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For the Promotion of Industrialization

Technical Upper Secondary Schools in Sweden 1855–1920

The lack of middle-level technical education, which could provide local and regional industries with technically skilled labor and prepare students for higher technical studies, led to the establishment of technical upper secondary schools in five Swedish cities from the middle of the 1850s. When the Parliament made its decisions about the schools' locations, cities that already had significant industrial or proto-industrial activities were initially favored. In the case of Malmö, about 50 percent of the graduates became employed in the school region, another 30 percent in the rest of Sweden. Thus we conclude that the school functioned as a regional institute for technical education. Around 20 percent went abroad, mostly to Germany and the US, for studies or to further their career. Many of them returned with new knowledge and skills.

The large industrial exhibitions during the latter part of the nineteenth century constitute one sign of an international trend of technology optimism. In Sweden, this optimism sparked, for example, an interest in constructing a national railroad system to facilitate economic development and growth all over the country.[1] The emphasis on extending and developing technical education was another cornerstone along the road towards an industrialized society.

One reason for the early nineteenth century investments in technical education was a societal desire to increase employment in industry and trade, and thereby facilitate upward social mobility. These were common arguments when the Swedish parliament debated technical education, whereas administrators and school superintendents often emphasized industrialization as the road to a far-reaching societal transformation, social changes, and an increased competitiveness.[2]

Swedish technical education was on a comparably high level in the mid-nineteenth century.[3] The leading technical educational institution, the Technological Institute, gradually developed into an advanced school before 1850 but specialized in preparing workers for public administration and larger industries. This was far from unproblematic since small- and medium-sized industries gradually began to emerge.[4] Here, even persons in managerial and semi-managerial positions had no formal education to rely on. The lack of intermediate-level technicians who could contribute to industrial development throughout the length and breadth of the country was obvious.

The establishment of the technical upper secondary schools

Worried about the lack of intermediate technical education, the Technological Institute's principal Lars Johan Wallmark (1810–1855) sketched a new system and suggested the establishment of so-called technical upper secondary schools *(tekniska elementarskolor)*. Modelled on the German *Gewerbeschulen,* these schools were to supply locally based industries and crafts with an educated workforce, as well as prepare students for higher technical studies. The technical upper secondary schools were to fill the gap between a basic technical education at the already established Sunday and evening schools, and the Technological Institute's advanced education.[5]

The discussions that followed led to the establishment of technical upper secondary schools in four southern and central cities: Malmö (1853), Borås (1856), Örebro (1857), and Norrköping (1857). Northern Sweden had to wait until 1901, when a similar school opened in Härnösand. A few existing schools possessed a somewhat less clear position in the Swedish technical education system. For example, Wallmark viewed Chalmers in Gothenburg as a future technical upper secondary school, but this institute gradually developed into a top-level institution, second only to the Technological Institute. Nevertheless, this kind of systemized technical education was uncommon. In most countries, the definition of levels and the relations between the schools were less clear.[6]

Wallmark's suggestion was the foundation for the discussions in parliament, but the decisions taken did not follow it meticulously. The parliament decided to establish technical upper secondary schools in two unmentioned locations. Wallmark's suggestion, which he proposed to the government, was that the first two schools should open in Malmö and Stockholm. Wallmark also argued that schools should open in a number of cities around the country at a later stage.[7]

However, Stockholm never became a host city for a technical upper secondary school. The parliamentary committee considering the school locations emphasized that teaching in many subjects of a proposed technical upper secondary school already took place at the general upper secondary schools. They rejected Stockholm as a location, but acknowledged the need to prepare potential students for higher technical studies and suggested an extension of the already existing Handicraft school (*Slöjdföreningens skola*) with courses that met the requirements for entrance to the Technological Institute, the Mining school in Falun, and the upper Artillery school. The parliament took the decision in 1853/1854.[8]

The regional perspective was the focus in parliament – Swedish debates were characterized less than in other countries by a tension between a political-administrative center and periphery.[9] Almost none of the members of parliament argued for an establishment in Stockholm at the expense of an establishment in another city. One reason might have been the view of the Handicraft school as a school on a par with the technical upper secondary schools.[10]

While the members of parliament agreed to prioritize a city outside the capital, they were less in agreement when it came to where the technical upper secondary schools ought to be established. Wallmark suggested Malmö, Sweden's fifth largest city at the time. The city was willing to finance the construction of a school building, and had made far-reaching preparations to establish technical education in the 1840s. These local initiatives were emphasized as positive. A majority of the members of parliament agreed to prioritize the south. The southernmost province of Scania was Sweden's most populous and fertile province, but viewed as parsimoniously treated by the authorities. A technical upper secondary school in Malmö would function as an engine for industrialization and economic development in the entire region, and at the same time contribute to moderate student migration to nearby Copenhagen. Some members of parliament from northern and central Sweden, however, viewed the city of Scania as a border town that hardly could recruit students from the whole country, while others noted that Malmö had only few factories and fewer artisans as well as industrialists than comparable cities further north.[11]

This brings us to the core of the early debates. Less than 20 kilometers northeast of Malmö lies the prestigious university town of Lund, where local authorities also wanted to establish technical education. One major argument was the possible utilization of teachers from the university. However, some members of parliament were hesitant: Lund's academic environment was hardly suitable for a practically-oriented technical school. Similar arguments later led to the rejection of Uppsala, the other major university town, as a site for a technical upper secondary school. Malmö's industrial character offered better possibilities for study visits. The older schools in Malmö had graduated many talented students, and Chalmers had not had any problem in finding teachers in Gothenburg.[12] Therefore, one member of parliament argued that there was no reason to be worried about the viability of a technical upper secondary school in Malmö.[13]

The inauguration of the technical upper secondary school in Malmö in October 1853 spurred local initiatives to establish similar schools in other cities. The first to take up the challenge was Norrköping, Sweden's third largest city, about 140 kilometers southwest of Stockholm. Wallmark severely criticized the teaching at the Norrköping Handicraft school. Industry, especially textile and mechanical industry, comprised a larger share of the local economy in Norrköping than in any other Swedish city and was in need of appropriate technical education. Wallmark therefore argued that the city ought to be one of the new host cities for technical upper secondary schools. The earliest debates in parliament did not focus on "Sweden's Manchester", until Wallmark and the initiatives in Malmö provoked the Handicraft school to re-evaluate technical teaching. They consulted Chalmers's principal, who suggested a more practical approach to the teaching of technology.

In December 1853, the Norrköping burghers suggested to the parliament that their city should host a technical upper secondary school, referring to an advanced mechanical industry, access to waterpower, a functional harbor, and a geographical location in a populous and fertile province. There was a demand for knowledge of physics, chemistry, mathematics as well as mechanical and artistic skills from the top level to the shop floor. A school providing the local industry with competence would promote industrial development not only in the city and its surroundings, but also in the country as a whole. The local burghers wanted the same support as in Malmö. The members of parliament viewed Norrköping as the Swedish city with the best basis for further industrial development. However, the local authorities had to invest in an extension of the Handicraft school, which delayed the inauguration of the new technical upper secondary school until late 1857.[14]

Two other cities not suggested by Wallmark got technical upper secondary schools as well: Örebro, about 160 kilometers west of Stockholm, and Borås, 60 kilometers east of Gothenburg. Both cities were industrialized and possessed comparably large hinterlands. Local initiatives were also important in the processes.

Borås was center of a textile industry region with traditions of specialization going back to the seventeenth century. The weaving mills, however, had lost competiveness in the 1840s, partly because of liberalized imports. The local initiators of a technical upper secondary school, iron dealer Anders Magnus Salmenius and factory owner and member of parliament Carl Gustaf Rydin, feared that unemployment would follow on the introduction of free cotton trade. A technical school, however, would increase the local knowledge and skills as well as contribute to the regional industry's independence from international competition and new customs regulations. Factory owner Rydin took the suggestion to parliament, but was initially unsuccessful. One argument was the proximity to Chalmers and Gothenburg. Another argument related to the fact that local authorities had not promised to finance a school building; a position motivated by two severe city fires. Rydin was disappointed, emphasized parliament's inability to satisfy the demands of the cotton industry, and argued that Borås had not received any state subsidy for their schools since the "creation of the world". The 1854 death of the city's circuit judge, however, marked a turning point. He donated a large sum of money for a handicraft school, causing the parliamentary committee to reconsider their decision. The school in Borås was to provide teaching in the same subjects as in Malmö, but take its point of departure in the weaving industry. Teaching began in 1856.[15]

Wilhelm Gumælius, a technically interested dean in Örebro, noticed that many cities turned to parliament with requests for support to establish technical schools. He argued that it was important for Örebro to participate in the race since he considered the technical teaching at the Sunday and evening school insufficient. He suggested a technical upper secondary school to the local authorities, who commissioned their representative to write a suggestion to the parliament. Örebro's representative emphasized the central location, stressing that the surrounding county was both populous, fertile, and hosted more varied industrial production than any other Swedish region. Agriculture, forestry, copper, and zinc mining, iron works, foundries, and paperworks existed side by side in the relatively small-sized Örebro County. There were also plans to transform the city into an important railway junction, and this construction would gain from a technical upper secondary school. The already well-frequented general upper secondary school as well as the Sunday and evening school guaranteed the supply of both students and teachers, but railway engineers could also function as the latter. The parliament agreed that Örebro's location in the "center of the kingdom" motivated the approval of a technical upper secondary school.[16]

In 1858, Gumælius argued that the establishment of the four new technical schools had satisfied Sweden's demand for technical education at the intermediate level. He noted, however, that there might be a potential need in northern Sweden. More than 15 years later, a parliamentary committee underscored that northern Sweden was in a state of a positive industrial and population development. Thoughts of the region as a future industrial area and an alternative to America developed in the latter part of the nineteenth century. The committee argued that it was important to overcome the long distances and thus proposed the establishment of the fifth technical upper secondary school in the north.[17]

In 1899, the government suggested that a school ought to open in the provincial capital of Västernorrland County, Härnösand. Västernorrland was industrialized, the most centrally located county in Norrland, and almost a self-evident location, but heated debates between the county's cities preceded the inauguration in 1901. The battle of Norrland's technical upper secondary school was waged between academic Härnösand, which already had schools, and its neighbor Sundsvall, center of one of Sweden's most industrialized districts. The latter city reacted immediately after the 1899 government suggestion, and got support in the parliamentary committee. Despite the short distance between the cities – 40 kilometers – the cities' spokespersons argued over geographical location. The main question, however, was whether the northern technical upper secondary school should be located in an industrial or an academic area. Sundsvall's spokespersons referred to the 1850s locations and argued that a practical, rather than a theoretical school, should be located in an industrial city. Why, they asked, should Norrland have a different solution than southern and central Sweden? Härnösand referred to more easily accessible teachers, and argued that their city was smaller, cheaper, and more peaceful, as opposed to the larger and more American-like Sundsvall.[18]

Parliament voted for Härnösand. The city did, after all, have some mechanical industry. Furthermore, sawmills and papermills along a nearby river were easily accessible by train. Nevertheless, it was perhaps more

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important to choose industrial cities when industrialization was in the bud in the 1850s. Around 1900, Swedish industrialization at large had possibly reached a level where arguments about teacher accessibility and peacefulness were more relevant.

Students at the technical upper secondary schools

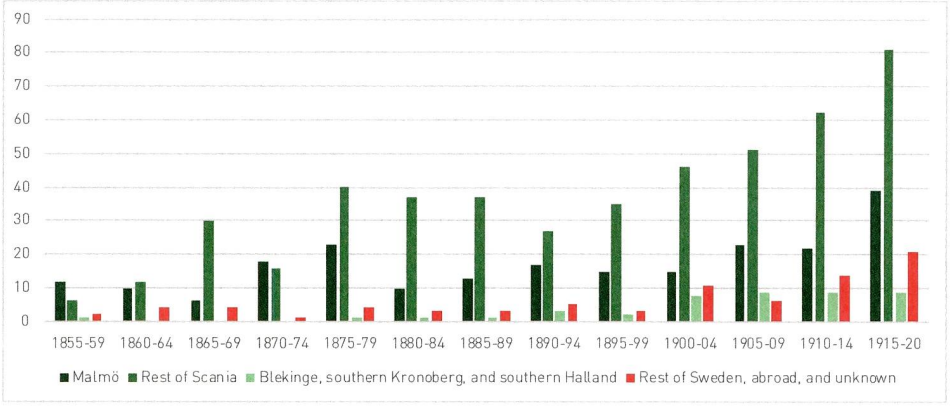
The technical upper secondary schools established in the mid-nineteenth century each trained hundreds of students in their seventy years of operation. The commemorative book issued by Malmö Technical Association in 1928[19] is a very good source for a study of the students' geographical origin, where they went after graduation, as well as in which branches they worked and whether the school prepared them for higher technical studies. The book contains almost complete biographies of the students until 1920. The biographies are usually less informative for the earliest graduates, but they still provide some information. Using these sources, we can investigate the success of the Malmö school as regional training center intended to bolster local industry.

The siting debates in parliament implied that the school primarily recruited students from nearby areas. Based on the 1928 commemorative book, this claim can be investigated. Figure 2 shows the Malmö pattern by birthplace. An average of 27 percent of the graduates were born in the city; the share was higher in the early years, but lower after 1880. The share born in Malmö and the surrounding province of Scania, however, lay more or less over 80 percent all the time. It appears that the school's catchment area extended a little from the 1890s as the share of students born in Sweden outside Scania and abroad increased.

Many of the applicants born in the rest of Sweden and abroad had, however, moved to the school's natural catchment area with their parents. A short check of the ten foreign-born graduates reveals that three of them lived in Malmö, four in other places in Scania, one in the neighboring province of Blekinge and one in Stockholm, when they applied. The 1893 chemical engineering graduate Gustaf Oscar Schulze from Drebkau, Germany, was the only foreign-born student who moved directly from abroad to the school. The technical upper secondary school in Malmö thus seems to have recruited even more from the vicinity than figure 2 indicates.

Where did the students go on leaving school? For the school to fulfil its regional commission, the students should have gone to work in the natural catchment area: the city of Malmö, the province of Scania, and the surrounding counties of Blekinge, and some of Kronoberg and Halland.

In figure 3, the three green columns show graduates who worked in the natural catchment area, whereas the yellow column represents potential employment in this area. Two years after graduation, at least 55 percent worked in the vicinity of the school, while the highest possible share was two thirds. The share for five and ten years after graduation lay between 45 percent minimum and 55–57 percent maximum. We can safely conclude that more than half of the graduates worked in areas closer to Malmö than to other technical upper secondary schools. However, working further away from Malmö, including foreign employment, was more likely the longer the period after graduation. It must have been easier to find the first employment in Malmö or the vicinity: students often established contacts with potential local employers before graduation. Prestigious public employment at, for example, the national railway or telegraph boards, was, however, almost always located in Stockholm. This kind of employments usually demanded some years of experience. Furthermore, stu-



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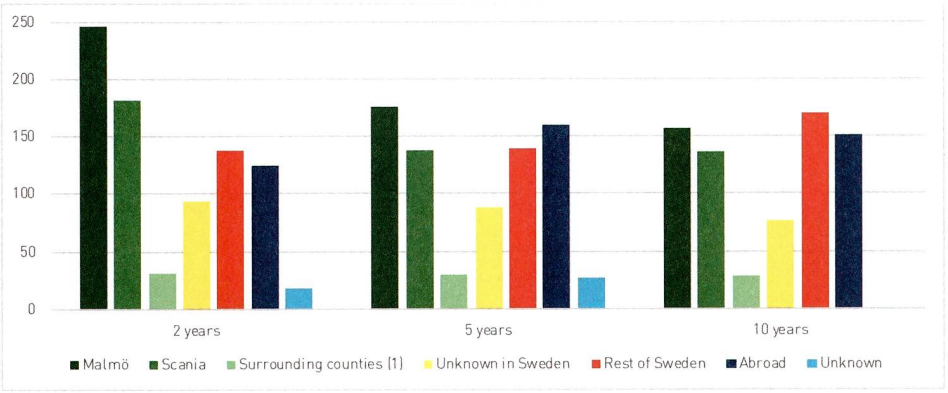
1 The Malmö technical upper secondary school-building in Kungsgatan.

2 Numbers of students graduating at the technical upper secondary school in Malmö with different birthplaces 1855–1920.



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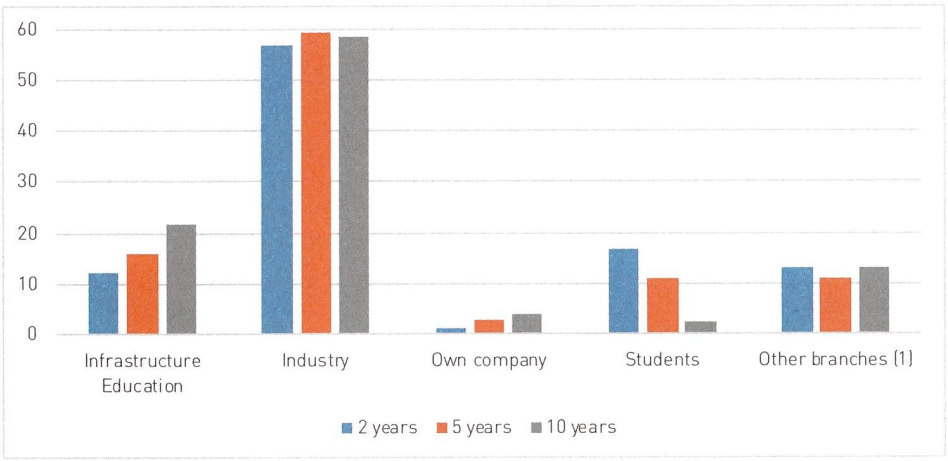
3 Location of students graduating from the technical upper secondary school in Malmö 1855–1920; 2, 5 and 10 years after graduation.

4 Branches of employment of students graduating at the technical upper secondary school in Malmö 1855–1920; 2, 5 and 10 years after graduation. Percentages.

5 Percentages of technicians graduating at the technical upper secondary school in Malmö 1855–1920 employed in the electrical industry; 2, 5 and 10 years after graduation.



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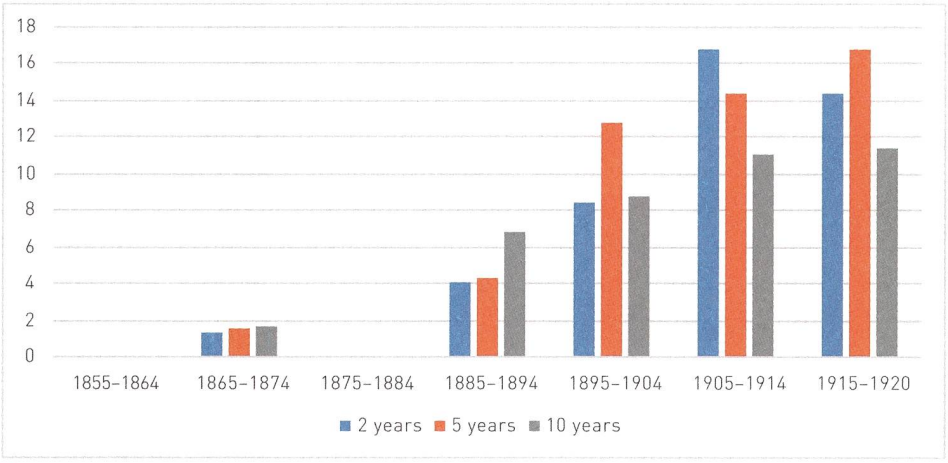
dents continuing to higher technical studies had to go to Stockholm, Gothenburg, or abroad. These studies were rarely finished after five years, and – if the graduate had worked some years in between – sometimes not even after ten. Employment or studies in the natural catchment area two years after graduation increased a little over time: from a minimum around 40 percent and a maximum slightly above 60 percent for students graduating in the years 1855–1864, to a minimum of around 55 percent and a maximum of around 65 percent for those who began at the school between 1915 and 1920. The trends were the opposite five and ten years after graduation. After ten years, more than 20 percent of the graduates from 1875 and onwards were working abroad. Figure 3 also shows that foreign employment was almost as common as employment in the city of Malmö five years after graduation: it might even be the most common pattern if we assume that those with an unknown workplace were abroad. Foreign employment was not necessarily a problem of brain drain: a large majority of the Swedish technical school graduates returned after some years in a foreign country.[20] Some loss of competence, however, occurred as some of the migrants did stay abroad.

Figure 4 shows that a majority of the graduates worked in industry, most of them in mechanical engineering. One major employer was the Malmö shipyard and mechanical workshop *Kockums,* but several graduates were also employed in the mechanical industry in nearby cities such as Helsingborg, Landskrona, Lund, Trelleborg, and Ystad. The chemical industry also employed many of the school's graduates; it was, for example, common to work at Scania's sugar plants.

The group of students founding their own company increased with longer duration after graduation. This is not surprising: starting a company no doubt required some years of experience. However, this group still never exceeded five percent. Hardly surprising, the share of graduates that continued to other studies decreased most of all. Studying to become a surveyor was rather common. Most students went to the Technological Institute and its successor, the Royal Institute of Technology, but it was also common to go to Germany to study – an expected pattern as Malmö is close to Germany. Most graduates went to the Technische Hochschulen in Darmstadt and Berlin-Charlottenburg. Just to give an example, Frans Fredriksson, who graduated in 1885, went to study at Charlottenburg and at the Akademie der Künste zu Berlin. He returned to become a practicing architect in Malmö. Inspired by German brick architecture as well as Art Nouveau, Fredriksson designed a number of buildings in Malmö and Lund.[21]

If we look into industrial sub-branches, we find an interesting pattern as regards the electrical industry in figure 5. The pattern reflects electrification in light of the second industrial revolution. Whereas very few graduates worked in the electrical industry prior to the mid-1880s, the share increased thereafter. The ones working in the electrical industry after two years doubled from 1885–1894 to 1895–1904, and doubled again by 1905–1914. The proportion working in the electrical industry after five years tripled



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between 1885–1894 and 1895–1904. No other branch had such a marked development.

Conclusion

Sweden established technical upper secondary schools after a 1850s dictum by the Technological Institute's principal Wallmark. He was worried about the low level of technical knowledge in regionally based industries and crafts, and suggested schools in seven cities around Sweden. While the members of parliament basically agreed that there was a need to strengthen intermediate level technical education, they argued all the more over the locations. After rather heated discussions, four cities in southern and central Sweden – Malmö, Norrköping, Borås, and Örebro – got technical upper secondary schools. Local initiatives were also important. The schools were located along certain lines: industrial cities were preferred over academic and clerical centers. Industrial Malmö was for example chosen over the prestigious neighboring university town of Lund. These principles were abandoned 50 years later, when academic Härnösand got a technical upper secondary school instead of its industrial neighbor Sundsvall.

The technical upper secondary schools were intended to promote industrialization and economic development in their part of the country. Our example, the technical upper secondary school in Malmö, can be interpreted as serving the southernmost province of Scania as well as the neighboring province of Blekinge and southern parts of Kronoberg and Halland counties. A large majority of the graduates were born inside this area, and those born elsewhere had often moved there with their parents before applying to the school. Clearly, the school functioned as one for the youth in the region.

Most graduates stayed in the region after they had graduated from the school: at least half of the students worked in the area in the period from around 1855 to 1930. Considering the large majority born in the region, this can at a first glance look like brain drain in the sense that not all the graduates remained in the region. However, we can hardly expect this to happen. Some technicians who had graduated at the other technical upper secondary schools went to southernmost Sweden for work, and compensated to some extent for those who went north on graduation in Malmö. Different Swedish regions exchanged technicians with each other. Some also went abroad of course, but this was often succeeded by a return migration. Did the returnees bring back valuable knowlegde and competence to Sweden? That is an interesting question, however, not explored in this article.

Most graduates went into industry, often moving to large industries in the region, such as Malmö's *Kockums* mechanical workshops, which over the course of the nineteenth century developed into one of Sweden's major shipyards. The graduates from the technical upper secondary school in Malmö followed, at least to some extent, in the footsteps of Swedish industrialization. Over time, the electrical industry employed more and more of them. They often represented Sweden's largest electro-technical manufacturer *ASEA* in Malmö and other south-Swedish cities, but they sometimes also worked at the company's main plants in Västerås in central Sweden. Other graduates were employed by foreign companies like Germany's *AEG*, in Sweden as well as in Berlin. In Sweden, as in other countries, electricity was a driving force when the country began to take the decisive steps around 1890 from a rural and agricultural society into the industrial age. ■

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Fay Lundh Nilsson has a PhD in economic history and is a researcher at the Department of Economic History at Lund University. Her doctor's thesis in 2007 was on technological change, skills, and wages in the Swedish engineering industry. After her dissertation, she has been involved in research projects with a focus on vocational education and economic change. She was leader of the project „Learning and knowledge transfer through labor migration" and is now leader of the project „Technical Education and Regional Development", both projects financed by the Swedish Research Council. During the last three years she has spent research periods at Nagoya University in Japan and is now starting a project about the history of technical education in the car industry – a comparison between Toyota and Volvo.

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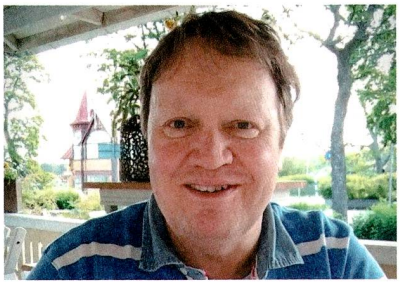

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Annotations

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Picture credits

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2–3 Database compiled from: Malmö teknologförbund, Minnesalbum utg. i anledning av Malmö tekniska läroverks 75-åriga verksamhet, Malmö 1928. (1) Blekinge, and the parts of Kronoberg and Halland counties that are closer to Malmö than Borås

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SERENITY SUTHERLAND

Women in Chemistry's Workforce

The Women's Laboratory at the Massachusetts Institute of Technology, 1876–1911

In the 1870s, the Massachusetts Institute of Technology (MIT) began offering educational opportunities to women scientists. Ellen Richards, the first woman to graduate from and teach at MIT, paved the way for future female students by beginning a Women's Laboratory that later transitioned into a Sanitary Science Laboratory. This paper outlines the network of women who studied in MIT's laboratories, and describes their scientific and technical research into the chemistry of water pollution and fire prevention. Beyond their laboratory work, women like Ellen Richards also engaged in the emotional labor of mentoring and network building.

Ellen Richards was the first woman to graduate from and teach at the Massachusetts Institute of Technology. Trained as a chemist, Richards broke into fields like nutritional science, mineralogy, mining engineering, water chemistry, and public health; first as a student in coeducational settings, and later as a professional in all-male settings. Richards started a Women's Laboratory at MIT as a place for women scientists like herself to train and practice chemistry. The Women's Laboratory, small and localized to MIT as it was, offers a glimpse into the type of laboratory work women did and how this work contributed to technological advances. This paper will focus on three specific areas. First, the establishment of the Women's Laboratory; second, a brief description of the women students in the laboratory, and third, a description of the type of laboratory work the women did. Underlying these three sections is the idea that "work" includes the emotional labor of mentorship and relationship-building that Richards undertook when she educated the women students in her lab. This emotional labor deserves consideration because it was the social context of women's exclusion from a majority of US scientific institutions that prompted women to network so efficiently to further their own educational and professional advancement.

Histories of women working in laboratories in the United States have received increased attention due to concerns over the lack of diversity in science, technology, engineering, and mathematics (STEM) as well as the popularity of books like Dava Sobel's "The Glass Universe" and the blockbuster film based on the book "Hidden Figures".[1] There are still many historians who do not know, though, about the kind of work women did in laboratories and how this training benefitted them as scientists. Scholars of women in science such as Londa Schiebinger have characterized the scientific opportunities available to women as ebbs and flows, never totally exclusionary but never completely inclusive, either. Historically, across one lifetime, the scientific "landscape was a varied one, rolling with peaks of