

Recruiting new groups of students to teacher-training in science and mathematics – experiences from a new combined teacher-training and engineering programme

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This paper reports on experiences from a new combined engineering and teacher-training programme, run by The Royal Institute of Technology (KTH) and The Stockholm Institute of Education (LHS) in cooperation. We give a brief description of the structure of the programme, where integration of subject matter, didactics and engineering skills is a key concept. We describe the profile and the expectations of the student group; it seems that this programme to a very large extent has attracted students that do have a wish to work as teachers in science and mathematics, but would have gone for a traditional engineering education in the absence of this new opportunity.

In Sweden, as in many other countries, the falling interest for mathematics, science and technology among young people is a problem to the society, particularly to the educational sector. Recruitment to teacher-training programmes and university courses in these subjects as well as to engineering educations are weaker than one would wish. This is highlighted in a recent Swedish official report (SOU 2004:97). Within the next ten years large groups of today's teachers will have retired, and there is thus a need to increase recruitment to teacher-training. In an investigation by the Swedish National Agency for Higher Education one finds that only 14 % of prospective upper secondary school teachers choose to specialize in mathematics and science, in contrast with an estimated need of approximately 33% (Högskoleverket 2004).

In 2002 the Swedish government commissioned The Royal Institute of Technology (KTH) and The Stockholm Institute of Education (LHS) to jointly develop new ways to educate prospective teachers in mathematics, science and technology. As a result of this, a new combined engineering and teacher-training programme, the so-called CL-programme (from the Swedish name *Civilingenjör & Lärare*, Engineer & Teacher) opened the academic year 2002-2003. A main purpose of this programme is to recruit new groups of students to teacher-training in mathematics, science and technology.

Purpose of the Program

The programme finds its identity in the intersection of pedagogical and engineering competences. Here are a few key points:

- Mathematics is combined with one more subject: chemistry, physics or computer science.
- The programme is for five full years, leading to a double diploma, in engineering and teaching.
- The international name of the diploma is *Master of Science in Engineering and of Education, Degree Programme in Mathematics and Physics* (or *Mathematics and Chemistry* or *Mathematics and Computer Science and Information Technology*).

- Didactics, pedagogy and practical training are integrated in the programme from day one.
- The programme is designed as a whole, rather than as separate blocks of subject matter, pedagogy and didactics each moulded in a different department.
- Practical training involves training in upper secondary schools and also in science centres.
- A large part of the courses are developed especially for this programme; in particular this is true for the courses in mathematics and mathematics education.
- The students follow courses for traditional engineering programmes in physics and engineering physics, chemistry and chemical engineering or computer science and information technology, depending on their choice of second subject.
- The master thesis should be in the area Technology and Learning, combining science with technological and pedagogical issues. The thesis work should relate to practical experiences in some kind of a pedagogical environment, for example an upper secondary school or a science centre.
- As engineers the students should, after finishing their studies, have a solid and broad basic competence in their field with an edge in technology and learning, thus being particularly well trained for in-house education and technical customer support as well as development tasks in knowledge industry. Technology is today developing with an increasing speed, and there is a great need for engineers with abilities in teaching and learning. This conclusion is supported by a report from the Royal Swedish Academy of Engineering Sciences, where for example skills in communication are pointed out as an example of new competences needed for the engineers of tomorrow (Kungl. Ingenjörsvetenskapsakademien 2004)
- As teachers in upper secondary school their special profile should be a broad understanding of the subject matter, special skills in problem solving and good knowledge of applied science, resulting in a good ability to make the subjects come alive. They should also be a good resource in course development. One important point is that they hopefully will come to play a prominent role in inspiring more students in upper secondary school to engage in academic studies in mathematics, technology and science, and to serve as link between upper secondary school and engineering studies.

It should be noted that, at least in Sweden, there has always been a flow back and forth between the engineer category and math/science-teacher category. The CL-programme wants to educate for this double identity right from the start.

A Short Description of the Programme

As mentioned above, the programme is for five full years. This is slightly more than for conventional engineering programmes or teacher-training programmes, which run for four and half year.

We now give a short description of the programme. We will refer to the Swedish credit point system, in which 40 credits correspond to one full year of studies. The CL-programme thus consists of a total of 200 credits. In Table 1 we list approximate portions of the different subjects.

Table 1
Overview of the Curriculum in the CL-Program

Subjects	Credits
Pedagogy, psychology, sociology and general didactics	30
Mathematics (including 10 credits of subject didactics)	60
Physics and engineering physics/Chemistry and chemical engineering/Computer Science and ICT (including 10 credits of subject didactics)	60
Interdisciplinary courses	20
Optional courses	10
Thesis	20

Note. The credits stated are approximate, and refer to the Swedish credit point system where 40 credits correspond to one full academic year of studies.

Please note the following.

- According to Swedish regulations, all teacher-training programmes should contain a common core of 30 credits corresponding to the first line in Table 1.
- A teacher-training programme should also contain 30 credits of interdisciplinary courses, in order to prepare the teachers for interdisciplinary cooperation. In the CL-programme there are 20 credits of courses in this category, for example *Engineering Science* that looks at the engineering profession from different perspectives, and *Communication and Media*. The thesis, as described above, is also of an interdisciplinary nature. This makes up for 10 more credits in this category.
- A total of 20 credits of subject didactics are included in the subject matter.
- At least 30 credits should be directly related to studies and practical work in school. In the CL-programme this means a number of shorter periods of 1-2 weeks of field studies and initial practical teacher-training during the first four years of the program, and a longer period of approximately 8 weeks of practical training during the fifth year, which also should contain the thesis work with further field studies and/or practical training.

Teacher-training specific courses are integrated in the programme from day one. The first year is common to all students, with mathematics, pedagogy, interdisciplinary courses, computer programming and practical training in upper secondary school and on a science centre. Years 2 – 4 follow the same pattern, with the addition of the second main subject (physics, chemistry or computer science and ICT). The last year, as described above, is mainly devoted to practical training and thesis work.

There is a definite ambition to work across the department and institution lines. For example, during the first year there is collaboration on a task in the didactics of mathematics between the math department at KTH and an introductory course in pedagogy given at LHS. In another project, teachers from KTH and LHS work together with the supervising teachers, from the upper secondary schools where students do their practical training, developing assignments for practical training. Tasks in subject didactics may also

be integrated into courses in general pedagogy and didactics. Furthermore we support and encourage pedagogical enhancements of standard engineering course compulsory to the CL-students; this could for example mean activities to enhance abilities in oral and written communication.

Mathematics courses

Mathematics is a common subject for all students on the program, and the courses in mathematics are developed especially for this programme. Compared to standard engineering math courses on KTH, there is an additional emphasis on ability in written and oral communication and on the use of technology, and there are also didactic tasks integrated in the curriculum. Here follows a brief list of compulsory courses in mathematics.

- Mathematics 1. Precalculus, linear algebra and single variable calculus. (8 credits)
- Mathematics 2. Linear algebra and calculus in several variables. (8 credits)
- Differential Equations and Transforms. (4 credits)
- Programming. (4 credits)
- Numerical methods. (4 credits)
- Discrete mathematics. (5 credits)
- Probability and mathematical statistics. (4 credits)
- Mathematics for teachers. On different number systems and their properties. Concepts from real and complex analysis. Geometry. (5 credits)
- Mathematics for physics/chemistry/computer science. (4 credits)
- The history of mathematics. (5 credits)
- Didactics of mathematics. (10 credits)

In addition to this there is of course a fair amount of applied mathematics, problem solving and modelling in standard engineering courses in the programme.

Further information on the CL-programme as well as other engineering programmes at KTH can be found on the website <http://www.kth.se>.

The students and their background, expectations and motivations

Nominally there are 60 places in the programme each year. The first year attracted only approximately 35 students, but the second year 67 new students were accepted. This should be compared to the fact that recruitment to Swedish teacher-training programmes in science has been poor for the last years. During the last three years, the CL-programme has attracted more students to upper secondary teacher training in chemistry than all other Swedish teacher training programmes taken together, when comparing the subjects chosen by new students. Please note that Swedish upper secondary teacher trainees normally take two main subjects, and that the choice of the second subject often is made once you have entered the programme, so this figures must be interpreted with caution. There are similar but less extreme figures for physics, while statistics for computer science is still under investigation. Math-teacher programmes usually do better in recruiting in most teacher training facilities.

There is approximately the same number of male and female students. Most students are young, 86% of those who started their studies in 2003 were then under 25 years of age.

We have surveyed the student's background, expectations and motivations. The result can be summarized as follows.

- Most of the students would have chosen a traditional engineering education, in absence of the CL option. In a web survey 23 of the approximately 60 students who entered the programme 2003 answered questions on which other educations they had applied for. It turned out that 18 of them had a traditional engineering education as second alternative, while only 1 of them had a teacher-training programme as a second option. Results for student who entered 2002 are similar.
- Most of students express commitment to teaching. In the same survey, they answered the question of what was their main reason for applying to the programme. Out of 23 answers, 19 declared that they were motivated by the combination of an engineering- and a teacher-education, 3 of them were mainly motivated by the engineering aspect and 1 by the teacher-training aspect. Once again we found similar interests in the group who entered the programme in 2002.

Although the percentage of answers to this survey was low, it does seem to indicate that the CL-programme indeed have succeeded in recruiting new groups of students to engage in a math/science teacher-training and that most, or at least many, of them expect a professional life where teaching is a large component. An ongoing extensive study of all entering students preferences in their applications for university seems to confirm the picture that the programme has to a large extent attracted students who would have chosen an engineering programme rather than a teacher training programme in absence of the CL-option.

Recent development, dropouts and future plans

In September 2004, 57 new students entered the programme.

Of the approximately 35 students who entered the programme in 2002, 24 remain in the programme two and half years later. Most of those who left did so during the first year. Among those 67 students who entered in 2003, 41 were still following the programme in 2004. In other words, we have had a dropout rate of approximately 1/3 during the first year. This is substantially more than for other engineering educations at KTH, typically 20-25% of students change programmes or abort their studies during the first year. We have performed an analysis of those who entered 2003.

- 26 students among the 67 admitted 2003 had left the programme one year later.
- Among those 26, 8 left almost immediately, and 4 more kept their places for a possible re-entrance later on. This leaves us with 14 students who started studying on the programme, but decided to leave during the first year. Interviews with this group reveals different reasons, but the following were recurrent answers: (i) personal reasons or change of interests, (ii) those who found the programme too focused on teacher training (iii) uncertainty about the professional status of the programmes engineering identity.

Being a new programme, educating towards a new type of engineer who is an expert in communication, teaching and learning within his/her field, reasons (ii) and (iii) are perhaps not unexpected. Students tend to compare with established engineering programmes in search for their identity, and since they know that for example KTH's programme in Engineering Physics is well-established and with high professional status, they may feel insecure when they realize that they will not achieve the same level of expertise in

engineering physics and feel reluctant to trust that their special competence in technology and learning will have the same value on the market.

This indicates that the content and the profile of the programme need to be better communicated when recruiting new students.

A major revision of the programme has been carried out during 2004, affecting the structure rather than the content.

Previously the first semester contained a first course in mathematics, which was not well adjusted to some of students background in mathematics, and a course in pedagogy, which was experienced as being too abstract and having too much focus on the development of younger children.

One aim of the revision is to make the first year more accessible, and to strengthen the students' identity as prospective teachers *and* engineers. To achieve this, the first semester now includes two introductory courses to the engineering profession and teaching profession respectively. We have also strengthened the first math course with 2 credits to get a smoother transition from upper secondary math. In parallel they study didactics of mathematics with integrated practical training; many students express the need for early practical experiences of teaching.

We also build on experiences from the first years in order to make school practise integrate in the programme in a better way. The logistics of synchronizing schedules for two university institutions, involving a number of different programmes, and also make adequate space for practical training has been extremely complicated. In the new structure we have special periods where practical training is abundant, and during these periods students do not take courses that have to be synchronised with other programmes.

Similar initiatives

A similar combined education programme exists at NTNU, the technical university in Trondheim, Norway. Partly inspired by the work at KTH and LHS, their programme opened the academic year 2003-2004. There is already a cooperation developing between KTH-LHS in Stockholm and NTNU in Trondheim. At Mälardalen University in Eskilstuna, Sweden, a combined engineering and teacher-training programme started in 2004, leading to an upper secondary teachers degree in technology.

At present we are not aware of any other similar programmes, neither in Sweden, nor abroad.

Conclusion

A combined engineering and teacher-training programme in Stockholm, run jointly by The Royal Institute of Technology (KTH) and The Stockholm Institute of Education (LHS), has been briefly described. Experiences from the first two years point to that this programme does well in recruiting new groups of students to teacher training. It has become clear that it is very important to communicate the goals of this new programme as clearly as possible to prospective students, in order not to give inadequate expectations, and to structure the programme in such a way that students double identity as engineers and teachers is strengthened. A positive side effect of this initiative has been the stimulating and challenging meeting between two academic worlds, the engineering culture at KTH and teacher-training culture at LHS.

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