Germany was much more of a "late industrializer" than the USA in the sense that civil society and the education system were much more penetrated with a "catch-up-mentality" *vis a vis* Britain and the other more industrialized countries (Veblen 1915/1954, Gerschenkrohn 1962).

1.3. Organization of presentation

I will discuss why the organizational fields of technical education in Germany and the USA developed in each their distinct ways. The paper will not proceed in the conventional historical way, with a chronological presentation of each case. Instead the model presented in figure 1 structures the paper.

Figure 1: Actors influencing the emergence and transformation of technical education systems.



The four relevant actors in this scheme are; 1) states, 2) professional associations, 3) academic entrepreneurs and teachers, and 4) business interests. The state is important both as a direct and indirect variable because it defines the interaction pattern between education, profession and industry. The basic distinction is between the state as a force for either integrated or loosely coupled systems.

2. Different perspectives on national models of technical education

Let me present the four conjectures in a more explicit way, and then discuss to what extent they may explain the various outcomes and ideologies in technical and industrial education.

1. Firstly, it may be argued that it was the state apparatus and the strategies of actors linked to the state that most decisively set the pace for the development of technical education systems.

2. Secondly, according to a more functionalist argument it will be assumed that it was industrial demands and particularly the increasingly powerful *business interests* that were the decisive forces behind the transformations and renewal of the existing educational systems.

3. Thirdly, such patterns of transformation and renewal may have been driven by internal factors, i.e. dynamics and conflicts within the education system itself.

4. Fourthly, it may have been the emergence of new technical and professional associations and strategies associated with professions that have most decisively influenced education systems.

It is possible to distinguish between a strictly structural and macroscopic argument and an argument focusing more at an organizational and collective actor level in each perspective. The structural-institutional positions will only be presented as a background here, and not as arguments that can by themselves explain a specific outcome. The focus is on social and collective actors at an organizational level. The argument is not that structural and basic institutional arrangements do not matter, but that actors and not structures act. In order to argue that structures are important or decisive it must therefore be possible to demonstrate their impact in the form of collective action. Structures and institutional frameworks do count, but the ultimate outcomes always have to be explained by a time-specific constellation among social actors with distinct organizational and cultural strategies and resources. It is thus necessary to identify relevant actors, organization structures, policies, critical events and transitional periods in order to check the relevance of each perspective.

Within the industrial argument one should be aware of how different industries with varying needs defined their interests in a given period, and to what degree industry developed internal education and training systems instead of attempting to influence the education system. According to the argument from education the important actors are those involved in scientific development, academic institution building and teaching. The teachers, the politicians and the scientists do not have identical strategies; conflicting views on the role of education in society and different self-interested strategies might be decisive in the formation of technical education systems. It is therefore necessary to identify the educational entrepreneurs and civil servants involved in organizing activities relating to industry. In the professional perspective it is important to be aware of the relationship between different segments in the profession, to what extent the profession was unified or diversified, and its program in relation to technical education.

2.1. The state-centered argument

The special character of the state is that it has the power to define or 'institutionalize' the relationship between the other organizations and actors in a society. "All the actors involved depend on the state", Burrage et al. (1990:222) argues, and "the decisions and policies of the state towards professional knowledge and professional services are therefore a subject of particular importance". The state is a privileged actor because it may take legal and political action and thereby pick the winner and looser in conflicts over conception of control and governance structures in a given sector or organizational field (Campbell and Lindberg 1990, Fligstein and Byrkjeflot 1996). Legal traditions and accreditation procedures are important, for instance whether it is possible to create cartels in industry, or whether an education institution or a professional must satisfy certain requirements in order to remain in business. The fundamental difference between Germany and the USA was that the German states promoted cooperation and cartels in industry, whereas the American states promoted competition and had several types of cooperation outlawed. This had important consequences for the educational system also, since the early American universities were corporations, and since the various academic groups were directly affected by the restrictions on cooperative arrangements in product and labor markets. The laws relating to cartels and industrial relations, then, may have had important consequences for the strength of industrial, occupational and educational associations in Germany as opposed to the USA.

The state in Germany did not issue licenses for engineers or control all institutions for technical education. The major governance method was to bring the partners together in cooperative organizations and promote compromises between them. Specific educational requirements for engineers were not established in German law until in 1967, when a vague distinction between a technician and an engineer based on educational criteria was introduced. In the case of the USA the state was a lot less active. Individual states started to require licenses from engineers employed in public service from around 1920 (Rothstein 1969:83). There was, however, no agreement among the professional associations on licensing, and the state did not attempt to bring the partners together in order to establish a standard or a compromise. Practical experience is still an acceptable equivalent for formal education, and the registration procedure remains ineffective.

Sorge (1977) has emphasized the role of the state in the formation of technical training systems in Germany, France and Britain. What is important about his account is that he considers the whole technical dimension from vocational schooling and up to engineering and managerial education. The state took different roles at each these levels. State schools for vocational training were not developed in Britain because most employers looked upon them with distrust. "It was their firm laissez-faire belief that if state schools were to be successful in giving practical training they would have to give away trade secrets of individual firms" (Sorge 1977:51). This explains how education came to be considered as something that ought to be conducted in a general way in schools and universities while training was properly done within a corporation. There was an aversion against school-based technical training in firms and schools. The situation on the Continent was different. The state school views dominated in France at all levels, but particularly at the highest levels. Germany was a "mixture of strong state school and association views", the state dominated at the higher levels, associations at the lower levels. The states in Germany did not develop the same aversion against vocationalism and practical training as the British. The links with industry were more developed and there was a greater industrial willingness to make use of educational facilities by employing engineering graduates (Sorge 1979: 52-53).

The American field of industry-relevant education was not regulated by governmental agencies. This was a problem according to the Wickenden report, since "the leaving of all initiative to individual institutions, with no coordination of policy, has resulted in the failure to work out a well-rounded national system of technical education in its several natural divisions" (Wickenden 1930:823). [3] Streeck (1989; 90-93) has suggested that this is an inherent phenomenon in liberal societies like the US and Britain where the market has traditionally played a dominant role. The skills needed for industrial development have so peculiar goods properties that they can neither be generated by unilateral state provision or by private utilitarian interests. Skill formation will be most effective when the enterprise is embedded in a system of institutionally enforced social obligations. Societies that treat learning as investment or, for that matter, as entitlement or a citizen's right will end up with fewer skills than societies where learning is treated as an obligation. The reason for this is that firms will invest less in training than they should in order to satisfy their own demand. To be able to take full advantage of economic opportunities capitalists have to be placed under normative and regulatory constraints in order to avoid a constant underproduction of skills.

[3] The Wickenden report (1930) was the "most comprehensive study of technical education in history" (Noble 1977:48).

The distinction between state-centered societies and stateless societies may have some relevance in a comparison of Germany and the USA (Nettl 1968, Birnbaum 1988). It would be misleading, however, to argue that the formation of technical education in Germany was an outcome of state policies, and that the USA was a copy of another stateless society: Great Britain. Dawson depicts the development of technical education in Saxony as a social movement based on traditional craft and guild values, whereas Gispen argues that the engineering profession in Germany was a new and more liberal kind of profession, shaped in a struggle against the "old order". It is thus indicated that the state's role may have been indirect also in Germany, and that state actions may matter almost as much in nation-states with "weak" states (Gispen 1988: 568, Dawson 1919, Evans et al. 1985).

The state agencies in the USA took a greater responsibility for higher technical education than the British. The land-grant colleges developed as a direct response to a state initiative (the Morrill land-grant act of 1862). The dislike of state involvement in vocational education was strong also in the USA, however. Fisher (1967:114) notes that the corporation schools' association in the USA had a "rather astounding blindspot; until 1917 when the Smith Hughes bill (on vocational education) was passed, they hardly mentioned federal aid to vocational schools". One understands from this that the state may be fundamental, even if it's role is more indirect. The practices that emerged in industry, professional associations and in the education system were responses to the conception among statesmen and bureaucrats of what was their proper role in technical education and the legal framework on the basis of which they developed their strategies. The basic difference between the German and American states, at a federal and regional level, was that the German states were more instantly involved in the development of higher technical education and in cooperative agencies related to this purpose. The American Government was more inclined to let the professions, the industrial associations, and the educational institutions govern their own matters. Archer (1979:161) has distinguished between development processes of imperalism and confederation. In the first kinds of processes a political elite will seek financial support to implement its plan for national education, whereas the second pattern emerges when a wider variety of educational entrepreneurs seek political support to consolidate their control. . In the first case educational systems develop by governmental initiative spreading outwards; in the second centripetally, from peripheral innovations which converge on government. The state did not play a completely imperialistic role in any of these cases, but the need and scope for governmental initiative was undoubtedly felt much stronger in the German case.

2.2. The argument from industry

The basic structural argument has been that changes in industrial and economic arrangements cause educational change. Functionalists argue that schools merely develop the skills and attitudes needed at work; as work requirements change, so do schooling practices and the structure of education (Garnoy and Levin 1985:3). In this perspective the differences between Germany and the USA in the early twentieth century are explained simply by pointing out the contrasting industrial structures and growth patterns in the two countries. Differences in industrial output, size of national markets and position in the international trade would inevitably lead to different education systems. The larger markets and associated strategies for mass production in the US indicated a higher demand for managerial-technical manpower at the higher end and more unskilled labor power at the lower end. Struck (1930:91) argued that "specialization in industry had, by 1905, already progressed to the point where it had almost killed apprenticeship in all but a very limited number of skilled trades such as the machine shop, printing and building trades." [4] American industrialists, according to this perspective were driven by market demands, and it was rational for them to develop a top-heavy polarized technical education system as opposed to the Germans who needed more skilled workers on the middle level and on the shop-floor.

Table 1: Industrial output in Europe and the US from 1860 to 1913.

	Germany	Great Britain	France	USA
1850	100	100	100	100
1870	129	129	131	138
1900	464	232	254	675
1913	714	294	385	1,250

Source: Dyas and Thanheiser 1976: 44.

A prominent place in functionalist lines of argumentation is assigned to the increase in output from education systems, since these numbers are supposedly a function of the growth rate in industrial production. Tables 1 and 2 provide some support for this argument. The explosion in engineering education in the United States came between 1900 and 1915, with an increase from 17 000 to 55 000 engineering graduates. In the same period the production index jumped from 675 to 1,250 points. Germany did not match this growth pattern with an increase from 464 to 714 points only. Its population of engineers did not grow as fast (from 41 000 to 65 000, non-academic graduates not included). The most rapid growth in engineering and production in Germany came a few decades earlier. The slower growth in engineering education in France as compared to Germany, might also be "explained" by the comparatively slow production growth. What can not be explained is why the number of graduates in the USA was so much lower than in France and Germany until 1890.

Table 2: Estimated number of Engineers with degrees in France, Germany and the USA between 1850 and 1914 1)

	France	**Germany**	**USA**
1850	6 687	3 343	n.d.
1870	12 050	11 856	866
1880	15 994	24 452	3 125
1890	21 504	32 166	6 962

[4] Struck also argued that the industrial education system of Germany was developed at a time when apprenticeship was still strongly supported and when the nation was a country of small shops. The methods of production had *not yet* become so highly specialized as in the United States (Struck 1930:91). Robertson (1981: 56) makes a similar argument in order to account for the difference between Great Britain and the US.

1900	28 829	41 657	17 392
1910	38 317	59 738	38 392
1914 2)	42 850	65 202	55 392

Source: Mann 1918:6 (USA) and Ahlström 1982: 106-8 (Germany and France)

1) The data on the USA is based on cumulative data on numbers of graduates from engineering schools. Ahlstrøm's methodology is somewhat different (see Ahlström 1982, p. 70-71). Non-academic engineers are not included in the German case.
2. The basis year for the USA estimate is 1915

The functionalist perspective of education does not specify by what mechanism education systems adjust to changing skill demands in the workplace. According to a new school of critical functionalists such adjustment follows from the powerful position business interests have in society. Noble (1977) argues that the education was transformed into a "unit of the industrial system". Industrialists were able to impose their views on the profession and the education system 1) by developing cooperative educational programs. Secondly, he notes that it was common for large industrial firms to develop in-house training programs. Thirdly, he lists several new agencies that were created to coordinate activities between education and industry (1977:169-70). I will now discuss these three arguments. [5]

Cooperative programs

Noble maintained that industrial interests were able to increase their control over engineering education by the introduction of cooperative programs. It may be useful to present an alternative view on these cooperative programs. Carlson has presented a detailed study of the cooperative program between General Electric and MIT between 1907 and 1920, which challenges Noble's interpretation (Carlson 1988). Noble has also put much emphasis on this case in his book *America by Design* (1977), and his narrative centers around the actions of Magnus Alexander, who was in charge of the training department at GE. In Carlson's alternative narrative, however, the driving force behind the cooperative program was not Magnus Alexander, but Dugald Jackson, an "academic entrepreneur" at MIT: "From the outset, Jackson strove to shape the course to reflect his vision of the engineer rather than simply serve GE's manpower needs" (550). "In Jackson's engineering philosophy the vision of the engineer as a leader and expert was fundamental, … and he pursued it even when it ran counter to what big business wanted or needed" (546).

Whereas Noble see an almost conflict-free relationship between corporate engineers in GE and Jackson and his colleagues in engineering education, Carlson thinks the whole process was marked by tension and conflict and that it was the educators vision who won out. Carlson argues that it was Alexander's purpose to educate "designer engineers and factory supervisors" that fitted in with General Electric's immediate manpower needs. Jackson, on the other hand, advocated that the MIT cooperative program should produce men " of larger vision and finer training .. for the distinctively higher executive positions," and not just "better $2000 - 3000-men". As

[5] Noble's account of the history of engineering in the USA has become quite authoritative and is therefore reproduced in many history books written for a larger audience (see e.g. Hughes 1989:244-45), and it is therefore necessary to spend some time and effort to probe the validity of the basic argument

other engineering educators in the USA Jackson was not interested in training technicians; he wanted his students to be leaders of industry.

Noble does not mention any such conflict in the development of the program. In his version the process of transformation seems to have taken place smoothly and with a minimum of conflict. What business wanted was exactly the managerial engineer envisioned by Jackson. It was not possible that a successful vision could originate and develop in conflict with industrial interests. The two scholars disagree fundamentally about how successful the cooperative programs were and how much support Jackson and Alexander had in their respective organizations. Carlson argues that neither the staff at MIT as a whole or managers at General Electric saw the cooperative course as an integral part of their institutional strategies (557). The plans were postponed because of the recession, and the first cohort did not graduate until 1922. The classes were much smaller than planned because General Electric maintained that they did not need as many as originally planned. From 1924 to 1929 GE hired between 328 and 342 new engineers annually. The cooperative program courses graduated between thirty and fifty students, but GE took no more than half of these students in any year. (562) In Noble's account this was a success, and he argues that the graduates increased their salaries at a faster rate than regular engineering graduates (192). Carlson argues that the course did not satisfy the firm's demand for technical manpower. The graduates from the cooperative program were not regarded as better prepared for firm-specific jobs than other engineers and there was no special recruitment policy for graduates from the cooperative program. The same procedures for recruitment and promotion was used as for other engineers, and this meant that they would be assigned to the "testing department", the regular in-house training program for all graduate engineers. Jackson was not pleased with this reluctance to accord special status to graduates from the joint program, and he pointed out that this was not in accordance with the original intentions of the cooperative program. Dissatisfaction with this turn of events may explain why only 5 of the 25 students in the graduating class of 1922 chose to stay with GE. (Carlson 1986:560-61) [6]

By the mid-1920s the cooperative idea had been adopted by sixteen institutions, or about 10 % of all engineering schools (Carlson 1988:548). Several of the cooperative programs failed, and the movement for cooperative education was not able to establish a position as a major model for American engineering education. If the cooperative idea was the industrialists' model for engineering education, then this case contradict Noble's claim that industry was able to "take over" the engineering schools. One might, of course, argue that these programs represented a major ideological alternative in education and that other institutions adapted to this competition by incorporating major elements from these programs in their curricula. This does not seem to have been the case,

[6] David Noble's book, although impressive in its extensive use of primary sources, may have made a few claims that cannot be sustained by the listed sources. It is maintained that D.Jackson's plan for a cooperative program was received favorably among corporate engineers. A survey referred to as evidence for this claim was constructed by Jackson himself, and Noble does not consider that it may have been biased. Noble also refers to a paper by M.Alexander presented at an engineering convention in 1908 that was supposedly very positively received. It appears from a reading of this source, however, that out of the 12 engineers participating in the discussion after the presentation only Jackson himself and Eliah Thomson of GE spoke explicitly out in favor of the course. Some of the other participants were, indeed, very critical. One educator found Alexander's plan the "most vicious educational innovation that has been proposed in recent years". Even the chief corporate engineer in General Electric, Charles P. Steinmetz, was critical of the proposals from M.Alexander (Carlson 1988:552, *Transactions from the AIEE* 1908 p.1485.)

however. Wickenden (1930:232) argues that the plan had gained mainly by establishment of new schools and that it was rarely introduced in already established schools. He notes that two schools had abandoned the idea. Among the most prestigious colleges only MIT adopted the model. Evidence at the time indicated that graduates trained under the plan did not "surpass others of equal ability in either responsibility or earning power".

In house training programs

If the emergence of cooperative programs demonstrated industry's increasing influence, then the question is why they did not become more widespread along with the rise of industrial power. An answer might be that industrialists would not take the risk of sharing the costs with education institutions, that they would want to organize their own proprietary programs. This is what one would expect according to an argument put forward by many that skills are not treated as collective goods in the Anglo-Saxon economies, and that the threat of loosing one's skilled employees to one's competitor poses a serious obstacle for investing in skill-creation (Streeck 1989; Rieble-Auborg 1996). If this was a major problem, then one should expect that it was critical for them to avoid a situation in which their own graduates sought employment in other corporations. This seems not to have been the case with the famous General Electric postgraduate test program for graduate engineers. Wise argues that GE took twice as many engineers as its expected needs into its "test" classes every year, and that placement interviews were arranged not only with company components, but also with other organizations (Wise 1979).

Another possibility is that these corporations simply were satisfied with the way that existing engineering institutions adjusted their curricula to industrial interests. If this were the case, however, one would also expect them to decrease the internal training costs by cutting down on their own in-house training programs. To the contrary, GE expanded their in-house programs for graduate engineers in the twenties; "Except during the depression years 1932-36 some 400 to 600 men .. would enter the test. ... 52 % of GE's engineers were Test graduates in 1919" (Wise 1979: 174-5).

A number of the larger industrial enterprises, such as AT&T, General Motors, General Electric, Chrysler, IBM have maintained schools of their own. Zaret (1967:388) reports that the total enrollment for such schools was many times greater than that for all engineering technology institutes and engineering colleges combined. Corporate schools were an important and consistent part in the skill formation strategies of many larger American companies already in the inter-war period. It is difficult to believe that these firms would be willing to develop such costly in-house engineering programs if they could satisfy their skilled manpower needs through development of joint programs with engineering schools and by participating in associations for accreditation in engineering education. Lazonick (1991: 217) argues that American firms traditionally has depended heavily on recruitment of lower level technical specialists, which were subsequently rotated from one department and function to the other in order to enable them to gain the experience necessary to move up the corporate ladder. It may be the case, then, that the conflict between General Electric and MIT, as referred above, illustrate a more common pattern of conflicting world-views and skill-formation strategies among engineering educators and business representatives in the United States in the inter-war period.

Cooperative agencies

The most striking fact with the development in the USA in contrast to Germany is the lack of such cooperative agencies, especially agencies in which industrial interests were directly represented. The Society for Promotion of Engineering Education *(SPEE*) was the major governance agency, at least until the establishment of the Engineers Council for Professional Development (*ECPD*) in 1932. [7] SPEE, composed of men teaching civil, mechanical, mining and electrical engineering, was founded in 1893. *SPEE* was by then the only professional society devoted solely to education (Grayson 1977:254). This association of educational interests was "able in a few short years to gain complete control of curriculum, admission standards, and other basic constituents of engineering education" (Calvert 1967:58). Although it maintained close relationships with the four major engineering societies, the organization's membership and leadership were largely composed of engineering educators, not practicing engineers (Zaret 1967:54, McGivern 1960:116).

Mcgivern and Grayson both argue that SPEE was able to keep the control of engineering in the hands of engineering educators (Grayson 1977:254, Mcgivern 1960:166). David Noble has presented another opinion on this issue, according to which the industrial interests gradually took control over SPEE and its offspring ECPD. The major evidence he presents for this is an editorial from 1912 stating that there is a "great increase in teachers and businessmen". [8] The occupational distribution of the membership was published annually in *Bulletin of the Society for the Promotion of Engineering Education (*later *Journal of Engineering Education).* These statistics show that the teachers continued to dominate the association between 1908 and 1923-24, and that only 5-6 per cent of the membership was "industrial officers". [9] There was a slight increase in practitioners among the membership after 1910, but teachers may have regained some of this position as the SPEE began to admit educational institutions to institutional membership in 1914 (Zaret 1967: 87).

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[7] Of 70 people at first meeting of *SPEE* there were 58 professors from engineering schools, 3 practicing engineers and 2 from abroad (Zaret 1967:54). *ECPD* was established in 1932 as the official spokesman both of practicing engineers and engineering educators in matters of curricular accreditation (Zaret 1967). Noble argues that this establishment "signaled the complete triumph of the corporate engineers and their particular brand of professionalism".. "as never before , technical education .. had become an integral part of the corporate industrial system" (1977:243). It is difficult to see that the establishment of *ECPD* could bring about such a dramatic change in the power relationship between educators and practitioners/business interests, however. Most of the founding institutions behind ECPD were also heavily involved in SPEE and the most powerful force within both associations were academic entrepreneurs and teachers (Zaret 1967).

[8] "Editorial", *Bulletin of the Society for the Promotion of Engineering Education*, III (1912), 354 quoted in Noble (1977:206).

[9] 767 out of 938 members were teachers in 1910. The share of practitioners increased from 19 per cent in 1910 to 25 per cent in 1911, but not all those counted as practitioners are practicing engineers, (e.g. journalists and publishers). The distinction between teachers/practitioners was not used in the statistics after 1915. There was a decline in the share of the membership listed as industrial administrative officers from 6 to 5 per cent from 1918 to 1924. The total membership increased from 1441 to 1775 in this period (*Bulletin of the Society for the Promotion of Engineering Education* 1910:377, 1918, 1924).

Germany

Higher technical education in Germany was established as a separate system, independent from the traditional university. This was a result of a compromise between the liberals and the conservatives in the 1820s, after which the Department of Commerce and Industry in Prussia was allowed to set up its own system of specialized instruction. This marked the beginning of an era with conflict about the status of engineering education in relation to traditional education. The technical education system was built in a single movement against "the old order", represented by the state and the traditional education system. Modernization was thus achieved through a separate program of special education for private industry. Engineering education was accepted as having the same status as the traditional academic education in 1899, when the *Technische Hochscule* was granted the right to issue doctorates.

The main conflict was between the state and the engineering professionals and educators [10] before the 1870s and between the state and the professionals/industrialists after this decade. A major compromise was reached around 1910, and as a result of this came *DATSCH* (*Deutsche Ausschuss für Technische Schulen*), the German Committee for technical education. This was an association in which educational institutions, professional associations, industrial associations and state representatives participated, and among which the German Engineering Association- *Der Verein Deutscher Ingenieure* (*VDI*) - took the central position (Wickenden 1930: 802). If there had been anything like *DATSCH* in the United States, then Noble's argument that interests external to engineering education were able to design the whole system in their image would have been a more plausible hypothesis. Gispen argues that "there is no question that the managers of Germany's large engineering firms dominated *DATSCH*" Gispen 1989:211. Through this committee, Gispen maintains, "industrialists and the managerial elite of the engineering profession was able to mold and subordinate the noneconomic functions of the engineering schools to its own needs". He does not seen any contradiction between this and that *VDI* took a commanding position, since he thinks that the industrial interests also were the predominant segment within the engineering association (Gispen 1989:218).

A closer look at the membership lists and protocols of *DATSCH* and *SPEE* makes Gispen's claim more credible than Noble in the case of the USA. Both *DATSCH* and *SPEE* had institutional as well as personal members. The *SPEE* only granted educational institutions such membership, however, and the teachers were in overwhelming majority among the personal members. In the American context it is likely that the practitioners identified themselves more with the school they came from than their specialty and business. DATSCH was not primarily a voluntary cooperative agency or an accreditation institution as the *SPEE* and later *ECPD* in the USA, but rather "a private body endowed with de facto public powers" (Gispen 1989:212). Among the institutional members in *DATSCH* were the powerful association of the engineering industry, the *VDMA*, and the major technical and professional associations. Several state agencies participated although they were not listed as institutional members. The academics and teachers constituted a minority. As *DATSCH* developed further the representation of industrialists and state agencies expanded more than educational institutions. The implication of this

[10] Professionals here means the elite in the professional association. This elite was dominated by the professors until the 1870s and industrialists after this date.

according to Gispen (1989:219) was that "the engineering society's leadership had now emerged next to the Prussian government as co-sovereign in the determination of technical education policy".

This remarkable *corporatist arrangement* is essential if one wants to understand how the German comprehensive system was planned but nonetheless operated relatively independent from the state. *VDI* took this initiative to *DATSCH* after having been urged to do so by the state. Using their own consultants and experts, *DATSCH* studied all forms and aspects of technical education. First on its agenda was the controversial question of non-academic engineering. This question had led to a split in *VDI*. Professor Riedler, along with a group of engineer-educators broke out and founded *VDDI – Verband Deutscher Diplom-Ingenieure,* which was explicitly meant to be an association for academic engineers only. This was protest against *VDI*'s support of the non-academic engineering schools in a period with overproduction of engineers. It was in the wake of this conflict that *VDI* reached a compromise with the state and the industrialists. The guidelines and recommendation following from the work of *DATSCH* became law almost exactly as proposed in 1910 (Gispen 1986:215). After the successful resolution of this question, the *DATSCH* next turned its attention to academic schools, and then lower technical training. The result of this work was a nationwide coordination, consolidation, and standardization of a system for technical education. It was the reform program initiated by industrialists and *VDI* as part of a national movement for a more practical and specialized technical education that provided the guiding idea for DATSCH between 1908 and 1912. In the case of the United States there was no equivalent national agency for the governance of engineering schools and technical education. Different interests specialized in different fields. Industrialists were for instance more important in the association for promotion of industrial education than in engineering education (Fisher 1967). They also had an *Association of Corporation Schools*, set up to develop in-house apprenticeship programs and management training (Noble 1977: 170-185).

So far I have not found much evidence for Noble's theory of a corporate "takeover" in American engineering education. It is not possible to identify a clear program or any systematic attempt from industry to impose their views on the engineering schools. It does not seem like any of the major groups, it being the engineering-managers or the academics/teachers, had a clear strategy for how to satisfy their own interests at the time.

The functionalist way of reasoning may be the wrong way to approach the issue, then. There is always an element of choice in managerial and professional strategies. The choices that are eventually made will depend for instance on the professional background and career-patterns of the managers and professionals that are involved, and accordingly their world-views and ways of conceptualizing manufacturing processes. It may however also have been the case that the industrial interests had a common conception of their interests, but that they lacked the organizational capabilities that would allow them to take the lead.

There are several indications that managers and industrialists in the USA actually wanted a more comprehensive type of education system similar to the German. Indeed, one of the most often repeated critical remarks in the trend-setting *Wickenden report* on engineering education was that the American system of technical education was "unbalanced and top-heavy". It was necessary to look to Germany and develop a more comprehensive and rational system. [11]. According to Elbaum (1991:208) the decline of the apprenticeship system in the USA was "by no means due to lack of employment interest. Indeed, during the later nineteenth and early twentieth century US employers often bemoaned the decline of apprenticeship and a perceived association with skilled labour scarcity". The quality of engineering schools has been repeatedly criticized from a business viewpoint, and there has for the most part been a demand for a more practical orientation. This indicates that the prevailing inclination among American managers was not always to promote deskilling and to recruit "Taylor-made" engineer-managers directly from schools, as indicated by the trend-setting works by Braverman (1974) and Noble (1977). There are other ways of explaining the American industrialist's lack of interest in technical education, than referring to their tayloristic attitudes. It is for instance possible that constant immigration of skilled personnel from Europe, and the abundance of engineering drop-outs ready to take the position of technicians was an important reason for the American businessmen's acceptance of the exclusive focus on academic education. If immigration was that important, however, then their strategies should have changed in the twenties when immigration of skilled technicians were down to 51,000 from 180,000 in 1905 (Struck 1930: 68).

So far I have argued that American managers were unable to influence the education system in any systematic way. Was it the traditional entrepreneurial "shop" dominance in the American engineering profession that accounted for this inability? It might indeed have been difficult to develop the apparatus needed to govern these sectors, because the entrepreneurs had been so influential both in the professional associations and in top management. The academic brand of professionalism won out in the technical associations in the USA in a period where *general managers* took over as role models in industry, but this transition from entrepreneurs to managers may have come too late to shape the basic institutional structure of the education system.

My preliminary conclusion, then, is that industrial interests did not dominate engineering associations and education institutions in the United States before 1880, but the educationalists. The business interests in Germany did not develop the same "trained incapacity" in education policies as the emerging corporate strata in the USA. It was this incapacity, in addition to aversion against state funded cooperative programs that drove the new corporate industrialists to create their own schools in stead of relying on the education system.

2.3 the argument from education

The argument from education is that educational systems develop autonomously from industry and professional associations. Schools have their own dynamics rooted in the institutional framework as it appeared historically and the field of knowledge and arena of politics associated with it. Cross-national variations, then, might be understood to be a consequence of different educational traditions and world-views among academic institution-builders, scientists and teachers. Their strategies are not determined but constrained by the respective institutional frameworks, and by available economic and ideological resources. These elements can be seen as

[11] When he was hired to do the project Wickenden was vice president in AT&T and part of the "business camp". Nonetheless, the whole report was based on the philosophy that improvement should come from within the profession (Zaret 1967:143) The other major report on engineering education between the wars, *the Mann report* (1918) did not see the lacking comprehensiveness of the American system as a problem. Mann was a physicist, and his academic background may have influenced the conclusions in the report.

"building blocks" for educational entrepreneurs (Meyer and Rowan 1977:26). It might therefore be appropriate to ask what kinds of resources they were looking for and in what kinds of settings they were most likely to find them. According to common knowledge about these societies, it should be more room for institution building and entrepreneurialism in the educational sector in the USA because of the lack of any national regulations or standards (Rheingold 1967). Secondly American society was more multicultural and had developed a value system and a mobility pattern based on achievement and ascriptive values (Parsons 1991).

The institutional entrepreneurs in the USA had an easy job compared to their potential counterparts in Germany. Economic resources, ideologies and clients were "littered around the social landscape: it (took) only a little entrepreneurial energy to assemble them into a structure" to use a phrase from Meyer and Rowan's classical article (1977: 26). The dynamics were different in the German states, where state officials provided the major funding and had a clear interest in developing a national education system infused with bureaucratic rationality and patriotism (Lash 1989:70).

The early impact of industrialization on American higher education, on the other hand, has to be understood in relation to the confederate forces gradually seeking governmental support to defend their professional territory. Academic entrepreneurialism exploded in the decade after the introduction of the Land Grant Act in 1862, which provided for the allocation of public lands to the foundation and support of colleges. The number of engineering schools increased from about a dozen in 1862 to 21 in 1871, to 70 in 1872 and 126 in 1917 (Grayson 1977:250). The most prestigious colleges that came to function as role models also in engineering education, such as Columbia, Harvard, Yale, were predominantly initiated by donations from wealthy businessmen. After the dramatic increase in the 1870s the coming of the engineering school in the U.S. was more of a continual trend. Between 1870 and the World War I the number of engineering graduates swelled from 100 to 4300 annually (Noble 1977:24,39). Just as remarkable, especially seen in relation to this high rate of organizational proliferation and the variety of entrepreneurs and strategies involved is the following conclusion about the outcome of the process:

> "It is surprising to find so little variety of types of instruction and of levels of entrance and completion among the one hundred fifty colleges of engineering, and so few substantial technical schools of any other type. Tradition, *the influence of early modes and imitative growth evidently may impose even greater uniformity than bureaucratic authority*" (Wickenden 1930:1000, my emphasis).

In order to explain this outcome it is necessary to sketch the major development patterns in the previous decades. It appears that the origins of the larger number of American colleges cannot be attributed to the industrial revolution or the demands of the economy (Collins 1979;121). Religious ideas and an emphasis on discipline and piety, the education of a democratic citizen, equality of opportunity etc. was more important than the demand from employers and professions for provision of practical skills and licensing of qualified labor power. This traditional model, however, faced a serious crisis in the 1850s. Failure rates were high, the colleges too small and financial difficulties were common. "Feverish entrepreneurship" in the educational sphere had founded perhaps 1000 colleges before the civil war, of which over 700 failed (Collins 1979:121 and Rudolph, 1962/1990:219). The lack of any national regulations or standards, and the variety in resources and ideologies continued to lure academic entrepreneurs into higher education. There were at least four types of actors involved; wealthy men of vision, pioneer educators, politicians and political leaders and college presidents (McGivern 1960; 164). Among these, the college presidents were most important until well into the twentieth century (Collins 1979, 120). [12] It was due to their administrative gifts, and the unifying power of the ideology of "science" that a system in crisis and disarray came to be stabilized and entered into a phase of expansion and consolidation. [13]

Wickenden locates a formative stage in American engineering education in the decades before 1870. This phase was marked by the creation of new and distinctive schools and programs; "its dominating personalities were more often scientists and publicists than engineers; and its chief aim had been the training of civil engineers" (Wickenden 1930: 818). Given the fact that the most preeminent institutional entrepreneurs did not have a practical background and that they imported a "science" model, it was no wonder that they alienated their clientele in the industry and the profession. The historical dominance of a shop culture in industry made the cooperation between the colleges and the elite in the professional associations difficult. The early academic entrepreneurs had to orient themselves towards practical and administrative engineering in order to gain acceptance for their graduates in the business community and in the professional associations.

The same type of crisis did not shake the German education system. This must be explained by the strength of the "old order". Whereas the industrial revolution and the development of a technical education system antedated the creation of large civil services in the U.S., in Germany the situation was reversed. All the academic technical schools were state institutions, and the proprietary middle-level technical schools, which mushroomed between 1890 and 1910, were also gradually brought under state protection (Gispen 1989:216-17).

The stability in the number of academic engineering education institutions was exceptional, in comparison with the USA. The total number of universities and technical universities increased from 13 in 1875 to 16 in 1920. In order to say something about the "impact" of the industrial revolution on higher education in Germany, it is therefore necessary to concentrate firstly on the processes of *internal diversification* in the technical universities. Secondly, it is necessary to study the development of separate educational institutions at a lower level, such as the non-academic engineering schools. In contrast; it is the institutional proliferation of institutions at the academic level that is most striking about the American case. There was an increase from 4 engineering schools in 1860 to 126 schools of college grade in 1918. Among the 126 schools in 1918 were forty-six land-grant colleges operating under the Morrill act, forty-four professional schools in universities, twenty schools attached to colleges, and sixteen independent institutions (Mann 1918). As other American professional schools these schools adopted the same degree structure as other departments, B.A., M.A. , Ph.D. and were also increasingly integrated in universities (Collins 1979). [14]

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[12] The new leaders were not clergymen, as the old college presidents had been. McGivern mentions Charles Eliot, a chemist, Gilman, with background in political geography, and Andrew White, a historian (McGivern 1960:119).

[13] For accounts that emphasize professionalization as a strategy to create order in insecure and chaotic environments see Bledstein (1977) and Wiebe (1967).

[14] McGiverns (1960:166) has argued that the engineering schools were even more intimately associated with the American 4 year college programs, since the individual professional societies had been established after the school administrators had established a curricula.

Whereas horizontal differentiation within institutions (curricula, chairs) and vertical differentiation among types of schools (lower vs. higher technical education) was the common pattern in Germany, competition also took place among different institutions at the same level in the USA (Lundgreen 1983:49, Herbst 1982, 205). The curricular diversification within German technical universities took place at a quite early stage. Until about 1870 there were 50 to 60 technical and scientific teaching subjects in institutes of technology, while by 1880 it was more than 100, by 1925 nearly 200 and by 1900 at the Berlin technical university more than 350 (Manegold 1978:153). Herbst (1982:205) argues that the diversification among colleges in the United States initially tended to hold back curricular diversification within them, but that American universities later diversified also internally. The major difference was that the American universities were more oriented towards teaching and that they were
organized according to more egalitarian principles.

Another important effect of the dramatic increase in the number of institutions offering university degrees between 1860 and 1920 was the development of associations for accreditation and standardization. The Association of American universities were engaged in accreditation activities from 1914 on, and the Flexner report on medical education has been given much credit for the invention of accreditation associations (Zaret 1967:178). The American Council of Education (1918), of which SPEE were among the founding members, was another pioneer in accreditation activities. In 1924 over 170 institutions were members. The author of the famous Wickenden report urged the engineering societies to create their own accrediting agency and this agency (ECPD) was set up in 1932. This association arguably took on some of the same tasks as educational ministries and governmental committees in continental Europe. [15]

The need for setting qualifying standards in engineering education was supported by reports of the high failure rates among students in the USA compared to Europe. The Mann report published in 1918 revealed that 60 per cent of freshmen failed to obtain their degrees (Mann 1918: 32 -33). Almost 3/4 of the loss took place in the first two years of the study. This was an improvement over the 75 % of freshmen who dropped out in the 1870s (Robertson 1981, 52). The high number of dropouts may be related to the traditional strength of the "shop tradition" in American engineering, however, since it may be easier for non-academic engineers to enter the engineering profession from the shop floor. Accordingly, a large group of American technicians distinguished themselves from academic engineers not by type of schooling but by their failure at achieving a degree. This must have strengthened the trends towards relying on degrees and school ranking as criteria for a new status hierarchy also in engineering (Collins 1979:171). In the longer run the academic engineer was the only type of engineering graduate, and the strong drive towards standardization in engineering education strengthened the influence of the elite schools.

[15] Accreditation is defined as "the process whereby an organization or agency recognizes a college or university or a program of study as having met certain predetermined qualifications or standards" (Zaret 1967:177).

Table 3 : Academic Institutions in Prussia, 1875 - 1920

	1875	1885	1895	1905	1913	1920
Universities	10	10	10	10	12	12
Technical Universities 1)	3	3	3	4	5	4

1)Technical institutes before 1898
Source: Statistische Jahrbucher fur den Preussischen Staat, Lundgreen 1983: p. 184

The major institutional framework in German and American technical education was in place around 1870, except the technical middle schools in Germany that mainly were established from the 1990s. Growing from a few hundred in the 1830s and 1840s, the enrollment in the higher technical schools in Germany fluctuated between 1,000 and 2,000 in the 1850s. By the 1860s, enrollments shot up rapidly, reaching a total of nearly 5,000 in the academic year 1871-2, and over 6,600 in 1875-6 (McLelland 1980:241). It then increased to 12,576 in 1903-1904 before leveling off at about 11,541 in 1914. At the same time, student numbers in the non-academic engineering schools increased from about 1400 in the late 1880s to almost 11,000 by 1910 (Jarausch 1990:18).

State responsibility for higher education in Prussia gave professors autonomy from private funds and professional contributions. This meant that they depended on the state and that they as civil servants were obliged to implement state policies. One might then have expected that the established civil service and *Bildung* ideal would have penetrated the early engineering schools profession in Germany. As mentioned above this was not the case. Engineering was developed as a science before industrialization took off. The dominant status group in Germany, at this early stage, was not the entrepreneurs as in the USA, but the academics, the state engineers and other civil servants that predominantly had a legal education (*bildungsbürgertum*). Industrial engineers and engineering professors were not usually allowed to advance into these positions. It was for this reason that they had to turn their attention to commerce and business occupations with a lower status (Wirtschaftsbürgertum) (Lash 1989:70). It was also their strategy to increase the status of the engineer through academization of technology (Manegold 1978), and the struggle for approval of the *Technische Hochschule* as equivalent with the traditional universities continued also after it had been granted the right to educate doctors in 1899. But as the industrial revolution took off in Germany, these engineer- educators faced an increasingly strong reform-movement among practitioners, teachers and industrialists. Apparently they did not see it as a realistic and appropriate model for academic engineers to claim a monopoly on all qualified technical positions within the firm, and they gradually had to accept the formation of a new separate system of technical schools at a middle level. [16] It was partly for this reason that German engineering gradually developed into a more practically oriented profession than its American counterpart.

[16] There had been established a wide range of proprietarys schools outside of Prussia at this level from 1890 on, and the Prussian state had also started to fund technical schools at this level. It was these schools that later developed into *Ingenieurschulen* and *Fachchocschulen* (Gispen 1989:216).

The engineering-educators in the United States did not face any broad social mobilization of this kind, and it appears as if they were able to govern their own matters to a larger extent. They also faced processes of rapid industrialization and a rather disorderly environment, however, and continued to upgrade their educational services towards a scientific model, presumably based on a German prototype. Like the engineering pioneers in Germany the American engineers also aspired to establish their science as a pathway to elite positions in society. Confronted with entrepreneurialism in industry and an elite of "gentlemen" from the shop culture in the professional associations they established their own brand of managerial professionalism. Calvert (1967:281) argues that "the conflict between shop and school began in the late 1860's when the first engineering schools for mechanical engineers were set up". This conflict intensified until 1890, but was followed by a period of self-examination and compromise that led the school forces to get an upper hand from 1905.

The period from the 1860s through the 1920s was a golden age of prestige for the American engineers, precisely because so many of them were entrepreneurs. The men who founded the professional associations in the USA were secure in social status, and their associations served to lend the occupation of mechanical engineer the status they already possessed as individual entrepreneurs. One might also use Bourdieu's distinction and talk about an attempt to defend their status by transferring economic capital into cultural capital (Calvert 1967:131, 1972:49, Bourdieu 1984). But this was also the start of the golden age for the large industrial corporation and the application of science to industry. The original entrepreneurial ideology was therefore increasingly outdated, and the new professional program and cultural capital came from the new education institutions. In Germany there was no need for renewal in this direction, since the status of the entrepreneur had always been low, and since the engineers had used their cultural-scientific capital as arguments for increased status since the 1850s.

In the USA private funds were important in the establishment of a technical education system, but as was the case with the politicians in Prussia, the providers of these funds seem not to have been able or willing to control the development of the school system. A parallel to the entrepreneurialism in higher education in the USA was found in lower technical education in Germany. There was one difference, however. The major institution-builders were not individual entrepreneurs, but collective actors, such as associations and local state authorities. Dawson had observed in 1912 that "disregarding altogether the regular schools - primary, continuation, middle, and higher - there were in this comparatively small country (Saxony), no fewer than 515 special schools exclusively engaged in imparting technical knowledge of one kind or another" (Dawson 1919:105). Dawson noted that there were major differences depending upon type of schools regarding which interests had founded and supported them. The trade schools (*Handelsschulen*) were in the hands of the merchants and manufacturers' associations, differently named. The Industrial Schools (*Gewerk- und Gewerbeschulen*) were also the result of private associated effort, most of them having been established by Trade Guilds and other associations, though many were municipal and a few were state associations. Chamberlain (1908:9) also emphasized the role of guilds and corporate associations, which "may organize, equip and foster schools of such character as train directly for their particular lines of work". Such institutions specializing on technical education on a lower level were much less developed in the USA. In the Douglas Commission of Massachusetts' report on industrial education in 1905 it was estimated that technical education on high school grade was fifty times as extensive in Germany as in the United States (Struck 1930:91).

2.4. Technical education as part of a strategy for professionalization

The argument from the profession, eventually, is that the formation of two models of technical education may be understood as part of a professionalization project among the new middle classes, and most preeminently among them the engineers. I will compare the collective strategies and the organizational resources among engineers in order to explore this argument. It follows that the policies and the emergence and consolidation of professional associations may be of major importance. How successful their common strategies were will again depend on their ideological content, the degree to which they were unified and to what degree other and more powerful organizations engaged in the same issues and organizational fields. I have earlier noted that the industrial associations and the corporate managers in charge of training in the USA tended to concentrate on lower technical education and in-house training programs, and that the state left the task of standardization and cooperation among educational institutions to the educators themselves. It was the professional models advanced by these educators that won out in the USA, and not the original entrepreneurial "shop" models fostered by the early engineering associations. This fits with a classification of the American pattern of professionalization as university-led or school-based (Burrage et al. 1990:219, Burrage 1993:180).

In Germany, I argued, the succeeding professional model had its base in the professional associations, but was modified by the advancing industrial interests. The traditional brand of professorial professionalism oriented towards occupational closure partly "lost out" when it was faced with a strong reform movement among practitioners and industrialists. One reason for this failure was the historically weaker status of the German engineering profession in comparison with the American engineer-entrepreneurs. The status of German engineers increased, however, whereas it may seem like the status of the American profession decreased as a consequence of academization. By focusing on the distinct role of *engineering associations* I want to account for the emergence of the new educational models and technological cultures. I will explore the impact of the professional associations on the work organizations; whether they acted as a force for unification or polarization and how they influenced the self-perception (*leitbild*) of engineers.

The question of engineering professionalism has been subject to controversy in the literature on professions. It was a lot of interest for this in the wake of the perceived Soviet scientific advantage or the so-called "Sputnik" shock in the sixties, and a discussion on engineers have been a standard exercise in various contribution in the sociology of profession since then. It was argued that engineers was an "open profession" (Rothstein 1969), a "profession without a community" (Perrucci and Gerstl 1969) and that engineering was a *weak profession* in comparison with the archetypal lawyers and physicians. Burrage et al. (1990: 214) argues that neither collective organization or ideology has been effective strategies for strengthening the engineering profession:

> "It appears, in fact, that the upward, managerial 'exit' route is the Achilles' heel of the profession, undermining both their solidarity and their ideology". … Strong professions on the other hand have no alternative career outside the profession, no such exit".

Similarly, Layton has argued that American engineers defined themselves as an industrial and managerial profession and that this accounts for their subordinate status. Business interests in the United States have favored technical societies built around single industries. A count in 1963 listed 130 national engineering and allied societies (Layton 1969: 56). The nature of engineering work itself is also used as an explanation for its weakness. Engineers do not have individual clients and the engineering profession is one of the most occupationally assimilative of any profession; "its higher-level segment tends to merge with that of managers in general, its lower group into the class of skilled craftsmen"(Collins 1979:174). But engineering can also be perceived of as the core occupation in the technical division of labor among craftsmen, technicians and engineers, a perception that may be used to bolster the position of engineers, as the German case illustrates. This gives credibility to another perspective on professions, putting less stress on the nature of the work itself, and focusing instead on the division of labor within organizational fields. This division of labor take different shapes depending on what society we are talking about. It might be polarized/ integrated and skewed towards the managerial or the craft end of the continuum (Abbott 1988,1991: 33, Armstrong 1984). What is interesting about the suggestion that strong professions have "no exit" is that it implies that the strength of the engineering profession will vary with the degree to which they have successfully gained access to and occupied space in the managerial dimension or not. Abott (1989) suggests that the strength of the profession will be influenced by its relationship to other occupations and the relative strength of these.

Let me assume that *status* is a good indication of the strength of a profession. Evan (1969:127) finds that the status of engineers decreases with the progress of industrialization and that it is higher in less industrialized societies. This thesis fits in nicely with the observed development pattern in the USA where engineering was increasingly defined as a preparation for management. Its status position seems to have deteriorated accordingly, as the "no exit" hypothesis suggests. This may not have been the case in Germany and Japan, however. At the time of Evan's study the lower level of industrialization in Japan/Germany was commonly thought of as an explanation for the difference. This kind of argument does not have as much credibility today. Let me suggest the following alternative hypotheses:

1) The "exit" option was not as strong in Germany; engineers did not advance into management to the same extent.
2) Engineers did advance into management, but they were more successful at defining management as a technical dimension and a value based calling, as opposed to a general profession in which marketing and financial knowledge would matter more than technical knowledge. A career from technician to engineer to manager, then, was not perceived of as an exit from the profession to the same extent as it was in the USA.
3) The one-sided emphasis on the academic engineering-end of the technical spectrum in the USA and the neglect of the other occupations and specialties involved in technological development has weakened the status of technology as such and therefore also engineers.

Hypothesis 1; that engineers did not advance into management to the same extent in Germany as in the U.S.A., is apparently wrong. Academic engineers, indeed, were even more successful in management in Germany. The other two statements, however, are supported by a great deal of literature (Hartmann 1959, 1967, Lawrence 1980, Locke 1984 and 1989, Byrkjeflot 1998). [17]

Burrage's hypothesis about the relationship between an exit-option and weak professions, then, has to be modified. Engineers are weak when they have to leave the engineering profession and enter the managerial profession as they climb into leadership positions, whereas they are stronger when it is possible to identify as manager and engineer at the same time. The engineering profession, then, is weak or strong depending on the social context. This modification actualizes the recurrent criticism against the literature on professions that it is too time and context-bound. Engineers are not weak everywhere because they are weak in the U.S. and Britain. The notion of profession was initially developed in an Anglo-American setting, stressing markets, associational self-control and autonomy; features that are likely to be less important in Germany and other continental European countries (Millerson 1964, Larson 1977). The method among the first sociologists studying professions was to compare single professions in a mono-cultural setting, and the purpose was to describe inevitable development patterns rather than to understand the consequences of various types of professionalization processes. Several historians, drawing on both Anglo-American and Continental comparative studies, have realized the need for a more historical and context-sensitive perspective on professions. They argue that it is necessary to include legislating or regulating politicians, university professors and other academics as actors in the professional struggles. This approach is much more promising since it focuses on relationships between "internal" professional development, other professions and specific policy outcomes and arrangements, such as for instance development of technical education systems or managerial strategies (Jarausch 1990, Burrage et al. 1990).

In this perspective professional associations are not "everybody's" association but "loose amalgamation of segments which are in movement" (Bucher and Strauss 1966:193, Gispen 1990:8). Depending on the dominance of a particular segment of actors, patterns of development such as industrial hegemony or practitioner control might be elaborated, and specific phases of evolution can be discerned, which are conditioned by the prevailing forms of professional strategies and organization models. This perspective allows me to look for competing and dominant segments within the profession and the brands of professionalism associated with these. I do not subscribe to the view that if associations are dominated by non-representative elites, such as scientists or industrialists; then they may also be merely tools for these interests. [18] This kind of argumentation collapses the business interest type of argument into an argument about the role of professions. If the professional association is influential and corporate engineers (i.e. business interests) predominant in its daily activities then it is corporate interests that have won out. The implication is that a profession in order to be a "real profession" should define its members interests independently from industrial interests. In the argument from profession, however, a professional association is never exclusively an agent for an external principal, such as a business association or an educational organization, even if one segment dominates. Since professional associations are

[17] See also Harbison and Myers (1959:129) who argues that German managers do not tend to think of themselves not as professional managers but as engineers, lawyers, accountants etc. The top managers resist professionalization in the belief that it may threaten their formal authority position.

[18] Hortleder (1970) argues for instance that the VDI was a service organ for German industrialists. Hughes (1989) and Noble (1977) make a similar argument about the USA.

coalitions of their respective competing segments, and since their leaders are elected, their policies tend to be a compromise between dominant coalitions and the leadership's interest in promoting their own interests.

Since engineers in Germany and the USA were organized in several types of associations during this time-span [19], and since we cannot cover everything, we have to narrow our investigation down to the dominant organizations. In the case of Germany this was the V*erein Deutscher Ingenieure* (*VDI*), which was established by engineering graduates at the technical institute in Berlin in 1856. None of the founders of *VDI* were industrial entrepreneurs. The purpose of the association was to promote "intimate cooperation for the intellectual powers of German technology for their mutual encouragement and continuing education in the interest of the whole of German industry" (*VDI-Zeitschrift* 1857:4, quoted in Gispen 1989:51). Gispen (1989:55) reports that these early founders conceived of technology as "an autonomous intellectual-practical and national achievement, not an activity tied to profit or money". It was this conception of their role in society that drove the engineering professionals in *VDI* to unite with teachers and see education policies as a major strategy for professionalization. The initial marginality of both the engineering association and the technical school system in comparison with the state bureaucracy and the traditional university gave them a change to develop alliances and it has been argued that the *VDI* had a strong group-formative effect on German society.

Table 4: Membership in VDI 1856 - 1920

1856	172
1860	367
1870	1 821
1880	3 959
1890	6 925
1900	15 245
1910	23 952
1920	23 917

Source: Ludvig and König 1981: 562

The segment of engineering professors dominated the engineering association in Germany until the 1870s. These engineering scholars promoted a conception of engineering as science based on the foundation of classical secondary education and other quasi-aristocratic measures of social honor. In contrast to the situation in the USA these technical educators had arrived on the scene well before the breakthrough of industrial society (Gispen 1989:16). The engineering associations in the United States left these matters to the teachers and academics, and the relationship between these two groups were much less cooperative. There were no membership criteria in the early period. Calvert (1967:55) classifies the association of mechanical engineers (ASME) as a "gentlemen's club".

[19] The pattern was similar to what took place in the education sector. Institutional proliferation at a professional and horizontal level was the pattern in the United States as well as Great Britain (Buchanan 1981).

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Table 5: Foundation date and membership distribution among the four "founder societies" in the USA

	Founded	Membership 1900	Membership 1916
Civil engineers	1852	2227	7909
mining engineers	1872	2661	5234
mechanical engineers	1883	1951	6931
electrical engineers	1884	1273	8212

Source: Mann (1918:19)

Only 866 engineers had graduated in the USA before 1870. There were 179 members of the American society of civil engineers, as compared to the 7,374 listed as engineers of that date. McGivern (1960:108) concludes that 88% must have received training by the apprenticeship method. This supremacy of the "shop culture" could well explain why there was a lack of interest in formal engineering education among the engineers themselves, and why technical education during the first half century developed independently of the engineering associations, which did not engage in educational matters.

As noted, there was one engineering association (VDI) that clearly took the lead in Germany, whereas there was a power balance between four associations in the USA. The more unchallenged status of *VDI* was one of the reasons for its strong influence in educational and professional matters. Wickenden wrote about the German association that " its publications on educational matters probably equal those of all the engineering societies of France, Great Britain and America combined" (Wickenden 1930, 802).

3. CONCLUSION

The objective has been to explain why the German states developed a more comprehensive system of technical education, whereas the American system for industrial education was heavily centered around academic engineering education. The movements for establishing technical education at a lower level was much less coordinated in the U.S., and the ideology and the nature of the associations involved in activities at this level was more individualistic and oriented towards social uplift for the disadvantaged classes. While the field of industrial education system in Germany developed at a time when apprenticeships were still strongly supported by trade associations and guilds, it was presumed that the apprentice system was dying in the USA. Missionaries and philanthropic and social reformers were interested in vocational education in the United States, not artisans, state politicians and industrialists as in Germany. Manual training was developed for cultural and social, not industrial purposes. This model was not very successful, and in the early twentieth century a new movement for a more industrially oriented vocational education took form. It was as a result of this that a tradition of federal aid to vocational schools was eventually established through the National Vocational Act of 1917.

The institutional entrepreneurs behind these reforms, however, were schoolteachers and industrialists strictly separated from the institutions involved in the promotion of professional engineering education. Secondary vocational schools and apprenticeships were therefore not linked up to and coordinated with engineering schools as they were in Germany**.** This failure to develop a direct career-path from apprenticeships and vocational schools into engineering might be one of the major explanations for the persistent and unbroken trend towards management dominance in American engineering. Engineering education in the U.S. was built on the top of an existing, generalist model for general secondary education. It is thus not a coincidence that the American education system "for all the talk of its vocational emphasis, is still the most massively non-vocational system of education in the modern world" (Collins 1979; 162).

In Germany there was drawn a sharper line between the traditional university and technical and industrial education. This distinction had been developed already in the 1850s. The rise of the more technically oriented secondary schools and middle and top-level education institutions was part of a movement for industrialization. A system of institutions was built up from the ground, and the outcome was the most comprehensive and vocationally oriented technical education system in the world.

Each of the four actors presented above; the state, the educationalists, professional associations, industrialists contributed to the distinctive development patterns. Some actors were more influential, however (figure 2). The stronger state and the influence of the civil servant as a role model in Germany gave the professional association a powerful position in educational matters. The German engineering association was among the major forces in the formation of a technical education system. Wickenden (1930) thinks that the industries provided the "motive power" while the technical professions were guiding the movement. The state used the profession against industrial interests and the profession used the state. The emerging consensus between industry, the professional association and the state around 1910 was the result of a long process of political negotiations and adjustment. The educational policies of all the respective partners in Germany have to be understood in relation to the institutional framework developed before 1880 and the school reform movement from around 1880. The school reform movement was part of a strong movement among the German *wirtschafts-bürgertum* for increased status and acceptance among the educated and privileged middle classes (*bildungsbürgertum*). This explains partly why business interests in Germany developed different strategies and world-views than businessmen in the USA, and that the various groups of actors' perception of their interests were heavily influenced by their nationality. Each group was were more influenced by the nature of the major political processes and conflicts they participated in and their respective fields of knowledge than is assumed in more structurally and evolutionary oriented explanations.

Wickenden has made an explicit 'argument from education' in the American case:

> "In no other country have the engineering schools been so free from outside domination. They owe little to statecraft other than the provision of means for their extension and support. They owe little to the organized engineering profession except the benefits of occasional criticism of their aims and methods. They owe little to the industries except an ever-widening field of employment for their graduates" (Wickenden 1930:823).

The discussion above supports his argument. In the USA the industrial interests were not participants in the decision processes to the same extent as in Germany, where industry traditionally had been engaged in apprenticeship training and education on a cooperative basis. The abundance of technically skilled personnel and institutions for technical education may be interpreted both as a constraint and a resource for industrialization in Germany. Technicians and craftsmen were more powerful, and it was therefore not as easy to replace them with academic engineers. The different situation in the USA might partly be explained by the mobility in the labor markets (Elbaum 1991), the waves of immigration of skilled personnel from Europe, and the abundance of engineering drop-outs ready to take the position of technicians.

This account has emphasized the different institutional framework, the political constellations, and the differences in organizational resources among academics, practitioners, states and business interests. Since the boundaries of each organizational field was drawn differently, and since the academization process started so much earlier in Germany, the industrial revolution was bound to have different impact on the development of technical schools. The rise of the large corporations in Germany increased the influence of the practitioners and the industrialists in the education system, and not the teachers and academics as in the American field of industry-related education.

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