Leadership and Pedagogical Skills in Computer Science Engineering by Combining a Degree in Engineering with a Degree in Education

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Abstract—**In this full paper on innovative practice, we describe and discuss findings from dual degree study programmes that combine a master's degree in engineering with a master's degree in education. This innovative study programme design has emerged in Sweden due to an alarming demand for more Upper Secondary School teachers in STEM subjects. Studies on alumni from these programmes indicate that the graduates are highly appreciated not only as teachers in schools, but also in business and industry, e.g. in roles as IT consultants and computer science engineers. Data indicate that the breadth of the combined education, and especially leadership and pedagogical skills, are important factors for these graduates' success as engineers.**

Keywords—Dual degrees, combined education, computer science engineering, teacher education, pedagogical skills, leadership, problem solving, critical thinking, equality, gender, IT consultants

I. Introduction

For decades, studies on engineering education have emphasized the need for an engineer to also master other skills in addition to the purely technical. This need has resulted in reform efforts, e.g. the CDIO syllabus 2.0 [1], as well as policy documents, e.g. the SEFI Position Paper on Engineering Skills [2]. In computer science, the value of e.g. breadth, flexibility, critical thinking, and the ability to work well in cross-disciplinary teams has been highlighted [3]. Do students in study programmes with a broad perspective become better trained in such skills?

In Sweden, there are two dual degree study programmes that combine master's degrees in engineering and in education. These innovative programmes are 'Civilingenjör och lärare' (in English, Master of Science in Engineering and in Education, here called CL) at KTH Royal Institute of Technology [4], and 'Lärande och ledarskap' (in English 'Learning and Leadership', here called LoL) at Chalmers University of Technology [5]. These programmes were initially started because of fear that future recruitment to engineering education was threatened by poor knowledge and weak interest in science, technology, engineering, and mathematics (STEM) among students in Upper Secondary School [6]. By combining a degree in education with a degree in engineering, the technical universities wished to increase prospective students' interest in teacher education, as well as to have a direct influence on the subject knowledge of future teachers. These combined programmes have recently been evaluated in the category *mathematics teacher education* by the Swedish Higher Education Authority (UKÄ) and received the highest rating: "High quality" [7].

There was also a desire to contribute to the apparent needs of society. Graduates get two degrees, one in engineering and one in education, and these programmes thus contribute to society not only by graduates working as teachers but also in several other roles. About 60 percent of the graduates from CL as well as from LoL are employed in organizations and companies, many as consultants in the IT sector. Naturally, cutting edge programming and system building skills are essential in the computer science engineering role, but social, pedagogical, and leadership skills may also be of crucial importance. The ACM/IEEE curriculum guidelines for undergraduate programmes in computer science [8] state: *Curricula must prepare students for lifelong learning and must include professional practice (e.g., communication skills, teamwork, ethics) as components of the undergraduate experience.* Studies on the careers of alumni from CL at KTH indicate that graduates are highly appreciated in companies, especially as IT consultants [9]. The programmes contribute with engineers that have a different profile compared to the traditional computer science engineer, and their abilities to explain and lead seem to be especially appreciated.

A study on motives for applying to the combined study programme at KTH reveals that some students have hesitated to choose an engineering education for fear of becoming trapped in a lab with little social interaction [10]. There seems to be a subset of applicants to higher education who are well aware of their own social needs and skills and may therefore be hesitant to choose a traditional computer science or

engineering education. They would rather choose an education where they can combine interests in STEM and/or computing with the social activities offered by the teaching profession.

In this paper, we investigate two research questions:

1) How do graduates from programmes that combine engineering and teaching perceive their opportunities in the job market as computer science engineers?

2) How do graduates from combined programmes and from computer science engineering rate their education regarding pedagogical skills, critical thinking, problem solving and leadership? Do men and women have different views?

II. Description of the Studied Programmes

The dual degree programmes, CL at KTH Royal Institute of Technology [4] and LoL at Chalmers University of Technology [5], each lead to two Master's degrees. Graduates receive both a Master of Science in Engineering and a Master of Science in Education, within one of the subject combinations mathematics and physics, mathematics and chemistry, or mathematics and technology. A difference between these programmes is that CL at KTH is a five year integrated first and second cycle study programme, where students choose to aim for both degrees from year one, but students at Chalmers can choose LoL for the second cycle, at the end of year three, after having completed a regular first cycle bachelor programme. The specialization in computer science, which is the focus of this paper, is linked to the subject combination mathematics and technology at CL/LoL.

To give an overview of the content of these programmes, we present the proportion of course credits in different areas in the current curricula of CL and LoL, see Fig. 1 and 2. The category "Other" contains for example courses in sustainable development. In Fig. 2, we have included the courses in the three-year computer science bachelor programme to make the figures comparable.

As a reference point, we use the five-year Master of Science in Computer Science and Engineering study
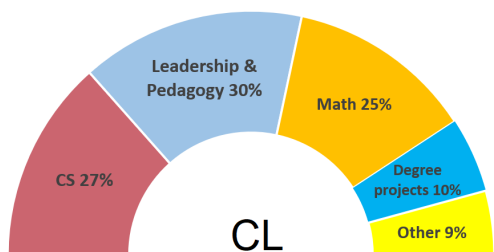

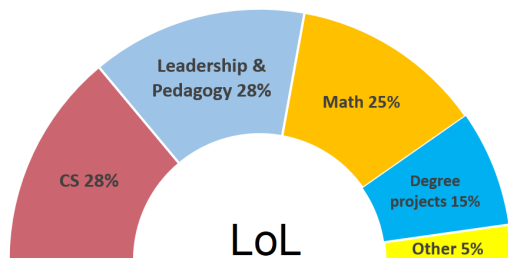Fig. 1. Percentage of types of courses in the CL programme at KTH.

Fig. 2. Percentage of types of courses in the LoL programme at Chalmers.

programme at KTH (CS) [11], where years 4 and 5 are identical to the Master of Science programme in Computer Science. The CL students with computer science specialization share many of their courses with CS students. Since both programmes are of equal length and the CL programme also gives a degree in education, the proportion of computer science courses in the CS programme is larger, see Fig. 3. The curriculum of the CS programme is built to meet the requirements of the ACM/IEEE curriculum guidelines for undergraduate programmes in computer science [8]. In some comparisons to LoL at Chalmers, we will use the corresponding five-year CS programme at Chalmers, which is similar to CS at KTH.

III. Methodology

The present study is based on quantitative and qualitative data gathered in questionnaires. Data come from materials gathered for a study in 2016 on careers of CL alumni, from a LoL alumni survey in 2019, from the general career follow-ups at KTH in 2018 and at Chalmers in 2019, and from a programme survey to CS students in their final year in 2016 and 2019.

The CL career study monitored how graduates from CL viewed their employment, careers, and opportunities at the job market [9]. The questionnaire was distributed by the KTH alumni network. The respondents had graduated at least two years before answering the questionnaire. 136 graduates were addressed and 49 answered the questionnaire. Of these, we here use data from all respondents that have studied the computer science engineering profile of the programme. There were in total 11 such respondents, all of them working in computer science engineering. Four of these are women and seven are men. These questionnaire data enable us to investigate how alumni from CL perceive their opportunities and their role in computer science engineering.

The LoL alumni survey was sent to 64 out of 67 alumni that had graduated at least one year earlier, and was answered by 36 of them. Out of these, three had a computer science bachelor, which proportionally is a bit less than the alumni group as a whole as 8 of the 67 alumni have a computer science bachelor. Of these respondents, one was a woman and two were men. The questionnaire had 26 questions within three areas: path to work life after studies, relationship between competences needed in work and what they had developed in their studies, and finally, what competences they now need to develop and how the university could support that.

In an exploratory approach, qualitative data are analyzed with content analysis, including manifest as well as latent content. The codes were generated from the data during the analysis, and grouped into two categories, depending on if they expressed advantages or drawbacks with the study
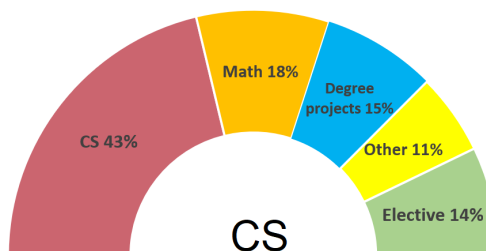

Fig. 3. Percentage of types of courses in the CS programme at KTH.

programmes. In cases where different meaning-bearing units were identified in an answer from a respondent, several codes were applied. A code was applied at most once for each respondent, even if an issue was expressed repeatedly, perhaps in several ways.

A general KTH career follow-up is carried out regularly by Statistics Sweden (Statistiska centralbyrån, SCB). The survey in 2018 addressed all graduates from KTH in 2013, 2014, and 2015. The aim is to map the job market opportunities and the careers of all KTH graduates, to provide data that can be used as a basis for the development of KTH study programmes. The ultimate goal of the follow-up is to monitor and improve the employability of KTH alumni.

In the data from the general follow-up survey, we focus on how graduates perceive their past education at KTH. In this context, it is difficult to use data regarding the employment of graduates, as CL is a broad study programme and graduates are employed in a diversity of positions. Only about a third of the graduates from CL had a computer science engineering study profile. In the career follow-up, it is not possible to distinguish the study profile or individual employment of the respondents. Many graduates from CL are employed as teachers, and some have positions related to e.g. chemistry, physics, or sustainable development. In the statistics, in cases where the number of responses is less than three, no data are provided by Statistics Sweden. This is to protect the respondents and assure that it shall not be possible to identify any individual. This explains why the total in the statistics may sum up to less than 100 percent. In the data from Statistics Sweden, all figures are extrapolations to the population level. Thus, the presented results represent estimates for the entire population and not only the actual respondents. Presented numbers represent the estimated number of individuals in the population that have the specified feature, including confidence intervals. There are 84 respondents from CL in the follow-up survey, of which 45 are women (54%), and 329 respondents from CS, of which 25 are women (8%).

The general career follow-up at Chalmers is sent to everyone who graduated three years earlier. Hence, the survey of 2019 was sent to those who graduated in 2016. Only five of the respondents are LoL alumni, three women, and two men. Unfortunately, it is not possible to determine from the questionnaire whether any of these have a computer science bachelor. Hence, the data has to be used with caution when comparing with CS alumni. The aim of the questionnaire is similar to that of the KTH follow-up, i.e., to map careers of alumni and their perception of how well the studies have prepared them for their professional work.

At the end of each academic year, the students of the reference programme Computer Science and Engineering (CS) have to answer a survey containing questions related to different aspects of the programme, for example, the learning environment, the development of specific skills through the programme, stress and mental health. We can make the survey mandatory because it is a part of the assessment of the Programme Integrating Course [12], which among its learning objectives has *Review critically and reflect on both the setup and implementation of the education as well as their own study achievements*. Of the 90 students answering the survey in 2019, 84 accepted that their answers might be used in a research study. We also use a free text response from one student answering the survey in 2016.

Since the turn of the century, there have been reforms in the programmes. Therefore, the curriculum of the graduates that have participated in the surveys is similar but not identical to today's curriculum. In CL, there was a major reform in 2011, and most of the respondents started their studies before the reform, but in the case of this study, we will not distinguish these students from later students. The differences are mainly in which order the courses were given in the programme.

IV. RESULTS AND ANALYSIS

A. Programme survey at CL at KTH

We will here investigate results from the career questionnaires. In the CL survey, we study the eleven respondents from the computer science engineering profile of CL. This group of CL graduates is not representative of graduates from CL in general. Of the 11 respondents in the career questionnaire, all work in business, and none as a teacher. For comparison, about 60 percent of the CL graduates in general work in business or as self-employed, and about 30 percent as teachers [9]. We do not know the reason for this difference. It might be that those who wish to work in the engineering role choose to study the computer science engineering profile of the programme, but it may also be that those who are interested in computer science are attracted by favorable offers from companies looking for computer science engineers.

In the CL career questionnaire, there was a question about whether the graduates regarded themselves as advantaged or disadvantaged on the job market. Of the eleven respondents from the computer science engineering profile, nine answered this question (Fig. 4). Four of them regarded themselves as definitely or probably advantaged, and one as probably disadvantaged. The remaining four indicated that they were neither or both advantaged and disadvantaged. This is similar to the statistics for the programme in general [9] and indicates that the graduates are appreciated at the job market in the computer science engineering role.

There was a qualitative question in the CL career questionnaire, where alumni were asked: "What advantages and drawbacks do you experience with your dual degrees?" (translated from Swedish). There were three boxes for replies, called "Advantages", "Drawbacks", and "Other comments", respectively. In the analysis, all statements could be identified
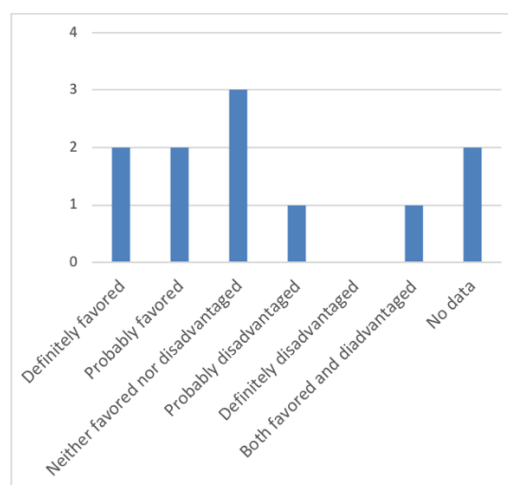
Fig. 4. Number of respondents that perceive themselves as favored and disadvantaged on the job market, according to the CL career questionnaire.

as expressing drawbacks or advantages, including two answers given as "other comments". Meaning-carrying expressions were identified in the answers and coded and categorized as illustrated in Table I. The numbers following the codes in the table represent the number of respondents who expressed the opinion.

We will here describe the codes, and give some illustrating quotes. We begin with the perceived advantages with dual degrees.

"Good combination" represents the opinion that engineering and education is an especially useful or fruitful combination, as illustrated by the quote "The two degrees provide added value in both directions, no matter which direction you choose, you benefit from them. They reinforce each other."

The code "Specific skills" is used where the respondents have mentioned that they have developed skills or features concerning specific areas or skills that they find useful. The mentioned areas are: presentation (mentioned by three respondents), understanding people (two respondents), the ability to learn (two respondents), pedagogy, leadership, group dynamics, conflict solving, flexibility, and communication (mentioned by one respondent, respectively).

"More alternatives" represents the opinion that dual degrees give the graduates more alternatives in their future careers. A representative quote describing this opinion is "Nice to have the opportunity to work as a teacher in the future if the conditions improve."

"Additional competence" indicates the opinion that this dual degree study programme offers something extra that few others have, i.e. opportunities to develop competences that are not developed in traditional engineering programmes. This is seen as an advantage on the job market, as illustrated by the quote "You have something that very few other engineers have."

"Broad competence" represents the opinion that gaining a broad profile is more important than technical excellence, e.g. due to a better understanding of other parts of the organization.

The code "Security" indicates the opinion that the dual degrees may offer security in times of uncertainty. Some worries regarding the future are expressed, as in the quote "Security to a teaching position if the market would crash."

"Merits" indicates a focus on getting recruited. The ability to get a job is in focus, as contrasted to the ability to perform a task, or carry out a job. An illustrative quote is "Looks good on paper."

Regarding drawbacks with dual degrees, the most common code is "Less technical depth or excellence". This

code is used when the respondents express that dual degrees imply less possibility of unspecified more advanced knowledge or specialized subjects. This can be illustrated by the quote "It is possible that in some individual cases you have missed some advanced courses / cutting-edge knowledge, but as an engineer you have the ability to learn very quickly."

A closely related code is "Miss a specific area", which is used when a desired but missed advanced course or area is specified. The code can be illustrated by the quote "Lack deeper knowledge in certain areas, e.g. programming, which is sometimes needed in working life. This demands that you solve it on your own and/or have the opportunity to develop it in working life." Areas that are mentioned as desired are information and communication technology, programming, entrepreneurship, and innovation. Note that this code is also related to the above-described code "Specific skill" in the category "Advantages", where the respondents express that the dual degrees offer more possibilities than a traditional programme.

There are three more codes that represent perceived drawbacks with dual degrees. Each of them is only applied once in the analysis. The code "Curricular knowledge gets outdated" represents a fear that when the respondent might want to work as a teacher in the future, the curriculum in school might have changed. The code "Low quality in educational parts" represents the quote "During education possibly when many experienced the quality of some teacher courses as low, but after? No." Seemingly, the respondent thinks that the study programme could have been more effective and/or contained more. The code "Fear for weaker status" indicates that one respondent expresses that the title "Teacher" might give a bad impression.

As mentioned above, two respondents gave "other comments", after having been asked to describe advantages and drawbacks. As we have categorized these answers as one advantage and one drawback, even if the respondents did not give these answers in these corresponding boxes in the questionnaire, we wish to describe and comment on these answers in particular detail.

The first was expressed by a female graduate: "The education is fantastic and I think it is difficult to realize what effects it actually has, but from my experience they are only positive. In a society where information and communication are becoming more important and growing, clarity is required and the ability to be understood all the time." We coded this as "special skills: communication", and categorized it as an advantage, as the education is described as fantastic.

The other was expressed by a male graduate: "I would have enjoyed participating in some work-related project during my studies. I think tradition and opportunities are greater on CS for this. For example, to make your own app and to try to build a company." This was coded as "miss a specific area: entrepreneurship and innovation", and categorized as a drawback, as the respondent expresses a belief that this would have been possible to obtain without dual degrees. It is true that many CS students work on external projects, both paid work and hobby projects, during their studies, but this is not a part of any course.

The advantages seem to be perceived as more prominent than the drawbacks. Often, when drawbacks are mentioned, a personal strategy for how to deal with it is also mentioned. This corresponds well to the quantitative results presented in

TABLE I. ADVANTAGES AND DRAWBACKS WITH CL

Advantages	Drawbacks
Good combination (5)	Less technical depth or excellence (5)
Specific skills (5)	Miss a specific area (3)
More alternatives (3)	Curricular knowledge gets outdated (1)
Additional competence (2)	Low quality in educational parts (1)
Broad competence (2)	Fear for weaker status (1)
Security (2)	
Merits (2)	

Fig. 4, expressing that graduates from CL, in general, feel that they have an advantage on the job market.

B. Programme survey at LoL at Chalmers

The three alumni with a computer science bachelor that had responded to the LoL alumni survey had all chosen to take their employment in industry as engineers. This is similar to the response at KTH. However, from the records of the 67 alumni from LoL, we know that among the LoL alumni with a computer science bachelor 2 out of 8 work as teachers, which is a smaller proportion than among the LoL alumni in general, among which 42% work as teachers. Hence, we find that LoL students with a computer science bachelor choose to work as engineers to a greater extent than the general LoL student do.

Using the same codes and categories as for CL alumni, the opinions of LoL alumni are displayed in Table II. One of the respondents (female) got two job offers in industry before graduating. One offer was as an educator and one as an engineer, i.e. the dual degree gave additional opportunities (More alternatives). In addition, the respondent points to leadership as an area of excellent (Specific skills) and important competence (Additional competence).

A second respondent was also employed before graduating but does not tell if the respondent had more offers to choose between. The respondent emphasizes that the leadership competences were an important ability (Specific skills) and that this was an advantage compared to other engineers (Additional competence).

The third respondent got a job after between 2 to 12 months and felt disadvantaged by the dual degree, as "most companies looked for technical knowledge and not the breadth I had". (Less technical depth or excellence).

C. General Career Follow-Up at KTH

Data from the career follow-up survey allow us to monitor how graduates from KTH rate their education regarding a number of skills. These data can be compared between study programmes at KTH. Here, we compare the dual degree programme CL with the computer science engineering programme CS.

All respondents from CL and CS were employed. A majority of both CL and CS alumni got their employment before they got their degree, 51 percent for CL alumni and 85 percent for CS alumni. 46 percent of the CL alumni declared that they work in research/education, while no CS students chose this alternative. 34 percent of the CL alumni and 73 percent of the CS alumni reported that they work in the engineering industry or as an IT consultant.

We will now focus on the survey question "*How do you assess the education/training you received at KTH in…*", followed by a number of specific areas. We have selected eight areas to include in our study, and present them in groups

of three or two. In the first group, we have included three areas that are related to pedagogical skills:

- Making written and oral presentations
- Explaining for laymen/non-specialists
- Making judgements with regard to equality and gender

The second group contains three areas related to leadership and teamwork:

- Working in a team/cooperating with others
- Leading others
- Planning, budgeting and leading projects

The last group contains two areas related to generic skills that are independent of a social context. These areas can be applied in any context, e.g. in programming:

- Solving problems independently
- Improving your own critical thinking

Respondents could choose between the answer alternatives "Very satisfied", "Quite satisfied", "Quite dissatisfied", "Very dissatisfied", and "Not received" (in Swedish "Förekom ej", i.e. the area was not dealt with in the education). To get a rough overview of the results in these areas, the answers of the respondents were represented by values 4, 3, 2, 1, and 0, respectively, where 4 corresponded to "Very satisfied" and 0 to "Not received". Averages for graduates from CL were compared to those from CS. We find that for all areas in the first two groups, i.e. connected to pedagogical skills, leadership, and teamwork, the CL graduates rate their education higher than CS graduates (Fig. 5). The most significant difference is found in the areas explaining for laymen/non-specialists, making judgements with regard to equality and gender, and leading others. On the other hand, CL graduates rate their education slightly lower than CS graduates regarding solving problems independently and improving your own critical thinking.

In order to get an overview of where women and men have different views, we also compared averages from CL women to CL men (Fig. 6), and CS women to CS men (Fig. 7). CL women rate their education higher than CL men do regarding making judgements with regard to equality and gender, and
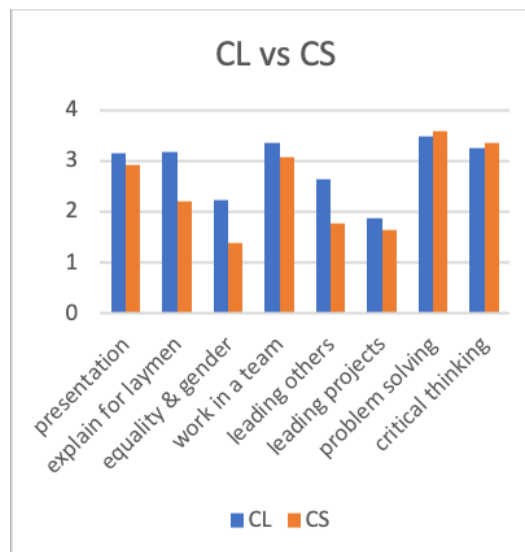

Fig. 5. Averages for assessments of education for CL compared to CS.

TABLE II.   ADVANTAGES AND DRAWBACKS WITH LoL

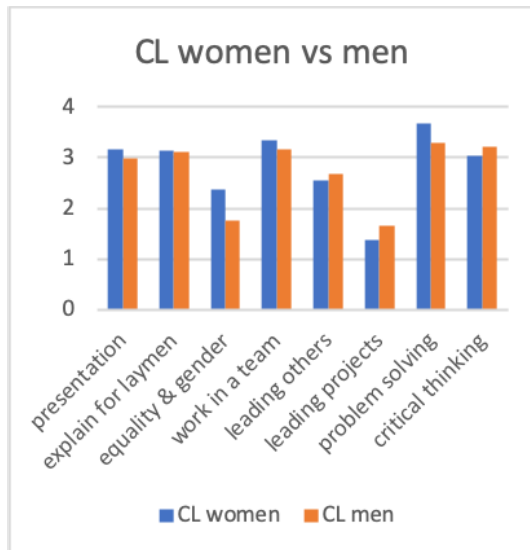| Advantages	Drawbacks
Specific skills (2) More alternatives (1) Additional competence (2)	Less technical depth or excellence (1)

Fig. 6. Averages for assessments of education for CL women compared to CL men.
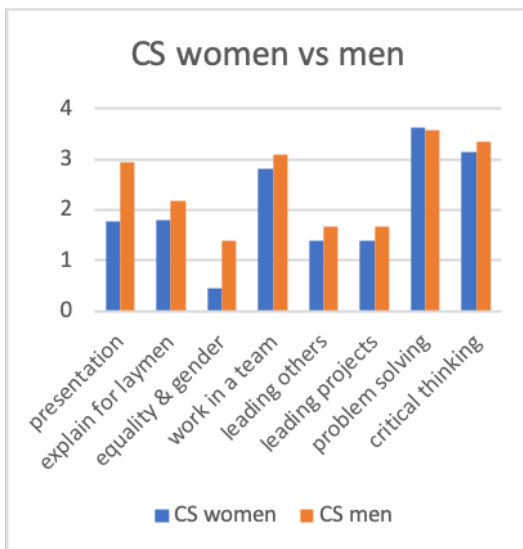

Fig. 7. Averages for assessments of education for CS women compared to CS men.

solving problems independently. At CS, the most significant differences between women and men are in the areas of making written and oral presentations, and making judgements with regard to equality and gender, and here CS women rate their education lower than CS men do. Otherwise, the differences between women and men are small.

A closer look at the original data reveals more details. Graduates from CL are in many respects significantly more satisfied than graduates from CS when it comes to pedagogical skills, even in areas where the differences in the overview based on calculated averages may seem small (Fig. 8). In the figure, green represents that the graduates are satisfied with their education, yellow and orange that they are dissatisfied, and red that they have not encountered it in their education. Regarding making written and oral presentations, twice as many of the graduates from CL are very satisfied with the education they have received (33%), compared to CS (16%). This difference is statistically significant. The confidence interval for CL is ±9% and for CS ±4%. With regard to explaining for laymen/non-specialists, 39 percent at CL are very satisfied, but only 7 percent at CS. 19 percent at CS state that they have not received education or training regarding this. Regarding making judgements with regard to equality and gender, at CL, 48 percent are satisfied, 37 percent are dissatisfied, and 16 percent answered "not received". At CS, 29 percent are satisfied, 28 percent are dissatisfied, and 40 percent indicate that they have not received education or training in this area.

Fig. 9 shows original data regarding leadership and teamwork. 45 percent of CL graduates are very satisfied with their education regarding working in a team, compared to 33 percent at CS. Here, the confidence intervals are ±9% and ±6%, respectively. The difference regarding leading others is the most striking. At CL, 14 percent are very satisfied and 54 percent quite satisfied, whereas at CS, the corresponding percentages are 4 percent and 33 percent, respectively, and 29 percent state that they have not received training in this.

Fig. 10 shows original data regarding problem solving and critical thinking. It is obvious that these are areas where the education at KTH is traditionally strong. Regarding solving problems individually, 63 percent of CL graduates are very satisfied, and 32 percent quite satisfied. Data regarding the other responses are not accounted for, as the numbers are low. At CS, the corresponding percentages are 68 percent and 29 percent, adding up to a total of 97 percent that are either very or quite satisfied. The confidence intervals for CL are ±9% and ±8%, respectively, and for CS ±6% and ±6%.

D. General career follow-up at Chalmers

The five LoL respondents to the career follow-up survey at Chalmers consider their level of employability to be exactly the same as the CS students at Chalmers, both groups with a high mean of 9.4 out of 10. Among the LoL respondents, three got their first relevant job before graduating, while two had to wait less than 2 months. These statistics are similar for the CS students, among which 80 percent got their employment before graduating, and the rest had to wait less than 2 months.
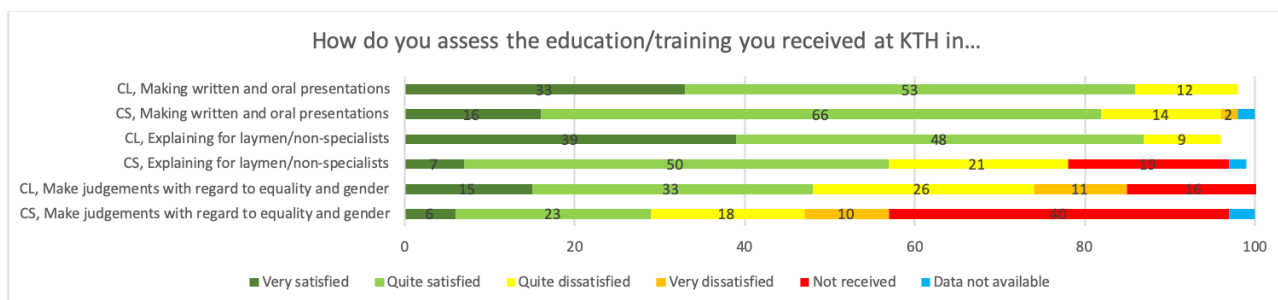

Fig. 8. Comparison of graduates' rating regarding making written and oral presentations, explaining for laymen/non-specialists, and making judgements with regard to equality and gender, respectively.
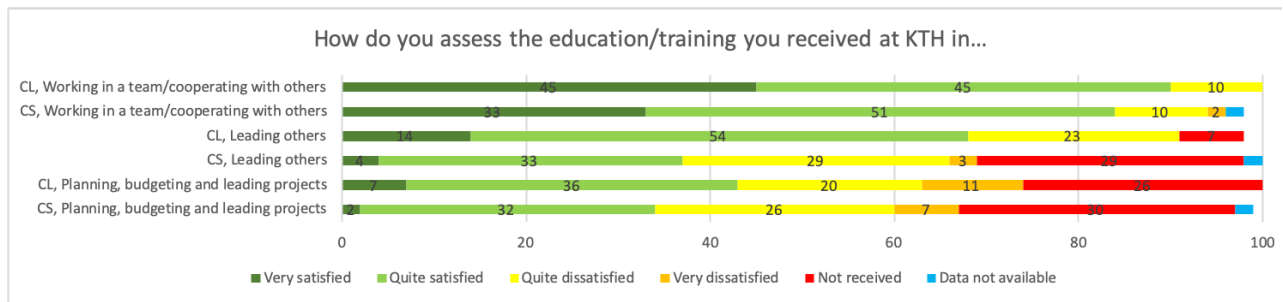
Fig. 9. Comparison of graduates' rating regarding working in a team/cooperating with others, leading others, and planning, budgeting and leading projects, respectively.
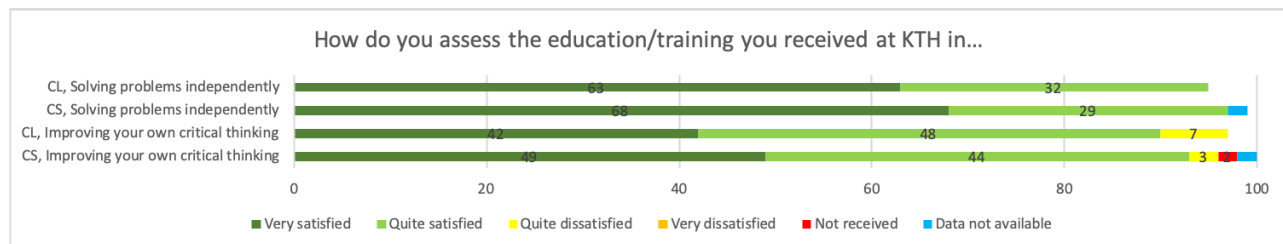

Fig. 10. Comparison of graduates' rating regarding solving problems independently, and improving your own critical thinking, respectively.

Four out of five LoL alumni had two or more jobs to choose between, while among the CS-students, 70 percent had two or more job offers to choose between.

One of the LoL respondents stated that he/she works in IT; all of them stated that they work with education. Among the CS alumni, about 80 percent declared that they work in IT, and more than 90 percent responded that they work with software development.

The questionnaire asked what in the education at Chalmers was important for getting the first relevant job. About 90 percent of the CS alumni chose the option "my specialization". The most common option of the LoL alumni was instead "my combination of specializations", chosen by three out of five.

When asked about what was most valuable in their education, the most common reply among the CS alumni was the "theoretical and technical foundation in my main subject" (60%), while among the LoL students the most common reply was "my specialization" (four out of five).

In the questionnaire, there was a question set about abilities acquired during the education. There are no big differences in the replies between the LoL and the CS students. For the ability "oral and written communication" the LoL alumni only rated themselves marginally better than the CS alumni with a mean of 8.8 out of 10 compared to 8.0 for CS alumni. On the question about "create new technical solutions", the CS alumni rated themselves as 8.7, which is a bit higher than the LoL students with a mean of 7.4.

E. *Programme survey at reference programme CS at KTH*

To supplement the data from the career follow-up survey regarding the reference programme CS from KTH, we use data from a mandatory programme survey, answered by the students in May 2019, at the end of their fifth and final year. In this survey, we asked the students to assess to which extent they had been able to practice different group working skills

within the programme (not at all, somewhat, quite a lot). We also asked which group working skills should be practiced more in the programme. Some of these skills are related to leadership. In Table III, the results are presented. The first column shows the percentage of the students who answered either not at all or somewhat. The second column shows, for the students who would like some skills to be practiced more, which skills should be practiced more. The skills are sorted with respect to the rightmost column. The skills that are closest related to leadership are bold-faced. We observe that the group working skills that the CS students lack most are mainly leadership skills.

In the 2016 survey, the students were asked to give a suggestion for improving the programme. One of the students

TABLE III. GROUP WORKING SKILLS AT CS

Group working skill	Experience that the skill has *not* been practiced a lot	Think that the skill should be practiced more in CS
to handle differences in opinions	55%	42%
to give constructive feedback	46%	42%
to split tasks within the group	37%	42%
to receive constructive feedback	48%	36%
to build on others' ideas	52%	33%
to coach and motivate others	64%	30%
to show leadership ability	52%	30%
to see strengths among the other group members	55%	24%
to get insights on your own strengths and limits	42%	24%
to work efficiently with people of different background	50%	21%
to cooperate and contribute to the results of the group	30%	18%
to carry out agreed tasks	29%	18%

suggested *Teach more soft values such as leadership and work ethics.*

V. Discussion and Conclusion

For many reasons, it is difficult to compare data from different study programmes. Many of our data monitor satisfaction. There are two ingredients in this: student expectations, and what is delivered in the study programmes. We believe that student expectations regarding leadership and pedagogical skills are significantly higher among graduates from CL/LoL than among graduates from CS. The fact that students from CL still are more satisfied with their education indicates that the differences in what is delivered in the programmes, and differences in the acquired skills among graduates from the two programmes, are larger than the statistics regarding satisfaction indicate.

It is expected that all graduates see advantages with their education. They have probably chosen the study programme due to personal interest and skills in the area [10], and during the education, they have developed these skills further. They are likely to look for opportunities at the job market where they can use these skills. Thus, graduates are likely to be in a context where they experience the advantages.

Different interpretations are possible regarding many data in the surveys. Respondents may interpret questions differently. Graduates from CL as well as CS rate their education very high with regard to problem solving and critical thinking. However, problem solving and critical thinking may have different meanings at CL and CS. At CL, it may be interpreted in a subject-specific or a pedagogical context, regarding e.g. a pedagogical challenge.

During their education, students of the combined programme receive substantial training in social interaction and pedagogy. For example, the CL alumni responding to the career survey had taken the course Identity Formation and Socialization which included gender aspects, while the CS alumni did not have gender aspects in any of their courses at the time. In 2015, teaching regarding minorities and equality was introduced in the Programme Integrating Course at CS [12], but the respondents in the general career follow-up have not participated in this. In Fig. 8, we can see that there is indeed a difference between the programmes in the answers to the question on how to assess the education/training they received in making judgements with regard to equality and gender. In fact, 40 percent of the CS alumni denied that they had received any education/training in this subject, while the corresponding number for CL alumni was 16 percent. Still, 16 percent is remarkably high considering the fact that this is part of the CL curriculum.

In computer science education, there are often few women, whereas the combined programmes display rather even balance. In Fig. 6 and Fig. 7, we can compare the answers to the above question split by sex. Interestingly, the men from CL and CS have approximately the same mean value, while there is a significant difference between the mean values for the women: 2.3 for CL and 0.4 for CS, which means that a majority of the women at CS (correctly) indicate that education/training in gender perspective has been missing. A possible explanation for this could be that women are more aware of gender aspects and therefore remember whether this was included (for CL) or not (for CS) in the curriculum, while men are less likely to notice this. It is not clear if those who

state that they have not received training in this would have liked to have it.

The data in all five questionnaires used in this study indicate that all three groups of alumni, CL, LoL and CS, easily find employment in relevant positions in industry, a majority even before graduating. This has been a well-known fact for CS students. That alumni from the innovative and less technical CL and LoL programmes have an almost equally successful path into the job market has not previously been recorded.

Still, some CL and LoL alumni express that they believe that they are disadvantaged on the job market, not least for lacking certain technical skills. However, as expressed by most CL and LoL alumni, there are also advantages with having additional competences and unique skills related to pedagogy and especially leadership. Having a CL or LoL background can hence be a hindrance to getting some technically oriented jobs, but opens other opportunities for engineering jobs where interpersonal skills, leadership, and pedagogy is of value.

In this study, we have found that the CL and LoL alumni find relevant jobs as engineers as easily as the very attractive regular CS students. We have also found that these dual degree programs contribute with a type of leadership and pedagogically skilled engineer that there is a high demand for, as a complement to the technically more skilled CS alumni. Many CS students consider leadership to be an area where they get little practice in their education, and they would like to have more.

References

[1] E. F. Crawley, J. Malmqvist, W. A. Lucas, and D. B. Brodeur, "The CDIO syllabus v2.0. An updated statement of goals for engineering education," Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June 20–23, 2011.

[2] SEFI Position Paper on Engineering Skills – Developing Graduate Engineering Skills, April 2016. Editors: M. Murphy, K. Hawwash, M. Vigild. X. Fouger. Retrieved April 8, 2020: https://www.sefi.be/publication/position-paper-on-engineering-skills/

[3] M. Exter, S. Caskurlu, and T. Fernandez., "Comparing Computing Professionals' Perceptions of Importance of Skills and Knowledge on the Job and Coverage in Undergraduate Experiences." ACM Trans. Comput. Educ. 18(4): Article 21, 2018.

[4] Civilingenjör och lärare 300 hp. Retrieved April 8, 2020: https://www.kth.se/utbildning/civilingenjor/civing-larare/utbildningsbeskrivning-1.4108

[5] Lärande och ledarskap. Retrieved April 8, 2020: http://www.chalmers.se/sv/utbildning/masterprogram/sidor/larande-och-ledarskap.aspx

[6] M. Cronhjort and L. Geschwind, "Double degree programmes in engineering and education - two cases from Swedish technical universities", in Technical universities: past, present and future, L. Geschwind, A. Broström, & K. Larsen, Eds. Higher Education Dynamics, Springer, in press.

[7] Universitetskanslersämbetet, "Utvärderingen av ämneslärarutbildningar är klar", February 19, 2020. Retrieved: https://www.uka.se/om-

oss/aktuellt/nyheter/2020-02-19-utvarderingen-av-amneslararutbildningarna-klar.html

[8] The Joint Task Force on Computing Curricula, "Computer Science Curricula 2013, Curriculum Guidelines for Undergraduate Degree Programs in Computer Science", Association for Computing Machinery (ACM) & IEEE Computer Society, 2013.

[9] M. Cronhjort, L. Naeslund, and S. Nyberg, "Double degrees: Hits and pits for the careers", in INTED2017 Proceedings, Valencia, March 6-8, 2017, pp 4302-4309. DOI: 10.21125/inted.2017.1026

[10] M. Cronhjort, "Motives for choosing a double degree programme. A case study in engineering and education", in INTED2017 Proceedings, Valencia, March 6-8, 2017, pp 4267-4271. DOI: 10.21125/inted.2017.1020

[11] Datateknik, civilingenjör 300 hp. Retrieved April 8, 2020: https://www.kth.se/utbildning/civilingenjor/datateknik/utbildningsbeskrivning-1.4116

[12] V. Kann, "Programme integrating courses making engineering students reflect". Theorizing STEM Education in the 21st Century, IntechOpen 2019. DOI: 10.5772/intechopen.88253 https://www.intechopen.com/online-first/programme-integrating-courses-making-engineering-students-reflect