Chapter 12 (DRAFT – DO NOT QUOTE)

Double degree programmes in engineering and education - two cases from Swedish technical universities

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Abstract
Some technical universities offer programmes where students receive two degrees, one in engineering and one in education. This is a rather novel phenomenon, that has been observed to occur in e.g. Sweden, Finland, Germany, Greece and Israel. Degree programmes in education challenge the boundaries for what technical universities have regarded as their sphere of interest. We investigate two such programmes in Sweden, started at KTH Royal Institute of Technology and Chalmers, to study why the universities have started these programmes, and how have they built competence in this field. We also study if the programmes are given in cooperation with other partners and where in the organisation they belong. We investigate these questions by analysing documents and interviewing people who were involved as initiators or programme directors. Key motivations for introducing the programmes are found to be ambitions related to long-term student recruitment, by focusing on teachers and the teaching profession. An ambition is to improve mobility between engineering and teaching, in both directions. Other ambitions are to increase future teachers´ subject knowledge and to improve integration of different parts in teacher education and make it more holistic. The significance of the engineering context and the self-image of the technical university are discussed.

12.1 Introduction

Technical universities are characterized by their focus on science and engineering subjects and programmes. These areas show considerable continuity over time but are also subject to renewal. As shown in Chapter 2, some of the classical engineering programmes in mechanics, electronics, chemistry and built environment have later been complemented by programmes in new areas such as information technology, computer science and biotechnology. However, as shown in other parts of this book, technical universities also host other scientific disciplines, including from the humanities and social sciences, allowing them to integrate a broader base of knowledge and skills into engineering curricula. In some cases, like in 'industrial engineering and management', the integration of social science areas has been taken one step further, currently representing one of the most sought-after programmes in Sweden. The topic of this chapter, how combined teacher training and engineering programmes were introduced at the two leading technical universities, should be seen in that light. However, the institutional priorities and strategies is

not the whole picture. The Swedish policy background needs to be understood as well.

During the last decades, there has been a shortage of teachers in the STEM-subjects in Sweden, and the situation has become more challenging in recent years (Ahlbom and Alpman 2015, Skolverkets lägesbedömning 2017, Universitetskanslerämbetet 2015). As an effort to improve the situation, a new type of education offering two degrees, one in engineering and one in education, was introduced in Sweden in 2002.[1] This education was started as a cooperation between KTH Royal Institute of Technology and Stockholm Institute of Education and was supported by a governmental decision regarding this specific case, offering some financial support. The programme was prolonged by half a year compared to other engineering educations. Today, the study time in other engineering programmes and corresponding teacher programmes is the same as for this combined education. This combined programme has become dominant in the field of teacher education in STEM-subjects in Sweden (KTH annual report 2011, Lärarförbundet 2014). A similar education was created in 2011 at Chalmers, designed as a master programme, also leading to degrees in engineering as well as in education.

In this paper, we study how two technical universities handled the introduction of non-technical curriculum in their degree offerings. We focus on the motives for starting these two programmes, and on investigating attitudes towards this new activity. We also study how the necessary competence was acquired. Two strategies are demonstrated in the cases included in this study. Competence can be acquired by building new groups or departments at the own technical university, or by cooperation with others. We also study how these programmes have been integrated in the organizations, which is connected to how the programmes are viewed. The study is based on contemporary documents, discussion articles, and interviews with people who were involved, either as initiators or programme directors. We compare similarities and differences between the two studied cases.

12.2 The programmes

The programmes included in this study are both taught in Swedish. It is common for teacher education programmes to be taught in the national language. At KTH and at Chalmers, courses in the later years of study in in engineering programmes are normally taught in English.

The name of the programme at KTH is ‘Civilingenjör och lärare’ (in English ‘Master of Science in Engineering and in Education’, here abbreviated CL). In the beginning, this was an engineering programme with specialisation in teaching. The programme is a continuous five-year programme (300 ECTS). It has been a cooperation since it started, first with Stockholm Institute of Education and then

[1] Similar programmes exist in other countries, e.g. Finland, Germany, Greece and Israel.

with Stockholm University (SU) when this university was integrated into SU. Other engineering programmes at KTH are composed of a bachelor programme and a master programme following the Bologna 3 + 2 model, but this is not the case for CL. Mathematics is a dominant subject in the programme, and all graduates will have mathematics as their primary teaching subject in their degree in education. The programme has a unique structure at KTH. The first year of study is common for all students in the programme, and after the first year of study students choose one of four specializations: Physics, Chemistry, Information and Communication Technology, or Energy and Environmental Technology. Workplaced learning (teacher practicum) as well as courses in pedagogy and other courses regarding teaching and learning are present in all years of study, with the major practicum session (year 4) in an upper secondary school. The majority of the courses in the teaching subjects are studied together with corresponding engineering programmes at KTH. In 2017 the number of applicants to the programme was 481. Of these, 98 applied for the programme as their first choice. 60 students were accepted (26 women and 34 men). About 30 % of the graduated students work in schools, about 60 % in business, and about 10 % at universities.

The programme at Chalmers is called 'Lärande och ledarskap' (in English 'Learning and Leadership, MSc progr', here abbreviated LL). The name describes what distinguishes this programme from other engineering programmes. This programme is a two-year master programme (120 ECTS). With some exceptions, applicants are welcome from most bachelor programmes at Chalmers. The admitted students come from a diversity of programmes. These students, having a relevant bachelor's degree, can obtain two master's degrees, one in engineering and one in education. In the degree of education, possible teaching subjects are Mathematics and either Chemistry, Physics, or Technology (pre-engineering), depending on what bachelor programme the student has studied before. In general, Technology is the primary teaching subject. In some cases, the student is required to have studied certain optional courses in order to obtain two teaching subjects. Two skilled and experienced teachers, called 'master teachers' ('mästarlärare'), from the upper secondary school are employed by Chalmers and involved as teachers in many of courses in the programme. In 2017, the number of admitted students was 10. In order to obtain skilled and motivated students, the applicants are interviewed. In the courses, there are also students from a 90 ECTS Bridging Teacher Education Programme (kompletterande pedagogisk utbildning, KPU) with nine admitted students in 2017. This gives a total of up to 20 students in the courses. About 40% of the graduated students work in schools, and about 60% in business.

12.3 Methodology

This study is based on documentary studies and interviews with five key individuals involved in starting the programmes. Some of the interviewees are well known by the interviewers. Two of the interviewees took initiatives to start the CL and LL programmes at KTH and Chalmers, respectively, and three have been pro-

gramme directors when the programmes started and during many following years. At KTH the programme directors remained in this position for about 10 years. At Chalmers the interviewed programme director is still in this position.

The interviews were transcribed and served as the primary data source for contents analyses (Cohen et al. 2011). Both latent and manifest contents were considered. Separate contents analyses were performed for the situations at KTH and at Chalmers, respectively, and data regarding the reasons for starting the programmes and perceived or experienced difficulties were labelled and categorized. The categories were generated from the material. Considering data from both KTH and Chalmers resulted in the following categories:

Categories regarding motives

a) Worries and a sense of urgency regarding future recruitment of students to engineering education
b) To influence the contents of teacher education
c) To create competition
d) Personal interest and experience
e) Contribute to meeting the needs of society
f) Positive side effects for the technical university
g) Existing examples

Categories regarding concerns and difficulties

a) Concerns regarding number of applicants and economy
b) Concerns regarding weakening of the engineering content
c) Concerns regarding retention and demands on students
d) Concerns regarding the teaching subjects
e) Concerns regarding difficulties to cooperate
f) Differences regarding epistemology

Within each category, data from KTH and Chalmers were compared. Similarities and differences between the two cases are summarized in tables 1 and 2. In the interviews we asked not only for the opinion of our interviewees, but also for what they remember that others at their institute expressed. We also gathered data from the interviews on how competence in this field has been built and how the programmes have been organized.

As a complement to the interview data, we have studied contemporary documents expressing the official arguments, e.g. a governmental decision regarding CL, press releases and debate articles. In some cases, the authors' familiarity with the programmes is used as a data source.

12.4 Results

The results are organized by four themes: Motives for starting the programmes, perceived or experienced difficulties, how competence was acquired, and how the

programmes were organized. Data from interviews and documents contribute to all themes.

12.4.1 Motives for starting the programmes

Many motives were similar at KTH and Chalmers when these programmes were considered. In order to illustrate similarities as well as differences, the results regarding motives and fears are presented in tables. The tables contain two columns, one for KTH and one for Chalmers. Motives that are expressed regarding both Chalmers and KTH are presented across both columns, but motives expressed only regarding one of the institutions and explicit illustrating quotes are presented in one of the columns, depending on to whom they refer.

Table 12.1. Major motives expressed by interviewees for starting double degree programmes in engineering and education

KTH	*Chalmers*
a. Worries and a sense of urgency regarding future recruitment of students to engineering education	
a1. Lack of teachers in STEM-subjects in upper secondary school	
a2. Low quality in existing teacher education due to low application rates, which can be helped by the high application rates of engineering education	
a3. Questioned quality regarding examination and progression in existing teacher education	
	a4. The present situation is not satisfactory and something needs to be done: "[…] you [the established teacher education] don't recruit any teachers to be in chemistry, physics and hardly in mathematics. We can't just stand watching while the basis for our activities is falling apart"
b. To influence the content of teacher education	
b1. Towards deeper knowledge in teaching subjects, especially in mathematics	
b2. Towards a more holistic view with better integration and progression between different parts of teacher education	
	b3. Towards more professional relevance
c. To create competition	
c1. A desire to increase competition and mobility between the engineering	

and teaching professions, in both directions, in order to improve status and working conditions for teachers and make their knowledge appreciated in business

c2. Frustration regarding established education: “This [established] teacher education ought to have some competition.”

d. Personal interest and experience

d1. Interest in education

d2. Personal connections with politicians

d3. Experience as headmaster for a technical upper secondary school

d4. Experience as parent to school children

d5. Experience as chairman for teacher education

e. Contribute to meeting the needs of society

e1. Educate teachers where the shortage is most challenging

e2. “It was probably more of a societal interest. […] send signals to the system that we were prepared to take responsibility for this and do it in a manner that was characteristic for KTH”

f. Positive side effects for the technical university

f1. Increasing the awareness at the technical university regarding teaching and learning in these school subjects and the connection to society

f2. More emphasis on educational development, teaching and learning at the university

f3. Synergies with other educations focussing on leadership

g. Existing examples

g1. Good experience of combining technology with other subjects in the programme “Industrial Engineering and Management“

g2. Experience from the first years of having CL at KTH

g3. Experience from similar education in the USA.

The picture provided by the interview data can be complemented with what is expressed in documents. In the governmental decision by the Ministry of Education,

2002-03-07, Mission to Stockholm Institute of Education and KTH Royal Institute of Technology, it is expressed that starting this programme is a search for new ways to educate teachers with specialization in technology and science, in order to meet the demands of competence in these areas of primarily the Upper Secondary School. It is also expressed that a motive is to stimulate pupils' interest in science and technology, by renewing teacher education, as illustrated by the following quote (translated from Swedish): "Education and teaching for prospective teachers in elementary school and upper secondary school should be renewed for an education that increases and stimulates students' interest in technology and natural sciences."

In a joint press release by Stockholm Institute of Education and KTH, "Lärarhögskolan och KTH startar gemensam lärarutbildning" (Lärarhögskolan 2002), the following motives are mentioned:

- Economic development of Sweden
- Increase in status and better recruitment for teacher education
- Renewal of school teaching in science and technology
- Combining solid subject knowledge, provided by KTH, with knowledge about teaching processes and their prerequisites, provided by Stockholm Institute of Education.
- Development of research cooperation and cooperation for interaction with society.

Motives for starting LL at Chalmers were spelled out in three debate articles, one written some years before the programme was started (Engström 2005), one written when the plans were taking form (Bengmark et al 2009), and one written when the programme had been running for some years (Engström 2014).

Engström (2005) suggests that the established traditional teacher education would benefit from competition, as there are unsolved problems. The problems described are about weak connections between the teaching subjects and educational courses, and conflicts and antagonism between different parties involved in the education. The meeting between the problem-solving engineering culture and problematizing and reflective culture of teacher education was also suggested to become fruitful.

Bengmark et al (2009) focus on anticipated advantages of educating teachers at Chalmers. The CL-programme at KTH is mentioned as a successful example, but Chalmers' intention is not to copy this structure, but to create an education composed of a three-year bachelor programme plus a two-year master programme, according to the Bologna model. Many advantages are listed:

- The bachelor programmes at Chalmers would offer a large basis for recruitment
- The applicants would be good quality students, already used to demanding studies at a high pace
- Engineering studies and school subjects have many similarities, e.g. both include problem solving, sustainable development, economics, ethics, etc

- Programmes at Chalmers include training in general skills, e.g. team work, communicative skills and leadership

A significant overlap between a Master of Science in engineering and in education is emphasized. Increased mobility and competition between the engineering profession and the teacher profession, as well as educating good teachers, are mentioned as factors that will improve the attractiveness of the teacher profession.

Engström (2014) lists motives for starting teacher education at Chalmers in retrospective, but also describes problems that have been encountered, see next section. The motives include:

- Chalmers is described as dependent on recruitment of students with good pre-knowledge and the shortage of duly qualified teachers in the upper secondary school is described as a threat to Chalmers' existence
- The engineering background that students receive at Chalmers will enable the educated teachers to add relevance to society in the subjects mathematics, physics and chemistry.

12.4.2 Perceived and experienced difficulties

At KTH as well as at Chalmers, according to all interviewees, people were in general positive to the idea of having teacher education. None of the interviewees recall any strong objection against including teacher education in the tasks of a technical university. On the contrary, the management as well as colleagues were perceived to be very supportive, as illustrated by the following quote regarding the situation at Chalmers: "We received support from the management at Chalmers, and I feel that we have had it just the whole time, and from Chalmers as a whole and from everybody around Chalmers, that this is strategically enormously important."

Still, there were some concerns, worries or difficulties. Some difficulties were anticipated, either by those involved or by others, and some emerged as the programmes started. Concerns and difficulties expressed in the interviews are presented in Table 2.

Table 12.2. Concerns and difficulties expressed in the interviews

KTH	*Chalmers*
a. Concerns regarding number of applicants and economy	
a1. At KTH as well as at Chalmers, there were concerns about anticipated low number of students, due to low application rates to teacher education. Small student groups imply difficult economic conditions. Both programmes have received economic support from the university.	
b. Concerns regarding weakening of the engineering concept	
b1. Colleagues at other departments at KTH informally expressed personal concerns regarding reduced contents in classical engineering subjects.	
	b2. In recruitment contexts, stu-

dents expressed concerns regarding the engineering concept. ”Several [students] expressed that this is interesting, but I am not sure I would like to jeopardize my classical engineering degree by including this as well.”

c. Concerns regarding retention and demands on students

c1. The demands for passing a course are perceived to be low in some cases.

c2. In some contexts, students have had difficulties passing courses.

d. Concerns regarding the teaching subjects

d1. Technology is a comprehensive teaching subject in the upper secondary school. It is difficult to prepare students well in all aspects of it.

d2. Difficulties finding sufficient overlap between engineering and teacher education. The physics needed by a teacher should correspond to the curriculum for the upper secondary school, but most engineering educations need to specialize in one domain and have little interest for e.g. astrophysics.

d3. Most of the teaching subjects are studied in preceeding bachelor programmes. All of them but one (Electrical engineering) are recognized as acceptable (accredited) by LL. The teaching subjects included in the degree are determined by the courses studied during bachelor programme. In some cases, students must have done certain choices during the bachelor programme.

e. Concerns regarding difficulties to cooperate

e1. Some people expressed fear that KTH and Stockholm Institute of Education would find it difficult to cooperate due to cultural differences, and this was perceived to be a source of distrust and conflicts. This is also described by Geschwind and Scheffer (2007)

e2. During the initial stage cooperation with University of Gothenburg was considered. There was friction and conflicts between different

actors engaged in the established teacher education.

f. Differences regarding epistemology

f1. Distrust between KTH and Stockholm Institute of Education due to epistemological difference regarding learning, but also regarding subject knowledge especially in mathematics. Some people expressed that engineering mathematics was perceived to be focused on integrals and calculations rather than on understanding. "Teachers should study some other kind of mathematics."

Engström (2014) also discusses problems. Even though many bachelor students at Chalmers are qualified to apply for the LL-programme at Chalmers, the number of applicants is less than desired. The reasons are stated to be mainly outside of what Chalmers can control, in the hands of the employers (municipalities and educational companies) and the two major Swedish trade unions for teachers. Engström argues that rivalry between the trade unions for teachers has resulted in a major loss of status for teachers, and that the trade union for engineers would be the best option for the teachers graduated from Chalmers, and a means to regain status for the teaching profession in general.

12.4.3 How competence was acquired

As these programmes implied a development in a new direction for the technical universities, it was necessary to build competence in this field. How was this issue tackled?

At the time when discussions regarding teacher education started at KTH, teacher education was frequently criticized in public contexts. KTH made a draft proposing an alternative teacher education, that was rejected by Swedish National Agency for Higher Education (at that time Högskoleverket). This led to further contact and resulted in a governmental decision, implying that KTH and Stockholm Institute of Education were assigned to start a new education in cooperation with each other. The mission was to create an alternative to existing teacher education, with an explicit aim to renew school teaching in science and technology.

There was some funding associated with the governmental decision. This funding was used during some years for specific projects, regarding e.g. goals of teacher education and studying the intended learning outcomes of the upper secondary school. Efforts were made to start common research projects in educational science with Stockholm Institute of Education. These were, however, described as unsuccessful by an interviewee.

The design of the CL programme included traditional as well as new elements regarding the educational subjects. Some courses were based on traditional teacher education contents. Other courses contained new features or new aspects on learning. One particular issue in that respect was the development of a new final degree project, combining insights from both engineering and education, in collaboration with industry (Geschwind and Scheffer 2007).

Competence was needed from many fields to run the CL programme, from KTH as well as from Stockholm Institute of Education. The teaching subjects involved mathematics, physics, chemistry and computer science. The programme had three programme directors appointed when it started, two from KTH with backgrounds in mathematics and physics, respectively, and one from Stockholm Institute of Education. In order to have the necessary subject competence, people were involved from other parts of KTH as well. A steering committee that included people from KTH and Stockholm Institute of Education was formed.

At Chalmers, the original plan was to design an education in cooperation with some other university, either in Borås (Engström 2005), in Jönköping or in Gothenburg. However, due to political decisions, the application was to include only competence available at Chalmers. A group including two mathematicians, a chemist, and a person with background in administration was formed for starting the programme. The National centre for mathematics education, NCM, is situated at Chalmers, and their competence was included in the design of the programme. To strengthen research, two PhD positions were instituted on the border between subjects and pedagogy/didactics. Teaching and learning in higher education and an annual conference on teaching and learning (KUL) were seen as related areas, with possibilities for synergy with the LL programme.

12.4.4 Organization of the programmes

CL at KTH is an integrated 300 ECTS programme. Since the start, it has been run in cooperation with Stockholm Institute of Education and later SU. In the initial phase, from its beginning in 2002 to 2004-12-31, it was organized directly under the central administration of KTH. In 2005 there was a general reorganization, where KTH was divided into a number of schools. CL came to belong to the School of Engineering Sciences (2005-01-01—2013-06-30). Connecting the programme to Industrial Engineering and Management was discussed as an alternative. In an effort to strengthen the support for the program, the School of Education and Communication in Engineering Science was created at KTH, and the programme belonged to this school during the period 2013-07-01—2017-12-31. In 2018 a new reorganization was launched, and the number of schools at KTH was reduced to five. The CL programme now came to belong to the School of Industrial Engineering and Management, from 2018-01-01.

A minor revision of the CL programme was implemented in August 2005 (Skolan för teknikvetenskap, Årsrapport 2005, p. 15). The first year of study was revised, strengthening Mathematics and the introduction to the engineering and

teaching professions. Stockholm Institute of Education was integrated into Stockholm University 2008-01-01. A major revision of the programme was implemented in 2011, based on a new application for the right to award degrees and a new Higher Education Ordinance. In this revision, the first year of study was entirely redesigned in order to improve retention, and KTH received the right to issue both the degree in engineering and in education.

LL at Chalmers is a 120 ECTS master programme, according to the Bologna arrangement. Chalmers chose not to copy the design model chosen by KTH. By making this choice, the programme does not have responsibility in the same way for the bulk of courses in Mathematics, Physics, Chemistry and Technology/Engineering subjects. These subjects are mainly studied in the preceding bachelor programmes. Students from the bachelor programmes in Chemistry, Chemical Engineering with Physics, and Biotechnology become teachers in Mathematics and Chemistry. Students from the bachelors programme in Engineering Physics become teachers in Mathematics and Physics, and the others, e.g. Applied Mathematics, Mechanical Engineering, Computer Science, Information Technology, and Civil Engineering, but except those from Electrical Engineering, become teachers in Mathematics and Technology.

When LL was started it received active support from the president of Chalmers, by driving questions and conveying contacts. The programme received economic support for development of courses and employment of two teachers form the upper secondary school. In the organization, it was placed under Engineering Mathematics as the programme directors had background in mathematics. However, the communicational pathways were different from other master programmes. The programme director of LL mainly communicated directly with the vice president and deans of education (utbildningsområdesledare), and less with the programme director of Engineering Mathematics, as other master programme directors would do.

12.5 Discussion and conclusions

The materials from the interviews and the contemporary documents allow for triangulation. We see no contradiction between them, even though more aspects are covered in the interviews. The interviews provide a richer, more nuanced, and more specific material, whereas the documents contain original formulations unaffected by later events. Both authors are also familiar with the context of the double degree programmes, since many years.

The most prominent reasons for starting these programmes seem to be concerns regarding the education in Mathematics and Science in upper secondary school and a desire to improve future recruitment to engineering education. Teacher education has been seen as a key to finding a sustainable solution to the problem, but there has been anxiety regarding the quality of teacher education and a desire to attract more and better students to teacher education. As many teachers leave the teaching profession, an aim has been also to improve the status of teachers and

teacher education. The complex mix of rationales are both structural, like the ones above, and related to prominent individuals in each institution, championing this initiative (cf Geschwind 2018). The arguments, more or less pronounced, include a strong self-confidence as leading technical universities and a critical stance towards the teacher training provided by other universities. At times, this self-confidence has been mirrored by a strong confidence also from the responsible minister of education.

The basis of both programmes in engineering is evident, as reflected e.g. by the names of the programmes. Regarding CL, the initial name of the programme expressed that it was an education in engineering with a specialisation towards teaching, but this was changed to the more neutral present name where the engineering and teaching aspects have equal positions, even though engineering is mentioned first. Reasons for having a focus on engineering could be that the programmes have been developed in engineering contexts at technical universities, but it could also reflect the fact that engineering education has higher status than teacher education. During many years, the suitability of the name CL has been discussed by the students of the programme at KTH. Some students argue that the presence of "lärare" (teacher) in the name makes it more difficult for the graduates to get engineering jobs, and that the name of the programme should describe what kind of engineers they are, like other names of engineering programmes. Another indication of the importance of the engineering context is that CL students often in yearly evaluations express that they wish to learn more about adults' learning, as children's and adolescents' learning is in focus especially in courses given by departments mainly involved only in teacher education. In the reorganization 2013 when CL was moved to the School of Education and Communication in Engineering Sciences, many expressed concerns that this reorganization would imply that the engineering aspects would become less emphasized. These concerns were expressed by staff as well as students before and during the transition, but not afterwards.

How competence was acquired is connected to the university's view of its identity. The first draft about teacher education at KTH indicates a very confident self-image. The educational competence at KTH was considered to be too low, by the government as well as by some key persons at KTH, and the education started in cooperation with Stockholm Institute of Education according to the governmental decision. The identity of KTH was based on solid subject knowledge, in engineering and especially in mathematics. The cooperation revealed differences in culture and in epistemology. Although there was friction and KTH had strong self-confidence whereas Stockholm Institute of Education was used to being questioned, the self-image at KTH was affected and an awareness and appreciation of the differences in culture arose. Arguably, the self-image at KTH today is more nuanced and humble. Fifteen years of experience of educating teachers have given more people insight in the nature of this challenge. The self-image of the university is probably highly dependent on the views of a rather small number of individuals. The education is still based on cooperation, even though KTH today has a de-

partment of learning in engineering science and has had the right to award degrees in education since 2011.

During the studied period, there also existed a desire to reform engineering education. At KTH, the development of the CL programme coincided with the emergence of a reform movement of engineering education, CDIO. The traditional engineering role was questioned, as expressed e.g. in the CDIO syllabus 2.0 (Crawley et al 2011): "In order to be able to handle real-world engineering situations, engineers should not only master technical challenges. They must also have e. g. personal, interpersonal skills and system building skills." Both KTH and Chalmers are founder institutions for CDIO, and this desire to introduce interpersonal skills in engineering education in general may have facilitated the acceptance of the new engineering profile expressed in these programmes. In the European Society for Engineering education, SEFI, the traditional engineering role is also questioned. In the SEFI Position Paper on Developing Graduate Engineering Skills, (2015), this is expressed "Engineering is not just about applying technical principles.", and "Therefore, engineering education must broaden the engineer in addition to providing deeper specialized subjects (the "T-shaped Engineer"). Critical thinking and self-reflection are necessary ..." The "T-shaped engineer" is a good description of the ambition behind these programmes. The engineer shall have solid knowledge in one relevant area, but also needs a wide perspective and broad competence including many different skills, some of which are promoted by courses in education. Studies of alumni motives for having chosen CL (Cronhjort, 2017) and the careers of alumni (Cronhjort et al 2017a, Cronhjort et al 2017b) confirm that the wide span of subjects included in the programme has attracted many of the students to CL and that the students benefit from these joint competences in their careers.

The organizational positions of the programmes reflect strong connections to Mathematics. Both programmes have always had at least one programme director with a background in Mathematics. This corresponds to the ambition to promote subject knowledge. A connection to a department with high status supports the ambition to raise the status of teacher education. At KTH, the CL programme now belongs to the School of Industrial Engineering and Management. The long-term effects of this are still unknown but one of the rationales behind the change was that the future development of the programme would be supported in a supposedly stronger academic environment.

As mentioned, our material illustrates that engineering education has had strong confidence, whereas teacher education has had weaker confidence. However, conclusions regarding self-sufficiency, based on the strong confidence associated with the engineering identity of the technical universities, must be drawn with prudence, keeping in mind the very special conditions under which these programmes were developed. KTH wished to start an alternative to existing teacher education but was not allowed to do it on its own. In 2002, according to the governmental decision, KTH was forced to cooperate with Stockholm Institute of Education. This cooperation implied some struggle but proved fruitful and is still appreciated

at CL today, fifteen years later. In 2011, when Chalmers designed the LL programme, they wished to cooperate with other universities but were informed that this was not allowed. At that time, all universities had to make new applications for the right to award degrees based on a new Higher Education Ordinance. Thus, Chalmers was forced to start its programme depending on in-house resources. Both these cases show that governmental regulations regarding teacher education interfere with the ambitions and plans of the universities, and the actual developments cannot be interpreted as manifestations of the intentions of the universities.

Conflict of interests: Cronhjort is Programme Director of Master of Science in Engineering and in Education at KTH since 2014. Geschwind was Course Director for the final degree project 2013-2016.

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