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3. Educating Men: Women and the Swedish Royal Institute of Technology, 1880–1930

The institutionalization of engineering as a specialized and socially valued profession occurred in Sweden, as it did in many other industrializing European countries, by the end of the nineteenth century. Engineers acquired prestige and power because of their mastery of modern technology and socio-technical systems.[1] The profession organized itself as a masculine domain, monopolized by men and invested with masculine ideals and ambitions. My purpose in this chapter is to show that such genderization of professional engineering should not be regarded as a self-evident fact, but rather as an ongoing social process, as a form of 'history-in-the-making' within the realm of education and work. We shall see how identities were defined and redefined through social practices, in which the distinction between male and female positions in social hierarchies and the boundaries between masculine and feminine areas of technical expertise were at once being contested, defended, and sometimes, redrawn.

In what follows, I will focus on Sweden's most prestigious school of engineering, the Royal Institute of Technology in Stockholm, to analyze prevailing educational goals and everyday practices at the turn of the century. I will discuss the ways in which the institute prepared selected young men for positions as technical leaders within industry and public affairs. I will look at educational practices in a broad sense, including the school's curriculum, its pedagogical methods, and the homo-social relations and rituals of its everyday life. What kind of masculinity was forwarded to the pupils? What sort of man was being formed in this educational context? And what happened when women attempted, occasionally with success, to gain entry? Did their presence result in boundaries being redrawn, and was the school's homo-social culture challenged?

Previous Studies

Other scholars have addressed questions concerning the masculine character of the field of engineering and the response to women who wished to acquire technical expertise in different ways. There is a growing international body of empirically oriented historical research, some of which appearing in this volume.[2] These studies provide, as we shall see, valuable points of comparison and contrast. Their focus, however, is on the exceptions – i.e. the small number of women engineers – whereas my focus here

will be on the rule, that is to say, on *men*. Historians of ideas, such as Brian Easlea, Carolyn Merchant, and David Noble, have addressed the relationship between masculinity and technical expertise.[3] Such studies are broad in scope, and link up the development of science and technology, from the Middle Ages onwards, to ideologies of destruction, misogyny, or control, as well as to the creation of all-male institutions of knowledge, such as monasteries, universities, polytechnics, research institutes, and so forth. While interesting in themselves, both these studies and their arguments appear too straightforward for my purposes here. I regard the relations between masculinity and technology as more ambiguous, more changeable, as well as more contradictory than such studies appear to allow. In order to understand the significance of these relations, we must study everyday practices and modes of daily interaction at a particular time and place.[4]

Instruments for this kind of analysis are provided by the sociological and anthropological work of, for instance, Cynthia Cockburn, Sally Hacker, and Sharon Traweek.[5] Cockburn has shown in which ways manual technical skills became an integral part of the masculine self-image and a source of pride for the typographical workers she interviewed. Hacker has exposed the identification of mathematics and technical problem solving with male power at an elite technical university in the US. Traweek studied the career patterns and the various kinds of sociability that are rewarded in the highly competitive research field of physics, patterns which almost by definition exclude women and benefit a certain type of man.

Whilst these are important studies, enabling us to understand specific expressions of masculinity in different sociohistorical contexts, they do not help us with a detailed analysis of everyday *educational* relations and practices. I therefore also use theoretical tools provided by the sociology of education, despite the lack of gender awareness in this field. Studies by Pierre Bourdieu, and by Bourdieu and Jean-Claude Passeron, have not only enlarged my understanding of the *specificities* of educational institutions in relation to material and symbolic power, but also enabled me to focus on the particular cognitive and social '*habitus*' inculcated in specific educational contexts.[6] Basil Bernstein has discussed in which ways power is organized within *educational practices*.[7] His insights have had considerable influence on my own analysis below. Finally, a by now classic article by Ralph Turner has offered me tools for understanding the ways in which different regimes of *social mobility* produce a (masculine) form of sociability.[8] Turner's concept of 'sponsored mobility' has helped me to analyze the situation in the early twentieth century, when young men from an early age onwards were selected and ultimately incorporated into a societal elite, via grammar school (*Gymnasium*), and – in the present case – through higher technical education. How this was done will shortly become clear.[9]

Figure 14. The Chalmers Co-educational School, the future of engineering education as seen through the eyes of the well-known Swedish artist Carl Larsson. The drawing was published in the college engineering newspaper in 1903. Reproduced from Rasp *(1903).*

An Education For A New Elite

The period I focus on here, 1880–1930, was one of expansion and contradiction. Sweden was transforming itself from a backward, rural, and agricultural community into an industrial and increasingly urban society. As late as 1910, 70 per cent of the population resided outside the towns and boroughs. The income per capita was low, about half the average American wage at the time.[10] Only twenty years later, however, there were more people working in industry than in agriculture and forestry, the urban population had outgrown the rural one, and the standard of living was among the highest in Europe.[11]

The transformation of Swedish society took place in the context of fast economic growth. Early industrialization had been a predominantly rural phenomenon, based as it was on the demand for iron, wood, and agricultural products from abroad, but also on an internal demand for agricultural machinery and plain consumption goods. Small- and medium-sized companies dominated industrial production, which was closely connected to traditional mining and ironworks firms. By the end of the nineteenth century, this mode of production gradually linked up with a new industrial structure. From the 1890s onwards, industry grew rapidly, by the turn of the century, the new industries had replaced agriculture as the main contribution to the Gross National Product. More finished products, such as high-grade steel, engineering products, as well as paper and pulp, became the main products of exportation. Swedish engineers were instrumental in bringing about these developments. Large-scale attempts at exploiting Sweden's natural resources, notably iron ore and water power, were undertaken to benefit an expanding industry. 'Taming

the waterfalls' was a major preoccupation of many among the most prominent engineers in the early twentieth century.[12]

Another central feature of this period was that it saw the creation of several important engineering firms, which, to this very day, form the backbone of Sweden's industrial and export sector. These industries – such as SKF in spherical ball bearings, Alfa Laval in cream separators and steam turbines, ASEA in the generation and transmission of electrical power, and Ericsson in telecommunications – enjoy almost mythical importance in the Swedish public mind. Most of these firms found their basis in Swedish innovations, and were built on mainly Swedish capital. They soon set up subsidiary companies abroad, and became successful competitors on the foreign market.

Not surprisingly, then, professional engineering managed to establish itself during this period as a vocation for a modernizing elite. It was engineers' expert knowledge that lay the foundations for the important new industries of mechanical and electromechanical engineering, and for the new methods of processing in the paper and pulp industry. Engineers constructed the railroads, the gas works and the electricity systems for a modernizing country. They promoted scientific technology and 'scientific management,' and introduced new consumer goods, such as bicycles, telephones, sewing machines, and so forth. To many contemporaries, and indeed many subsequent generations, engineers were the heroes of industrial expansion and the modernization of society. Their ambitions for leader positions in both state and industrial domains were frequently fulfilled.

In order to keep down their numbers, and to avoid creating an 'engineering proletariat' such as the ones thought to exist in Germany or the US, the Swedish engineering community also managed to maintain high entrance qualifications and low student numbers in the most prestigious schools of engineering.[13] To enroll in the Royal Institute of Technology (KTH) in Stockholm, and to a lesser degree, in the Chalmers Technical Institute in Gothenburg, was thus a sure ticket to a position of leadership, whether in industry, state administration, or independent engineering practice. Most contemporaries took it for granted that this was to be an exclusively male domain.

Women's Employment and the Engineering Profession

The years around turn of the century were also those in which women's fight for education, work and social liberation gathered momentum and achieved important results. Many discriminatory practices regarding women's and men's respective social positions hence were not only established and defended, but also challenged and overturned. The universities opened their doors to women in the 1870s. Middle-class women subsequently tried, and in the face of considerable opposition, to acquire teaching positions at the *Gymnasia,* to gain academic recognition, and to take up new occupations related to technical progress, such as telegraphy and telephony.[14]

Sweden, with its low average income and strong rural orientation, knew a long tradition of female employment. Unlike the women in more prosperous countries, they were forced to work for a living. In 1920, 36.3 per cent of Swedish women registered as gainfully employed, as compared to 19.5 per cent of American women of European descent. If farm-wives had also been included in the Swedish total, the figure would have risen to 54 per cent. Outside the rural areas, the pattern of predominantly male breadwinners continued, however, and by the end of the nineteenth century, the notion of separate spheres for the different sexes was widespread. In view of the low per capita income, we can nonetheless safely assume that Swedish women, also those in the lower middle classes, had to supplement the family income through going out to work.

Add to this that Sweden had for a long time known a substantial numerical dominance of women over men in the total population; a difference that became even more marked when, around the turn of the century, many men left for the USA. In 1910, there were 105 women in Sweden to every 100 men. What is more, only 46 per cent of Swedish women were married, as compared to 60 per cent in the USA. All this entailed that many women had to earn their own incomes, not only to maintain themselves, but also to support their dependents. The number of single mothers rose in particular at this time: in 1920, the proportion of illegitimate children reached a maximum of about 15 per cent.[15]

The struggles for female civic, educational, and employment rights gained important successes after World War I. Universal suffrage was established in 1919. In 1921, most of the professional schools that had not done so before, e.g. institutes of engineering, opened up to women. In the late 1920s, it was no longer allowed to exclude women from middle- and higher-level state positions in, for instance the realms of teaching, law, and medicine. In 1924, finally, the major route to the middle classes, i.e., a baccalaureate from the public *Gymnasium,* which in turn led to professional and academic positions, was opened up to women. The only possibilities to gain a baccalaureate for women had earlier been through attending private schools or study at home.

In order to acquire much-needed jobs and to expand their influence in society, women thus tried to open many doors that had previously been closed to them. Especially the male educational and occupational monopolies led to several bitter fights. In the field of engineering, everything remained quiet, however – or almost everything.

In 1892, a young woman tried to enroll in the KTH. She was refused admission on the basis of the school's 1876 statutes, which stated that it was intended for 'young men who wish to pursue a technical occupation.' Several professors considered the statutes outmoded; women were, after all,

allowed into the universities and higher schools of law and medicine. A committee was installed to determine whether women could be admitted into KTH as regular students. In its report, issued in 1893, the committee came up with a negative answer, despite its acknowledging women's legitimate interest in studying technology. It also found, however, that the presence of women in the school would lead to important 'inconveniences,' which was the reason why they should not be admitted. Consequently, women would have to wait till 1921 before they were allowed to pursue higher technical education on the same basis as men.

What kinds of 'inconveniences' the committee members had in mind, we will look at in a moment. At this point, we may note that women's entry into higher technical education was not an important issue for an otherwise highly active feminist movement. Sweden did not witness anything like the attempts in Russia and France at establishing a technical institute for women only, as discussed by Dimitri and Irina Gouzévitch and Annie Canel in this volume – an endeavor, incidentally, which appears to have been quite unique in an international perspective.[16]

This lack of interest in engineering among early feminists may have various reasons. First, Swedish upper- and middle-class women had, after all, been able to study chemistry, mathematics, and physics at the universities since the 1870s, and many women indeed did so.[17] Second, women of fewer means were able to acquire some professional skills by attending the many lower-level technical schools that were open to them. And third, a degree in engineering would have been of little use to women at the time, since relevant state positions were closed to them, while openings for university-trained female engineers in industry were few and far between. Normally, a degree from KTH, Chalmers, or a Technical *Gymnasium*, was supposed to lead to managerial or leadership functions, i.e., positions that, by definition, were considered unsuitable for women.

The masculine character of a degree in higher engineering was thus largely taken for granted by both women and men, and much energy was put into 'identity work' in order to authenticate the profession as one exclusively reserved to a *male* elite. At the same time, new ideas and technological developments nonetheless produced a subtle redrawing of gender boundaries in the realm of engineering. This was also noted and supported by the 1893 advisory committee.

The Creation of 'Technical Man'

The cultural association between masculinity and technology was taught and perfected in the Royal Institute of Technology as well as in the less prestigious Chalmers Technical Institute in Gothenburg. Both the educational experience as such, and the knowledge they acquired, united the 'young men' admitted into these schools within a brotherhood of technical and industrial expertise. Through the brotherhood the schools' graduates

Figure 15. Translated from Swedish the cartoon reads: "In the Lab". The white respectable coat and gentleman's garb contrasts with the student's frivolous play with the lab equipment. Appearing in the engineering student newspaper in 1913, the cartoon might be a self-mockery of the working codes in the chemical lab and a display of the competence and arrogance of a new elite. Reproduced from: Rasp *(1913).*

not only distinguished themselves from women but, I would suggest, even more importantly, from other men with different qualifications and destinies in society. Group *solidarity* and *distinction* were the most significant effects of the educational process on the aspiring engineers, characteristics that would subsequently be used in the struggle for positions of male leadership in a rapidly changing society. 'If it is true that a new time is coming, and that the sun is setting on the age of the lawyers, the pedants and the bureaucrats – then it is also certain that a place of honor in this new era will be taken up by the engineers,' a leading figure in the association of engineers cried out in its professional paper *Teknisk Tidskrift* in 1909.

What kind of man was this 'honorable' leader of the new era supposed to be? In what ways was the connection between masculinity and technology expressed in the training and professional practice of engineers? To answer these questions, I will proceed by taking a closer look at the educational processes at work at KTH and Chalmers. Contemporary documents seldom take into account that both schools were exclusively catering to 'young men.' Only occasionally, when a break in the normal pattern occurred, was the schools' masculine orientation made explicit. This happened, for instance, when a woman applied, therewith provoking reactions of either rejection or delight. In combination with other, more implicit, characteristics of both institutions' ambitions and preferred practices, this gives us a fair picture of their gendered character.

In the next section, I will first try to show that the *knowledge* that was considered useful for engineers was coded as more or less suitable for women. It was also a means of distinguishing the university-trained engineers from other, less consequential men. I will go on to discuss *everyday educational practices* to make clear that these were intended to construct a particular versatile, mobile, and industrious man. These practices were simultaneously regarded as too strenuous, hence unsuitable for female students, who were thus excluded from the school. I will finally argue that the young men, through the school's *everyday homosocial relationships*, received the appropriate psychic and social preparation in a 'world without women' to take up their future positions as men of power within an well-educated elite.

Gendered Repertoires of Knowledge

The 1893 committee's report mentioned previously is particularly interesting for our purposes here, in that it actually singles out certain areas of knowledge as, in fact, suitable for women. The criteria for making them so are not exactly spelled out, but they can be inferred from various other documents, as well as from a general understanding of the social context in which engineering was practiced at the time. We may further note that, in a comparative European framework, they reflect a shared international understanding; an ideological position embraced, or so it seems, by women and men alike.

The first area of knowledge considered suitable for women was architecture. This was seen as a technical profession, hence offered at KTH, but also one in which aesthetics and ethical values formed constituent parts. Late nineteenth-century ideology stressed women's particular sense of beauty, as well as their moral duty in building a harmonious home. Many middle-class women took active part in public debates about the critical function of hygiene and cleanliness in both society and in individual homes. In the general crusade against disorder and disease, female architects were expected to take up an important role.[18] As Ellen Key, one of the leading feminist thinkers of the time, put it in 1896: Female architects' essential 'motherliness' will result in harmoniously and hygienically designed homes, and thus complement the more monumental work of their male counterparts.

Ellen Key had significant influence.[19] She moved in the same liberal circles in Stockholm as many well-known engineers and teachers of KTH, including the school's future vice-chancellor. Her suggestions – which were based on the idea of an essential *difference* between women and men – were nonetheless challenged by many of her feminist contemporaries. Do you want us to accept this 'castrated and semi-developed female identity?,' one of them exclaimed in a pamphlet published in 1896:

> Shall the man build the front of the house and the woman its back? Shall the man be in charge of the ornaments and the woman take care of the installment of the sewage pipes? What a beautiful entente between the sexes, or – what a terrible struggle for space between the marble-staircase-building man and the sunny-nursery-decorating woman![20]

The very same year in which the pamphlet appeared, a young woman by name of Agnes Magnell applied with the school of architecture at KTH. By Royal decree, and on the supporting advice of the collegiate teaching staff, she was accepted as a special student. Since there had been no change in the statutes, and it was only a few years ago that the advisory committee had recommended women's continued exclusion, the question arises how this could happen.

Various circumstances appear to have worked in Agnes Magnell's favor. First, there were, at least according to KTH, only a limited number of male applicants for the school of architecture that year: Magnell would thus not be taking the place of a man. Second, the ideological climate was, as we have just seen, favorable in pointing out the need for a 'woman's touch' in architecture. Then there was the example of Vivi Lönn, the first female architect to graduate in Finland in 1896; there were many ties uniting the Finnish and Swedish engineering communities at the time. And finally, Agnes Magnell herself was an asset in both social and cultural terms. She held a degree from the Technical School in Stockholm, one of the many lower-level technical schools open to women. This type of schools provided women with training in drawing, design, xylography, and similar skills considered useful for teachers, and qualifying students for lower-level positions in industry, handicraft, and public services. Magnell's former drawing teacher was also a lecturer (and later a professor) at KTH, and he encouraged her first to get a baccalaureate, and then apply with KTH. He may hence be expected to have put in a good word for her with the selection committee. And Magnell's social capital was not insignificant. Her father was a military officer as well as a landowner, and one of her relatives was a prominent engineer who would twelve years later become vice-chancellor at KTH. Taken

together, these various specific personal and social circumstances thus worked in Agnes Magnell's favor in trying to gain admission as the first female student at KTH. Such conditions were not to recur for nearly twenty years after, however, when, in 1915, the second female student of architecture made her entrance into KTH.[21]

The second field of expertise singled out by the 1893 committee as 'particularly suitable for women' covered chemistry, chemical technology, chemical metallurgy, physics, and electrotechnics', a quite surprising combination of subjects.[22] We might reasonably assume that these science-based modes of technological training would be classified as 'male.' Indeed, throughout the nineteenth century, only boys were thought to require the intellectual training and social status that came with taking a strictly scientific curriculum. Secondary-school education in science and mathematics was therefore mainly offered to middle-class boys at the public *Gymnasia*, and seldom to the students at the girls' schools. Why, then, should women be allowed to take up such subjects at KTH?

e 16. Cartoon in erly fashion and rokes represents Sandberg, the first ish woman student almers Technical ute, as a walking d striking her male dents with love. A tion on the theme men students' cting effect on students. She is ing trousers, the tional students' nd the architect's f the trade, a ing board. duced from: , college newspaper (1914).'

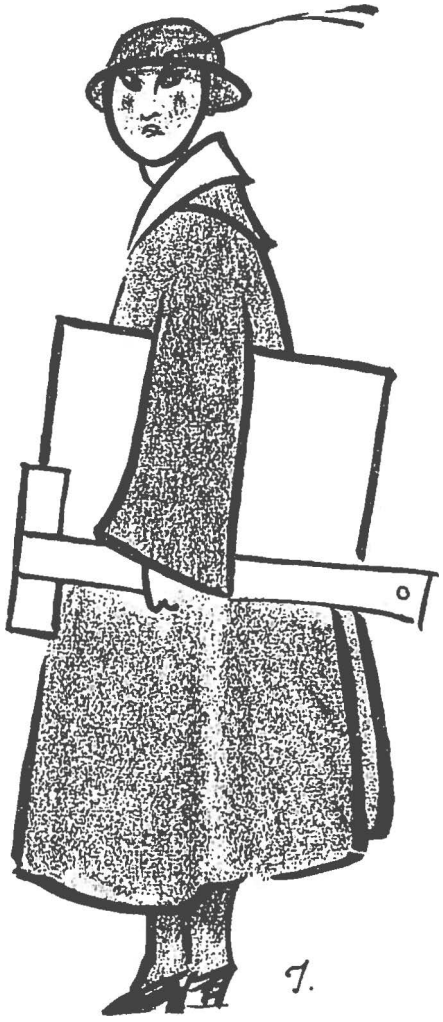
The idea that science-based technological subjects were suitable for women first of all appears to have sprung from a genuine divergence of opinion among the reigning elite in Sweden. An influential group of highly educated men in the dominant scientific, literary and business circles of Stockholm strongly opposed the conservative academic culture prevailing at the traditional universities. These men felt that everybody needed scientific training in order to fight superstition and to further social liberation. In fact, the same men had asked the Russian mathematician Sonia Kowalewski to take up a professorship in advanced mathematical analysis at the newly founded private University of Stockholm. Some engineers and teachers at KTH belonged in this liberal milieu, frequenting its social clubs, but they also taught at Stockholm University.

An interesting case in this respect is that of Leonilda Sjöström (1836–1898), who, for many years, taught mathematics and shipbuilding at her father's private school of navigation in Stockholm. She also gave courses in mechanical engineering, and was, for 25 years, a teacher of mathematics at the Stockholm Technical School. The latter establishment was open to both women and men and had – as we have seen in connection with Agnes Magnell – in many ways tied up with KTH. Sjöström was yet another living proof of women liberating themselves through science and mathematics; to my knowledge, however, her case was never mentioned in KTH documents of the time.[23]

Secondly, changes in technology and industry had led to a both a 'scientification of industry' and the 'industrialization of science.' This may have opened up new job opportunities for women. The *laboratory* made its entrance as an important site for technical work, in which quality analysis, development activities, and even research took place.[24] We recall that women in Sweden had to work for a living. The laboratory offered clean, appropriate jobs for middle-class women with some scientific training, acquired either at university or at KTH. Female laboratory workers generally functioned as the patient, careful, and competent assistants to male engineers, scientists, or doctors, for salaries that few men with a similar educational background would be willing to accept. This, I think, provides a viable explanation for the committee's decision to designate precisely these subjects as suitable for women. In practice, however, this particular niche in the female job market in Sweden did not actually develop until much later, primarily in the years following World War II.[25]

Masculine Fields of Technology

Since other technological fields were strongly gender-coded as masculine, women appeared to have found no place in them, even as assistants. Around the turn of the century, some 80 per cent of the approximately four hundred students at KTH studied mechanical, civil, and mining



'7. Set in strong modernist strokes, cartoon Lous-Moor, the first woman student to earn in architecture from the Swedish Royal of Technology, in college newspaper in 1915. rtrayed as a driven, singular woman without al and as the polar opposite of the lapper woman, the only alternative gender ailable at this time. Compare this with the ions from Austria. Reproduced from: ıdaren, *Stockholm (1915).*

engineering. The latter formed the core areas of engineering expertise and were considered crucial to Sweden's industrial growth. Mechanical engineering found its roots in metalworking, a traditionally all-male field of competence. Civil engineering had previously been taught at the military academy, and its graduates were part of a state elite corps that was by definition restricted to men. Mining engineering had been a highly important, and exclusively male, area of concern for both state and private industries from the seventeenth century onwards. Apart from

traditionally being seen as 'masculine,' these areas of knowledge led to jobs with specific characteristics that appeared very inappropriate for women to the contemporary eye.

Since the mid-nineteenth century, Swedish university-trained engineers had increasingly begun to define themselves as the carriers of 'scientific technology.' They had fought for the setting of high entrance requirements at KTH. To enter, the student needed a baccalaureate, something which was obtainable only for the small percentage of the male population, who was destined to assume positions in an educated elite, or, what the Germans call, a '*Bildungsbürgertum*'.[26] Training at KTH was geared towards 'scientific' technology, with a curriculum based mainly on mathematics, physics, and descriptive geometry, in addition to various subjects in applied technology. Such theoretical training was considered necessary for those in leading positions in industry and in public life, and would place the school's graduates several steps above such engineers as had a mere background in lower technical education. The latter were seen as lacking in both theoretical knowledge, as well as the kind of general edification provided by the *Gymnasia*. The graduate engineers' 'capacity to calculate,' i.e., their analytical skills, would, it was argued, place them way above those who were only able use their professional experience and 'common sense.'

Knowledge of mathematics and theoretical science was thus used as an argument in maintaining and thus reinforcing a *public hierarchy between men*. The notion of the 'scientific' engineer's superior character gained perhaps most importance in traditional technical fields such as metal, mining, and civil engineering. In these fields, academically trained engineers had to compete for the favors of potential employers with men having longstanding practical experience and lower salary demands.

And now we reach the major argument used in the 'scientific' engineers' favor, a characteristic that largely explains why the 'masculine' areas of technology were considered unsuitable for women. What the university-trained engineer supposedly had, was a *unique combination of theory and practice*. A successful engineer could never be a pure theorist, the kind usually produced by universities. He needed to know how to apply his theoretical knowledge in practice in order to solve problems in machine design, tunnel construction, iron smelting, and so on. He should further be able to combine calculation with leadership, and be adept at handling mathematics, as well as men and machines. Only by knowing how to get their boots and their hands dirty would academically trained engineers be able to aspire to technical leadership. Future civil, mechanical, and mining engineers thus spent many hours on field trips and excursions, in drawing rooms, mines, and on construction sites, learning to speak both the workers' and their superiors' language. The purpose of such practical experience on the shop floor or 'in the field'

was, as Ruth Oldenziel has remarked with respect to the situation in the US, for engineers to acquire *managerial* skills. Being able to give orders, manage large numbers of men with different skills and functions, move around and get to know all the details of a complex work process: these were class-specific skills that only men should master.[27]

The 1893 advisory committee saw in these everyday educational experiences – often taking place late in the evening, in primitive conditions in the field, and far removed from the controlling eyes of their superiors – yet another argument to exclude women from higher technical education. Women could simply not participate in such activities under the same conditions as, and together with, young men without causing 'serious inconveniences.' Without such practical training, however, women could naturally not become proper engineers. It would be much better, then, not to let women in at all.

So far, we have seen that the very notion of scientific technology in Sweden at the turn of the century was specifically gendered. Technological education was designated for a certain kind of man only, a man in the new mechanical age who was superior to other men. In other countries of Europe, engineering was similarly 'academized.' This gave women who managed to acquire a baccalaureate in science, at least in theory, the chance to apply with institutes of higher learning that were formally open to them.[28] In practice, however, the particular technologies that dominated the professional field at the time – mechanical, mining, and civil engineering – were not considered part of 'feminine' expertise. The specific combinations of theory and practice, and of technological skills and management they required were strongly gender-coded as 'masculine.'

Other forms of technology, however, were seen as more closely related to the home environment, hence to what were considered specifically female tasks and talents. Architecture is here the prime example. Despite its otherwise masculine image, i.e., common perceptions of builders and architects as heroic visionaries, there were certain niches in the professional field that were apparently regarded to suit women's 'natural' abilities and concerns. Various new technical fields, those that had not yet entered the heartland of industrial engineering, were also considered suitable for women. Advanced training in chemistry or electrotechnics, i.e., professional domains that led to white-collar, non-careerist jobs, in the quiet, home-like environments of laboratories and drawing offices, were among these. In her analysis of similar debates taking place in Austria at the time, Juliane Mikoletzky quite rightly remarks that it were, in effect, the more dreary and less prestigious jobs, such as those of laboratory assistants and drafts(wo)men, or jobs in less prestigious fields, such as interior decoration, that came to be defined as 'feminine.' She additionally comments that the line seems to have been drawn between 'indoor' jobs, considered to be more suitable for women, and the more

Figure 18. Five women students from the Swedish Royal Institute of Technology, all of whom were members of the Association of Female Engineering Students *which lobbied for improving their working conditions. Photographed and interviewed for the Swedish women's magazine* The Housewife *in 1927, the women pose in a collegial and convivial atmosphere. Laughing straight into the camera to their female audience and lined up to suggest a succession of women, they serve as potential role models for their female audience. Reproduced from:* Husmodern, *Sweden (1927).*

'manly' professions that were performed 'out of doors'. This was meant both in a literal sense in that they required engineers to work out in the field, and in a more general sense, in that they entailed public visibility, were positions of social authority.[29] It is further interesting to note that the subjects taught at the unique Russian Polytechnic for women around the turn of the century, were nearly the same as those considered suitable for women elsewhere: architecture, building, electromechanics, and chemistry.[30]

The message the Swedish school (reluctantly) sent out consequently entailed that, should women eventually be admitted, they could only enroll in certain fields. The 1901 version of a popular book by a leading engineer, who also worked as vocational counselor for young people, voiced the same opinion, by stating that: 'Women may be employed in technical work but only in certain limited capacities, that is, as draftsmen or chemists.'[31] In its previous editions, the book had not even mentioned the possibility of women in technology, so times were definitely changing.

In 1901 the discriminatory paragraph about 'young men' was removed from the KTH statutes; primarily, however, to allow slightly *older men* in. Women were admitted as (paying) students with 'extra' or 'temporary' status, but only 'if space and other favorable circumstances so permit.' Early twentieth-century Sweden thus presents us with a similar picture as, for instance, Austria, Germany, and the Netherlands, countries in which women also were admitted step-by-step into higher technical edu-

cation as 'paying guests,' as 'extraordinary students,' and on individual basis, before finally gaining entry under the same conditions as men.[32] The Swedish school's major concern was the education of *men*.

We will proceed by taking a closer look at everyday interactions at KTH. In what manner did the school prepare young men for their future positions in society? And how did this affect women's integration into or exclusion from professional engineering? Two aspects are of particular interest in this context: the pedagogical organization of everyday study activities, and their homo-social organization of school culture.

A Gendered Pedagogy

The explicit reasons provided by the advisory committee in 1893 for the continued exclusion of women offer illuminating insight into KTH's pedagogical methods. First, there were the field trips and other forms of practical work, which its members considered inappropriate for women. Secondly, they perceived serious obstacles even in the areas thought suitable for women, obstacles which were related to the kind of education offered by the school. Women's 'more delicate constitution' might suffer from the kind of hard work that 'even the most gifted of students' had to undertake in order to keep up with the educational requirements. Why should women be allowed in, if, as a result, their health would deteriorate?

To what extent was the argument of female frailty actually relevant? Many women were working long, arduous days in mines, factories, on farms, and in their homes at the time. They had to be both physically strong and determined to survive. These women were probably not the ones the committee had in mind, however. Middle-class women with the appropriate educational background were, it appears, frail and more delicate creatures. Their health had to be protected from the hard work at KTH. That many of them already were taking university degrees was irrelevant, the committee ordained; the kind of study required at KTH was much more demanding. A similar argument was – as Karin Zachmann reminds us – eloquently put forward around the same time by the (in Sweden also) influential German engineer and Professor Franz Reuleaux. In 1897 Reuleaux argued that women would encounter physical rather than intellectual difficulties in studying mechanical engineering. They furthermore would – horrible thought – in many respects have to give up their 'pure femininity.'[33]

What especially interests me here is whether the educational regime actually was so physically demanding as these various advisers made it out to be, or whether this was just a pretext for sustained discrimination. Study activities at KTH do appear to have been more strenuous than what was required at the universities. Everyday life at school was strictly organized. Students were divided up into annual cohorts. They all took the same courses within a fixed schedule. Each day was tightly controlled by professors or teaching assistants, and days were filled with many hours of lectures, drawing lessons, practical exercises, laboratory work, and the like.

As it turns out, many young men found the pace and organization of every life at school rather hard to take. Adverse psychosomatic responses, in the form of headaches and neurasthenia, were not uncommon, causing great concern among the teaching staff. Each year several students had to re-sit exams, or take long breaks from their studies. Despite student protests and demands for a lighter course load and less teacher control, the school did not budge. The high number of courses and the tight work-schedules were, or so teachers maintained, necessary for helping students pass their exams on time, keep them away from the 'temptations of life in the big city,' and to satisfy external demands.

While claiming to offer university-level scientific training, KTH did *not* really teach its students to think independently and scientifically. In this respect, it did not follow the university model, nor did it resemble the highly theoretical French *Ecole Polytechnique* – otherwise greatly admired by Swedish educators. Instead, the school's pedagogical aims were modelled after the Swiss and Austrian *Technische Hochschulen*, which also prepared engineers for careers in public as well as private industries by combining theoretical and practical training. Still, everyday educational practices at KTH appear to be have been based primarily on the example of the Swedish *Gymnasium*, the type of secondary school all of its teachers as well as the students had at some point attended. The Military Academy at Marieberg may have set another example. The Academy formerly used to educate a small, elite corps of civil engineers, among whom, at the end of the nineteenth century, the KTH vice-chancellor.[34] The educational principles prevailing at both institutions involved a disciplined schedule and strict control of students' time and morale.

In the light of the school's endeavor to create a *certain kind of man*, adherence to such a rigid organization of work bears further interpretation. The strict demands set on the boys prepared them for a life of tight work schedules, and helped them internalize a positive attitude to assigned work. Lying behind pedagogical practices was a certain image of the successful engineer. We discern a disciplined and adaptable person, oriented towards getting things done on time, and used to working under orders, but also one ready to take on a variety of technical problems in very different environments, and to solve them effectively. The successful engineer could rely upon his broad range of skills, which prepared him for work in any circumstances, from 'shipyards and workshops in America, to railway buildings in Russia and laboratories in Zurich, to drawing offices across the world,' as a student newspaper put it in 1906.[35]

KTH may not always have been successful in producing such men, but the image of the tough and versatile engineer appears to have been what it wished to present to the outside world. The 'habitus' that the school desired to create was focused on mobility and responsibility, with an ambition to take up leadership positions in the public world of men. Why, indeed, should women risk their health in trying to reach a goal that was impossible and unsuitable for them to begin with?

Homo-social Culture and the Creation of Community

Both teaching staff and school administrators at KTH prided themselves on providing an education that kept the students working arduously. Most students obtained their degrees within the allocated three- or four-year period. In this, the school maintained, its record compared favorably to other, more liberal institutes of technology in, for example, Germany.

An alternative way of seeing such a 'care taking' mission is what has been defined by the American sociologist Ralph Turner, as an educational system of 'sponsored mobility.'[36] In effect, engineering studies formed part of a larger, coherent system of public education that was created in the nineteenth century, a system that took the *Gymnasium* as its base and provided a mobility machine for men. Just as in many other educational systems in Europe at the time, it selected a limited number of male eleven-year olds, in order to train them for their future membership of a growing industrial and state-employed middle class. Therefore, the student entering higher education had already been socialized in seeing himself as a member of a select social group. KTH and Chalmers subsequently provided a final all-male environment in which students were not only trained as engineers, but which also would assist the young men in making their way in a competitive and demanding working life.

One aspect to take into consideration in this respect is students' relations with their professors. Initially, student-teacher interaction would be rather stiff and formal, with strict and demanding attitudes on the part of the students' superiors, who were duly depicted as quite awesome and distant. Over the years, when the young men began to approach professional maturity, such formality would give way to a more informal mode of exchange. This, at least, is the impression we get from students' memoirs written about their lives at KTH. A particularly striking story in this context is that of the mining students, whose period of practical work took place at the end of three years of study. For several weeks, they would share their everyday lives in the company of their professors, performing calculations and experiments in iron works and mines. Students and professors also interacted after work, however. It is hence not surprising to find the final exams (set in the following year) depicted as something of a family affair: taking place at the professor's home, him with his dog curled up on his lap, the exam being rather casually dealt with.

This particular story further informs us about the ways in which the school helped students, within the context of its 'manager's course,' in learning to establish informal social connections with their future employers and colleagues. Students were introduced into the homes of prospective employers in order to familiarize themselves with the social norms of interaction among their future bosses, colleagues, and subordinates, as well as learning practically to apply their knowledge of mining geology and steel production. They would drink tea with the wives of the mine owners, play tennis or dance with their daughters, and learn the tricks of the trade from the resident mining engineers over copious intakes of schnapps and punch.

The school itself and student life offered many occasions for such 'anticipatory socialization' into the industrial and technical elite to which the young men would soon belong. Many of the students came from lower middle-class backgrounds.[37] Their fellow students would teach them the norms and mores of middle- and upper class sociability. Students were additionally introduced to their superiors in the male hierarchy of engineers within the student organization, which was part of the professional engineering organization. The latter would help them fraternize with captains of industry, famous entrepreneurs and inventors, government ministers, and higher civil servants. Ambitious students were given the chance to distinguish themselves during debates, and to co-organize lectures and parties. The transitional step from being a student to becoming an adult engineer was thus partly taken while they were still at KTH.

The most important experiences of socialization, nevertheless, were those shared with the other young men at KTH. The student community was very much a homo-social world. Social interaction was almost exclusively among men, which led to the forging of strong bonds of camaraderie and friendship. About half of the student population came from outside Stockholm, hence lived in rented rooms, either by themselves or with other students. They spent long hours together in lecture halls, drawing rooms, and on field trips and excursions. Interaction with other students was thus intense. As one student wrote in 1915:

> It is not, as it is in other schools, that you only meet in classes and labs under teacher supervision: all the unscheduled time, you see each other in the drawing rooms. There you draw, whistle, and hum as soon as the attendant teacher has gone out the door, and everyone shares the hardships of work. Good comradeship is created there, better than anywhere in the world; there is no jealousy, no envy of the successes of a fellow student, and only rarely some fretting over an unexpectedly low grade… no fawning about giving assistance, and never is a request for help turned down.[38]

Both formal and informal activities outside the lecture halls and drawing rooms normally took place in a largely homo-social environment as well. Students at Technical Institutes were supposed to be *different* – more boisterous, hard drinking, and jointly united than other university students, who did not have the same kind of everyday intensive community experience. Student culture at KTH and Chalmers comprised a great many formal rituals of belonging and brotherhood: elaborate initiation rites for those who had just entered school, ritualistic pranks and carnivals, community symbols, such as the student cap and ring, elaborate insider jokes in student newspapers, and so on. Students' associations flourished; pub going and parties were favorite all-male pastimes. Alcohol was an important aspect of student culture. A 'real engineer' knew how to drink and sing with his peers, i.e., to drink quite a lot, but in such a way as to be still able to attend 8 a.m. lectures, or give early-morning orders to miners or railway workers. Student culture in many ways was highly organized and regulated, and what the young men learnt – the happy-go-lucky ideology notwithstanding – was, in fact, to deal with an excessive alcohol-intake in a socially acceptable and responsible manner.

The social world of engineering studies thus combined seriousness and irresponsibility. As one contemporary observer noted, KTH was 'both a primary school and a university.' The occasionally silly, occasionally serious relationships and rituals served, as far as I can see, two major purposes. First, they offered *individual* students a last refuge of organized irresponsibility before they would enter the world outside and assume professional and family responsibilities. Second, important social networks and friendships were created on the basis of intellectual similarity and mutual interests. They constituted a *collective* power base to be used to further individual careers and raise the profession's social standing.

Women in a Men's World

Both the social culture and the pedagogical regimes at KTH and Chalmers in many ways served, as we have seen, to unite men. However, both were also largely maintained to keep women out.

Around the turn of the century, both schools and society at large, were characterized by a strong sense of *gender dualism*. To many men, women were alien and distant creatures. They nonetheless entered the future engineer's (all-male) world in two major guises: as servants and as dream figures. The former belonged to another social class. They were the students' landladies, janitor's wives, and waitresses, i.e., the kind of women with whom he most frequently interacted. These women were often gratefully remembered in students' memoirs as surrogate mothers in their lonely school lives.

The second form in which women appeared on male students' horizon was that of 'Woman,' the love object of their dreams. This fantasy figure

Figure 19. Hollywood-styled cartoon of the movie star and the engineer as seen in the 1906 college newspaper. Even the most angular engineering student will attract beautiful women seems to be the somewhat ironic message, suggesting the high male sex appeal of the profession to women. Reproduced from: Rasp *(1906).*

was envisaged as the loving and soft alternative to the disciplined and rational world of engineers. She was everything that technology and engineering was not. She belonged to a private realm, not to the public world of men, and was, indeed, as one engineer retrospectively remarked, seen as an 'individual means of intoxication.'

It was generally considered an anomaly that women might like to enter the realm of engineering, occasionally even seen as a threat. Some men deplored the envisaged loss of their secret knowledge and togetherness if 'Eve' were allowed to enter schools of engineering. Such an intrusion would disrupt the all-male camaraderie of student life, and spoil the collective pastimes of drinking, singing, debating, and playing games. As late as 1927, students at Chalmers voted for the exclusion of women

from their 'Valpurgis Night' celebrations. Others found the idea that women would acquire the same kind of knowledge as men simply 'intolerable:' this would turn them into future competitors for what they considered to be all-male jobs. Such hostility, however, did not express the predominant mood. Even if the late nineteenth-, early twentieth-century engineering community was uniformly male, it was neither misogynist, not even uniformly dualistic in its views on questions of gender.

We recall that late nineteenth-century liberal scientists and engineers actively encouraged the recruitment of women students and scholars. The idea of a few 'token' women appealed to many of the students as well.[39] Several excited young men, giggling and curious, actually attended Agnes Magnell's public entrance examinations in 1897. The few women who, in the early twentieth century, completed courses in chemistry as temporary students, or the later (full-time) students of architecture, were the focus of much adoring male attention. The female students were treated as fascinating others, even if they had to struggle to be regarded as 'one of the boys.'

In this respect, two poems, written in 1915 by the first woman student at Chalmers, Vera Sandberg, are of special interest.[40] They accurately capture the sense of being 'outsiders inside' that many female engineers continue to experience to this very day. In the first poem, Sandberg deplores the loss of her 'female logic' and 'female point of view,' having learned to think and talk in a rational manner. There is 'sorrow in her heart': 'I am not a woman and I am not a man.' In the second poem, however, her tone of voice has changed. Work in the 'lab' is fun, and everything is going well. Sandberg is making sulfate now, and can no longer be bothered with cooking or dish washing. Professors bow to her and the 'lads' cheer her on! She ends on a note of optimism: 'The world will be ours when women are free.'

The prevailing, contradictory mix of gallantry and lack of understanding of women's needs was later described by the first cohorts of female students that began to be admitted on a formally equal basis in Sweden during the 1920s.[41] It can further be discerned in the experiences of early generations of female engineering students in Germany during the years between the two World Wars, as well as in the apparently even tougher atmosphere described by the first women students at the Case Institute of Technology in the US in the 1960s.[42] These early female students were, or so it seems, unexceptionally seen as 'guests' in the world of engineering, having been invited in on account of the goodwill of those who really felt 'at home' in it.[43] Not surprisingly, many of these women tried to 'normalize' their situation by forging emotional alliances with their fellow students. They married engineers, from whom they derived emotional and professional support both during their time at KTH and later on, in their working lives.

Figure 20. The 1930s cover of engineering student newspaper of women engineers on the march in socialist-modernist poster style. Displaying boyish masculinity and wearing trousers, the women may only be identified by their make-up. Reproduced from: Rasp *(1931).*

Moving in from the Margins as 'outsiders inside'

In 1921, women were formally allowed to enter KTH on the same basis as men. Thus ended a period when their admission had been a question of negotiation by individual case. From the late nineteenth century onwards, the occasional woman with exceptional qualities and/or connections had been allowed to enroll in KTH. But engineering – and especially university-level forms of training – was strongly gender-coded as male. The field's masculine orientation implied, as we have seen, a focus on technical expertise that was closely linked up with social and economic power in a rapidly industrializing Sweden. Studying engineering involved a pedagogical approach and a homo-social mode of interac-

tion that served to prepare men for professional mobility and sociability, skills considered unsuitable for women. Both the manifest and hidden aim of the higher technical schools was to forge bonds of solidarity among a select group of men, and to enable them to distinguish themselves from their less worthy competitors. This was a male game in a public world of industry and technology, of leadership and careerism; a world in which women were thought not to belong.

Even when the formal barriers that precluded female participation had been removed, the schools' informal, cultural message was still exclusionary male-oriented: they offered higher education for 'young men' destined to take up their positions in a societal elite. A great many Swedish women, more than in many other countries, were gainfully employed, mostly out of economic necessity. 'Women's work,' however, as, for instance, in the textile industry, did not lead to positions requiring particular expertise; in fact, no formal form of education of textile engineers existed in the country. Relatively few women found manual or office work in the engineering, mining, or paper and pulp industries, and thus did not get any firsthand experience in fields of technical expertise. Another important factor was that Sweden – in contrast to most of the other countries discussed in this volume – was not actively involved in either of the two world wars. Swedish women were therefore never called upon to do the 'men's work' in engineering, heavy industry, or armaments production. They hence had no opportunity to find their entry into, or acquire the required skills for a career in engineering. Thus, the majority of women who did find their way into engineering had been obliged to take the formal educational route.[44]

A trickling stream of quite exceptional young women began to find their way to the technical universities in the decades following 1921. Still, it would take until the 1950s for women to make up more than 5 per cent of the overall student body. As was the case in many other countries in Europe, most female students chose to study architecture and chemistry, both relatively small and marginal fields within engineering generally. Forty-three out of the sixty women graduating from the Royal Institute of Technology between 1924 and 1962, were chemists. Another seventy-eight earned their degrees in architecture.[45] The major professional fields, i.e., mechanical, civil, and mining engineering continued, until very recently, to remain specifically male preserves. Despite earlier predictions, electromechanical engineering also remained a strongly male-dominated area in Sweden, perhaps because of its early and lasting association with heavy engineering, as well as with the heroic, 'manly' taming of the waterfalls in the inaccessible far North.

The greater significance of these large, male-dominated domains has contributed substantively to the preservation of a strong homo-social culture and a male-oriented educational tradition at Swedish technical universities up until the present day. Engineering studies have offered a sense

Figure 21. I attend Chalmers Technical Institute because my chemistry teacher was so handsome," reads the caption of the 1941 college newspaper cartoon. Caricature of a woman chemical engineering student, looking like a sleepwalker with an extra large students' cap and puffy eyes with no knowledge or interest in her studies. Reproduced from: Rasp *(1941).*

of identity and community to generations of eligible 'young men,' and helped prepare them for careers in a public world in which men take the decisions. Female engineering students – latter-day successors of Agnes Magnell and Very Sandberg – make up larger numbers now than in the past, however, and many have successfully entered various formerly exclusively male professional domains. Their competence is highly appreciated and actually even in demand in the current technical labor market. Still, most are still made to feel that, doing what they do, they are 'not a woman, and not a man.' Many feel treated as 'guests' in engineering, or as 'outsiders inside,' by their male colleagues and superiors. The 'inconveniences' caused by women engineers in a man's world may be of a different nature today than a hundred years ago; they are still so much present as to influence many a woman's life.[46]

22. In eristic modernist style, this sement for the) company 'ux geared to its -speaking market :es the symbol of 'e inventor for te use, suggesting eative power of Reproduced ience behind 'ux' Folder olm: Electrolux,

Notes

1. Boel Berner, 'Professional or Wage Worker? Engineers and Economic Transformation in Sweden' and other contributions in Peter Meiksins and Chris Smith, eds., *Engineering Labour. Technical Workers in Comparative Perspective* (London: Verso, 1996).
2. Special Issue: 'Gaining Access, Crossing Boundaries: Women in Engineering in a Comparative Perspective.' *History and Technology* 14, no. 1 (1997).
3. Brian Easlea, *Fathering the Unthinkable: Masculinity, Scientists and the Nuclear Arms Race* (London: Pluto Press, 1983); Caroline Merchant, *The Death of Nature. Women, Ecology and the Scientific Revolution* (New York: Harper & Row, 1980); David Noble, *A World without Women* (Oxford: Oxford University Press, 1992).

4. This is not to say that cultural analyses of the metaphors and rhetorics linking technology to masculinity are not important; see, for example, Carroll Pursell, 'The Construction of Masculinity and Technology,' *Polhem* 11, 3 (1993): 206–219; Boel Berner, *Perpetuum Mobile? Teknikens umaningar och historiens gång* (Lund: Arkiv, 1999), chapter 5.
5. Cynthia Cockburn, *Brothers. Male Dominance and Technological Change* (London: Pluto Press, 1983); Sally Hacker, *Pleasure, Power and Technology* (Boston: Unwin Hyman, 1989); Sally Hacker, *'Doing it the Hard Way'. Investigations of Gender and Technology* (Boston: Unwin Hyman, 1990); Sharon Traweek, *Beamtimes and Lifetimes. The World of High Energy Physicists* (Cambridge, MA: Harvard University Press, 1988).
6. Pierre Bourdieu, *La noblesse d'état. Grandes écoles et esprit de corps* (Paris: Editions de Minuit, 1989); Pierre Bourdieu & Jean-Claude Passeron, *La reproduction* (Paris: Editions de Minuit, 1970).
7. Basil Bernstein, *Class, Codes and Control. Volume 3. Towards a Theory of Educational Transmission* (New York: Routledge & Kegan Paul, 1977 [2nd ed.]).
8. Ralph H. Turner, 'Modes of Social Ascent through Education: Sponsored and Contest Mobility' in A H. Halsey, J. Floud, and C A. Andersson, eds., *Economy and Society. A Reader in the Sociology of Education* (Publisher's place: The Free Press of Glencoe, 1961).
9. The article builds upon the research reported in Boel Berner, *Sakernas tillstånd. Kön, klass, teknisk expertis* (Stockholm: Carlssson, 1996). See also Boel Berner, 'Explaining Exclusion: Women and Swedish Engineering Education from the 1890s to the 1920s,' *History and Technology* 14, no. 1 (January 1997): 7–29; and Boel Berner and Ulf Mellström, 'Looking for Mister Engineer: Understanding Masculinity and Technology at two Fins de Siècles,' in Boel Berner, ed., *Gendered Practices. Feminist Studies of Technology and Society* (Stockholm: Almqvist & Wiksell International, 1997), 39–68.
10. Lena Sommestad, 'Human Reproduction and the Rise of Welfare States: An Economic-demographic Approach to Welfare State Formation in the United States and Sweden,' *Scandinavian Economic History Review* XLVI, 2 (1998), 10ff.
11. Berner, 'Professional or Wage Worker?', 173ff.
12. Bosse Sundin, *Ingenjörsvetenskapens tidevarv* (Stockholm: Almqvist & Wiksell International, 1981).
13. Boel Berner, *Teknikens värld. Teknisk förändring och ingenjörsarbete i svensk industri* (Lund: Arkiv, 1981) for contemporary comparisons with Germany and the USA.
14. Christina Florin and Ulla Johansson, *'Där de härliga lagrarna gro…' Kultur, klass och kön i det svenska läroverket 1850–1914* (Stockholm: Tiden, 1993).
15. Discussion and figures from Sommestad, 'Human reproduction', 107ff.
16. Gouzévitch and Gouzévitch, and Canel this volume. For the similar disinterest among German bourgeois feminists, see Margot Fuchs 'Like Fathers – Like Daughters. Professionalization Strategies of Women Students and Engineers in Germany, 1890s to 1940s,' *History and Technology* 14, no. 1 (1997), 53.
17. Thus there was no need for separate women's courses in mathematics such as the ones organized in the Austrian Technical University in the late 19th century. See Juliane Mikoletzky, 'An Unintended Consequence: Women's Entry into Engineering Education in Austria', *History and Technology* 14, no. 1 (1997), 33.
18. Boel Berner,'The Meaning of Cleaning: The Creation of Harmony and Hygiene in the Home,' *History and Technology* 14, no. 4 (1998): 313–352.
19. For recent discussions about the feminist movement in Sweden around the turn of the century, see Ulla Wikander, ed., *Det evigt kvinnliga. En historia om förändring* (Stockholm: Tidens, 1994).
20. Quoted in Berner, *Sakernas tillstånd*, 62.
21. This was Anna Lous-Mohr from Norway, a country which already knew some female architects. She was, in fact, the first woman to gain a degree from Swedish Royal Technical Institute, since Agnes Magnell merely fulfilled three of the required four years at the school and then left to marry a fellow student in civil engineering. Magnell may, however, have practiced her profession in collaboration with her husband. The second female architect in Sweden, who graduated in 1922, was Ingegerd Waern-Bugge, who came from a radical family, and knew Ellen Key. She was later to play an important role in the housing projects associated with the social-democratic construction of the Swedish welfare state. For sources and further discussion of this development, see Berner, *Sakernas tillstånd*, chapters 1 and 4.
22. Note that the field of 'General studies,' which attracted many female students at the German technical universities, did not (and does not) exist in Sweden. Fuchs, 'Like Fathers', 54.
23. Berner, *Sakernas tillstånd*, 317.

24. Berner, *Teknikens värld*, 110ff; Göran Ahlström, 'Industrial Research and Technical Proficiency. Swedish Industry in the Early 20th Century,' *Polhem* 12, 3 (1994): 272–310; Sundin, *Ingenjärsvetenskapens tideravv*.
25. In 1914, both Swedish Royal Technical Institute and Chalmers admitted their first women students of chemistry. The one at Swedish Royal Technical Institute disappeared after one year, but the one at Chalmers, Vera Sandberg, stayed on to graduate and to work for many years as an industrial engineer.
26. A concept used by the German historian Jürgen Kocka to denote the educated and professional part of the upper and middle classes, in contradistinction to the part which derives its position from economic and industrial acrivity. The professional engineer, in effect, often belonged to both. Jürgen Kocka, ed., *Bürger und Bürgerlichkeit im 19. Jahrhundert* (Göttingen: Vandenhoeck & Ruprecht, 1987).
27. Ruth Oldenziel, 'Decoding the Silence: Women Engineers and Male Culture in the U.S., 18ᵀ8–1951, *History and Technology* 14, no. 1 (1997), 84.
28. Notably Austria and Germany where most areas of higher education, including engineering, were opened to women in the early decades of the century. Mikoletzky, 'An Unintended Consequence', 35; Fuchs, 'Like Fathers,' 51.
29. Mikoletzky, 'An Unintended Consequence', 39. A similar attitude was expressed in the US, according to Oldenziel, 'Decoding the Silence', 87.
30. Gouzévitch and Gouzévitch, this volume.
31. Quoted in Berner 'Professional or Wage Worker?' 183.
32. See the references in note 28 and for the Netherlands: Frida de Jong "Sisters in Engineering. Women Engineers in the Netherlands", paper presented at conference at Frauen(t)raum Technik, Berlin, January 1999.
33. Karen Zachmann, this volume.
34. It should he noted, that Swedish university-trained engineers (with the exception of architects) were all called 'civil engineers,' irrespective of their area of expertise. Originally, this title was reserved for graduates from the Marieberg Military Academy, who, around the mid-nineteenth century, had enrolled in the Academy in order to assume non-military state employment. 'Civil engineer' became the official title for Swedish Royal Technical Institute graduates in 1915. There hence never was any Swedish state corps of engineers, like that in France, or in Russia at the turn of the century.
35. Quoted in Berner, *Sakernas tillstånd*, 43.
36. Turner, 'Modes of Social Ascent.'
37. Between 1881 and 1910, the fathers of 75 per cent to 80 per cent of the students at Swedish Royal Technical Institute and Chalmers were either business leaders or white-collar employees. See Rolf Torstendahl, *Dispersion of Engineers in a Transitional Society* (Stockholm: Almqvist & Wiksell International, 1975).
38. Quoted in Berner, *Sakernas tillstånd*, 91.
39. Rosabeth Moss Kanter, *Men and Women of the Corporation* (New York: Basic Books, 1977) is the classical study of 'tokenism'.
40. Published in the student journal *Rasp*, quoted in Berner, *Sakernas tillstånd*, 116.
41. Anna Karlqvist, *Från efiersatt till efiersökt. Om kvinnliga studeranden på Kungl. Tekniska Högskolan* (KTH: Avdelningen för teknik- och vetenskapshistoria, 1997).
42. Fuchs, 'Like Father…' for Germany; for USA, see Stephanie Smith-Divita, "Skirts and Slide Rules", paper presented at conference on Frauen(t)raum Technik. Berlin, January 1999.
43. For the concept of 'guest,' see Silvia Gherardi, *Gender, Symbolism and Organizational Cultures* (London: Sage, 1995).
44. A small number of women entered lower-level draftsmen or laboratory assistant jobs from the inter-war period onwards. For a study of engineers taking 'the long way' via the shop floor and evening courses from the 1930s to the 1960s, see Boel Berner, 'The Worker's Dream of Becoming an Engineer,' *History and Technology* 15 (1999).
45. The same numbers apply in Germany, Austria, and Greece; see elsewhere in this volume, and *History and Technology* 14, no. 1 (1997). In contrast, many women trained in civil engineering and aeronautical engineering; in the USA see Oldenziel 'Decoding the Silence', 79.
46. Ulf Mellström, *Engineering lives: Technology, Time and Space in a Male-Centered World* (Linköping: Department of Technology and Social Change, 1996); Boel Berner 'Women Engineers and the Transformation of the Engineering Profession in Sweden Today' *Knowledge and Society* 12 (2000).