Application

Centre of Excellence in Higher Education Award 2009

The Undergraduate Education at

KTH School of Computer Science and Communication

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Introduction

KTH School of Computer Science and Communication (CSC) runs undergraduate education (here we use this term for the first and second cycles), graduate education (third cycle) and research in scientific computing, computer science, media technology, human-computer interaction, speech technology, musical acoustics and language at KTH and Stockholm University. CSC bears the main responsibility for the two Master of Science in Engineering programs (300 ECTS credits): Computer Science and Engineering (the D program, from 1983) and Media Technology (from 1999). In addition, the school is responsible for three international Masters-level programs and several specializations in our disciplines.

The school teaches programming and numerical methods on all Master of Science in Engineering programs. This means that courses have to be adjusted to different target groups, ranging from students who will specialize in the subject to students who only take a single course in the subject. The language group of the school gives optional courses in foreign languages for all programs and in Swedish for exchange and masters students.

Our teaching strategy is geared towards active student learning, and the teaching and examination methods used in our courses are designed to promote learning mainly through the students' own active participation. These methods are constantly being reviewed, as is the pedagogy we are able and willing to use, and the infrastructure of undergraduate education.
The last few years have seen continuous changes in our teaching and forms of assessment to adjust to the financial constraints while maintaining high quality. After a seminar on "Pedagogy and Finance" in our pedagogical seminar series, we have implemented several changes resulting in considerable financial savings without noticeably lowering, and in some cases even raising, the quality. Lectures in large groups provide an effective foundation, and computer rooms offer individual instruction and examination as well as self-study outside scheduled class time. Many students appreciate this kind of combined learning and examination, to which the department accords a high priority, especially in the basic courses. Some courses include more comprehensive projects, in which students from different degree programs participate.
We will continue to concentrate on and develop alternative forms of teaching in which the students work and seek knowledge in many different ways. We have also drawn up a Code of Honor and Examination Regulations. This underlines the interest of both teachers and students in fostering an atmosphere of openness characterized by confidence and mutual trust, where everyone contributes to a positive academic spirit in the search for knowledge. It allows us to concentrate on pedagogical issues, using the available time to monitor and develop knowledge and skills, rather than checking on cheating.

Quality assurance and development system

CSC has high ambitions for its programs and carries out wide-ranging quality management on many different levels, which is naturally divided into *quality management of programs* and *quality management of courses*.

In the Computer Science program educational reforms have been implemented approximately every four years. The reforms typically move some courses, substitute some and change some. The reforms are characterized by extremely good student participation, resulting in strongly supported changes that have consequently worked very well. One example of a quality-driving course in the Media Technology degree program is the Program Integrating course, which stretches over three years. The course includes the following features:

1. It ties the whole program together and spreads (out) experience over the three years.
2. After each half-term, comments and views are gathered from all students, from the whole program and not only those who fill out the course evaluations.
3. The most important views are compiled and submitted to the program management.
4. The course provides the Media Technology faculty with excellent insight into the whole educational program.

The quality assurance and quality development work at program level also include:

- "Midway" questionnaires (distributed halfway through the program) and degree questionnaires analyzed annually.
- Board and management group meetings with student representatives, the students' permanent item on the agenda, and a close dialog with the Dean.
- The Undergraduate education advisory group with representatives of our undergraduates, other Schools, and the students' permanent item on the agenda.
- Regular meetings between program management and the student representatives responsible for the program.
- Coordinating faculty meetings (link meetings) every semester.
- Yearly program faculty meeting for all of the program's students and teachers.
- Education management meetings every week to identify and deal with emergency matters and setting the agenda for the Undergraduate education advisory group and the Director of studies group.
- Off-campus conference with freshman students and student administration every year.

Continuous and step-by-step improvement grounded in course analyses

The mainstay of the work of the school regarding course improvement is the course analysis, carried out for every course. This includes: facts about the course, such as number of students, number of teaching hours, course literature, number of students who passed the various parts of the course, performance rate and pass rate; what changes have been made since the previous time the course was run; an account of what worked well and less well during the course; questions and answers from the student questionnaire; and a discussion about desirable changes for the next time the course is offered. The course leader is responsible for the course evaluation and analysis based on the course questionnaire in which the students' opinions are collected. The

course analyses are then discussed by a group of teachers together with the professor responsible for the academic subject. All course analyses are compiled annually and posted on the web. At the annual staffing meeting the course analysis is the basis for planning the development for the next year. The Director of Studies and the course leader discuss the course development and agree on time frames and outlines for the work. The following year the teacher carries out the course development. When the next course begins, the students are informed about the main points of the course analysis and how the course has been developed since the previous year. In this way all courses are improved each year.
This modified Kaizen development resulted in praise from the Swedish National Agency for Higher Education in 2006 (Rapport 2006:8, pp120).
CSC also has a group that identifies shortcomings in administrative processes and corrects these (the AHA-group). Their latest work includes the scheduling process for the courses and a new system for reporting of results.

Quality of infrastructure

The School has a computer support group responsible for operation of computers and servers, both for personnel and students. We strive to offer computers to every student for three different platforms (Unix, Mac, and Windows), which requires very broad expertise from our computer support group. The computer support group co-operates with both students and teachers in two groups, one for long-term computer use and one for short-term use. The computer support group has its own quality assurance system, process descriptions and information systems, which are not further described in this report.

Tuition at the School takes place not only in computer rooms but also in lecture theatres, classrooms and seminar rooms. Over the last year, a special group of teachers has compiled an overview of all teaching premises, seminar rooms and reading facilities in the vicinity of the School, documented the functions, features and potential of each individual room, and noted what does not work. This has been recorded in a special form which we developed after having listed what different types of teaching would be possible or appropriate for these premises. The group has rectified minor faults and forwarded more serious ones to the appropriate people. Next, the group will monitor the lecture rooms and ensure that the School's own premises (seminar rooms) are effectively designed and furnished to suit the demands of the activities. The group is also discussing with KTH centrally how the teaching premises should be equipped.

Organization and competence

The School has chosen to keep the educational organization centralized. One important reason is to guarantee high quality through a planned development and uniform follow-up of all education. Other reasons are efficient administration and use of resources, not least teaching resources.

Much of the management work is done in the annual staffing meetings between the Director of Studies for each subject and individual teachers. Since all teaching is planned in advance, each teacher knows by the end of the spring

(final) semester what to expect during the coming academic year. Included in this planning are time and a plan for the teachers' own development. School-related duties such as responsibility for undergraduate education or programs, and acting as Director of Studies are included as part of the time plan.

Support from KTH

KTH's educational organization is decentralized. This means that the Schools at KTH have a great deal of freedom to shape their own education and organization. This freedom is a very valuable component in the task of developing first-class education through a continuous process.

Our long-standing interest in pedagogical development stems from the nineteen-seventies, based on initiatives by KTH, and our commitment to quality follow-up is from the nineteen-nineties. We have been allowed to further refine and form our own models and have become regarded as worthy of imitation and as forcing the pace of change. Both the KTH Executive and KTH students have shown their appreciation on many occasions through awards to several of the School's teachers (See below). We enjoy strong support from and cooperation with KTH Learning Lab, which offers courses for teachers and PhD students in teaching and learning for higher education. We frequently exchange ideas and give guest lectures for each other several times a year.

Excellence in leadership and teaching

The School regards undergraduate education as its principal mission and has a long tradition of appointing both leaders and teachers according to their excellence rather than their title. To prepare important issues, the School Board has appointed an undergraduate education advisory group for overarching educational questions at basic level and at advanced level The Head of the School, also known as the Dean, has appointed a staff member to be responsible for undergraduate education (GA) and a Chief Director of Studies with operational responsibility. Each program has a Program Coordinator (PA), a professor with program responsibility. The undergraduate education group is composed of the GA, two PAs, four teachers (two of whom are from other Schools with which we have close cooperation), and two students. The Chief Director of Studies has appointed subject Directors of Studies for the School's six subject areas. The subject Directors of Studies deal with the staffing of courses and have overarching responsibility for course quality.

Dean Ingrid Melinder is an established leader with many years of commitment to the development of the School. In 2008, she was awarded the Janne Carlsson Scholarship for Academic Leadership. The Chief Director of Studies, Professor Viggo Kann, won a STINT scholarship to Amherst College in 2006. Olle Bälter, responsible for undergraduate education (GA), who has won numerous awards for teaching, won a STINT scholarship to Williams College in 2008. Their experiences have rapidly influenced the activities of the School. The Directors of Studies hold their positions for long periods, usually a minimum of five years, and those responsible for programs often stay for at least ten years, which ensures continuity. The teachers with course leader duties virtually always hold permanent positions. Ninety per cent of them have research

training (eighty per cent, if the language Unit is included). Seventy per cent of the teachers have a formal qualification in teaching and learning in higher education (half of the teachers without teacher training are professors with little teaching). The breadth and depth of the academic subjects at the School is considerable. When recruiting, we strive after faculty that excels both in the subject and in teaching. When appointing an associate professor, we consult a special pedagogical expert teacher.

Recognizing and rewarding excellence in teaching

Through course analyses and cooperation, the Directors of Studies know which teachers have particularly excelled, and this is taken into account in salary talks and staffing. Moreover, the School annually awards three prizes to deserving personnel: The Green Dragon of Enlightenment, for meritorious achievements as a Teaching Assistant; The Creative Tie, awarded to a teacher for meritorious and inspirational work; and the Crystal Bear for meritorious achievements. To date, 19 prizes have been awarded. The names of the prizewinners and the motivation for the awards are posted on the School website.

Professional development of staff

The School encourages teachers to participate in various pedagogical and leadership courses arranged by KTH or other universities. A key component of the School's staffing strategy is planning time for individual development of competence, both subject-related and pedagogical: 20% for associate professors and 15% for lecturers. We are now investigating whether we can introduce a system of longer, continuous periods for individual development (sabbaticals). The School organizes its own pedagogical seminars and off-campus teacher seminars, and defrays the cost of journal subscriptions, book purchases and course fees.

International activities and exchanges

Most of the teaching staff are active in research and take part in the international research community on a regular basis.

CSC has been awarded more scholarships than any other Swedish higher education department in the STINT exchange program "Excellence in teaching". So far, six of our teachers have won scholarships or been accompanying partner, and have guest lectured for a semester (Viggo and Linda Kann visited Amherst college in 2006, Olle Bälter visited Williams college in 2008, Ninni Carlsund Levin will visit Amherst in 2009, and Örjan Ekeberg and Ann Bengtson will go to Vassar college in 2009). In April 2009 we will organize the ACM programming world contest with 100 participating teams from all over the world. We also take part in a European project, EduJudge, developing and testing an automatic programming assignment corrector. The other countries involved in this project are Spain, Portugal and Lithuania.

Five teachers of Media Technology have taken part in an exchange sojourn with Beijing University, China, as part of the Linnaeus-Palme Program, and the incoming teachers have been guest lecturers in various courses at the School.

The School offers three Master's programs given in English, one of which

started as early as 1997 (Scientific Computing). Most of the participants in these three programs are foreign students. For practical and financial reasons, the courses given to the Master's students are also attended by Swedish Master's students studying their major. The tuition in the Masters programs is in English, but all Master's students are offered courses in Swedish given by the School's language teachers.

Scientific Computing is also a double degree Master's program run jointly with Erlangen University. The Numerical Analysis group is crucially involved in the creation of a new Master's program at the Tashkent Automotive Road Institute, Uzbekistan. Five teachers have held compact courses in Tashkent. Some have had teacher exchanges with the universities in Erlangen and Freiburg.

Students attending the course in Cooperative IT compete in project groups. Since 1993, the winning group has been allowed to present their project in design competitions or at conferences. During the 1990s, this was mainly at Apple (where our group won in 1993) and then 2003 in Siena, Italy.

Comparison with similar environments

The Media Technology degree program maintains a continuously high applicant per place ratio; over the last eight years, it has been on average twice that of the corresponding program at Linköping University, and the number of first choice applicants is 30% higher than in Linkoping. In addition, the demand from industry for graduated Master of Science-level engineers from the program is high, and virtually all graduated students have quickly found positions. A further indication of the quality of the education is the fact that, when a Master of Science-level degree program in Media Technology was established in Norway in 2001, KTH was commissioned to plan the program and over a period of five years to act as inspector of the program's academic quality. The Program Coordinator has also been asked to assess new Media Technology programs in Croatia and Slovenia.

The educational environment of the Computer Science program (D program) is regarded as outstanding by students and employers alike, which is confirmed by the fact that the student body contains many first choice applicants and many younger siblings of senior students, and that the students easily find projects in industry for their final degree reports. Students often comment on the quality of neighboring schools in Stockholm and abroad in terms favorable to us. The D program at KTH has the highest applicant per place ratio of all the Computer Science programs in Sweden.

The Computer Science program regularly ranked first among Sweden's graduate engineer programs with respect to educational quality and teacher competence. During recent years, however, Industrial Economics has increased in popularity (See e.g., *Ny Teknik* 17, April 2007: http://www.nyteknik.se/nyheter/karriarartiklar/article43511.ece, where the Computer Science program is ranked first among Sweden's graduate engineering education programs, except for Industrial Economics) The program management's response to this has been to define two majors in Industrial Economics and Project Management for Industrial IT Systems.

We have been included in several Swedish Agency for Higher Education (HSV) subject assessments and program assessments and received good reviews. Criticism from the evaluation team has been carefully noted and appropriate measures taken.
(http://www.hsv.se/download/18.539a949110f3d5914ec800089006/0113R.pdf#search='datavetenskap')

Links between research and undergraduate education

In 2008, research at KTH was evaluated by international experts, and the School's research groups received very good grades, from "high international standard" to "world leading". The School's researchers, including the professors, participate to a great extent in the undergraduate education. Five professors work at least 50% of their time on undergraduate education and two of them teach second- and third-year students. The curriculum and course contents keep abreast of developments in the field and in pedagogy. The School's teachers are involved in several pedagogic projects and follow the international literature on subject-based teaching and learning.

The staffing plans allow for time to improve every course and considerably more time to develop new or fundamentally reworked courses. We have initiated whole Master's programs in fields where both our own research and the development of the subject area are strong: Computational and Systems Biology started in 2008, and we are applying to start Computational Learning in 2010. Since devising a new course is a lengthy process, and setting up a new program an even lengthier one, most of the research integration takes place in existing courses. We have set up courses called "*Advanced Individual Course in X*" for each of our subjects *X*. These courses are utilized partly to allow students to conduct research-like projects and partly to enable a researcher to offer a specially designed course at short notice within a highly topical area.

The interplay between research and teaching/learning is complex, and it is not automatically the case that the quality of a teacher's performance in the international research community is the same as in the interaction with our students (Swedish or international). There is a wide range of career plans among both students and teachers, and a few students and some more teachers go for world-class research performance. Many students have as first priority employability in industry, and teachers must be able to promote curiosity and independence as well as an understanding of industrial work practice. Another important ability needed is to develop the students' interest in the curriculum as well as self-confidence and pride where needed. These concerns influence both hiring of teachers and allocation of courses to teachers. The Humboldtian heritage is controversial with many interpretations, but his view of research and education as recreating knowledge by working with topics that are not completely ready and shelved – even if not in the hottest research frontier – is fundamental in all university education.

Research and development projects with students

The courses Software Engineering (mandatory for Computer Science, third year), Content and Expression in Media (mandatory for Media Technology,

fourth year), Cooperative IT Design (mandatory for MDI majors), Software Design-Business-Leadership (mandatory for computer majors in Industrial Economics), Artificial Intelligence and Multi-agent Systems (elective) and Distance Presence Production (elective for Media) are all project-work courses with development projects in large groups in cooperation with industry or research groups at KTH. Every year, over 150 degree projects (30 ECTS) are carried out at the School. These are often executed in industry, but fairly often (15%) as part of research projects at KTH.

Over and above this, it is common for students to carry out research-like projects prior to their degree projects in the above-mentioned courses "Advanced Individual Course in X". In Computer Science, where the need is greatest, there are three such courses of different sizes (6, 9, and 15 ECTS). From spring 2010, all of our third-year students in Computer Engineering and Media Technology will do a Bachelor's project worth 15 ECTS.

Fostering of student learning

Open and welcoming culture

The doors to the School's corridors are open during the day, and many teachers work with their office doors open too, all in order to make the students feel welcome. The computer lab premises are generous (220 computers) to which engineering students have access round the clock.

For 2008 and 2009, we have arranged a Family (Open) Day, a day when the School's classrooms are open to outsiders, when we have special popular science lectures, tours round the campus, coffee with the research groups and a number of amusing features on the program such as the Conjuring Professor, a combined open-air walking and quiz competition and a concert. The students attending our programs and courses are allowed to invite their families and friends, and the general public is also welcome to the Family Day.

Gathering and evaluating the views of students

The students are represented in all the important working groups and deciding groups at the School, such as the Board, the Executive Group, the Undergraduate Education Group, the Planning Group for Computer Matters, teachers meetings before each semester, etc. Every program has a Student Program Coordinator who is in close contact with the Program Coordinator and who takes part in all decisions about changes in the program.

KTH annually sends out questionnaires to all freshmen and students halfway throughout their education. The School has a graduation questionnaire to be filled out when the application to graduate is submitted. Every second year, KTH conducts a career survey of those who graduated 2–3 years earlier.

Every course has a final course evaluation, which is most often carried out in the ACE evaluation system, which we ourselves developed, or in KTH's learning management system Ping Pong. Many teachers also conduct a midcourse evaluation. KTH has begun to gather answers to five specific questions from all KTH courses. The course evaluations are compiled and commented on by the

teacher in the course analysis, which is posted on the course web page and made available to the following year's students (See above).

At CSC, all mandatory program courses are discussed at a so-called link meeting, in which program management, course leaders, student representatives and representatives from the secretariat raise particularly coordination issues in the topical courses. In the Media Technology program, all the students discuss all courses in seminars covering all years of study. These are led by a teacher, and the most important views presented there are forwarded to the program management, which subsequently decides in consultation with the student representatives what measures to take.

The student representatives work actively and the School listens to them carefully. For example, the three most recent audits of the contents of the D program began as student initiatives and were carried out in close cooperation between teachers and students. The Program Coordinator for D is the examiner for approximately 50 degree projects yearly, which means contacts with both senior students and industry (where about 85% of the degree projects are carried out.)

Development of innovative and successful teaching methods

The School's teachers have been using continuous assessment since the nineteen-sixties. There is a strong tradition of experimenting with alternative, formative types of examination rather than relying solely on the written examination, and today, all of the School's courses have some form of alternative examination. Particularly in our basic courses, which are given many times over for many programs, the development of new forms of examination and tuition is very rapid. Evidence of the teachers' purposeful approach to teaching and course development is to be found in the many pedagogical distinctions and prizes that several teachers have received.

A prerequisite for the success of alternative examinations is that the students do not plagiarize. We try to come to grips with this by various means, such as oral examinations for labs and take-home assignments, automatic plagiarism detection of individual lab assignments, and in particular the School's Code of Honor, which we go through with all freshmen at matriculation and which they must all sign. We refer to the Code of Honor in the course descriptions and syllabuses for all our courses, and use it as a guiding principle for the way in which assignments are to be treated. The Code of Honor has subsequently been used by other Schools and universities, as mentioned below.
Several courses have also used different methods to produce and distribute video recordings of lectures as a complement to traditional lectures. These have received consistently good reviews from students, been used in courses at other universities and resulted in prizes and distinction for teaching.

The degree projects

Every year approximately 150 degree projects are carried out at the School. Each project has a supervisor and an examiner, normally two different people. Both take part in the assessment and grading. We have developed subject-specific rules for how the degree project should be conducted. Two years ago,

we developed a system for allocating grades using a grading scale. The degree projects at the School generally maintain high-class standards. Some years ago, the degree project reports from various departments at KTH were compared with each other, and our reports achieved a high ranking in the list. Several degree projects have also won prizes.

International benchmarking

There is no formal benchmarking. In discussions about which route to choose in the D program, the ACM Curriculum Recommendations are consulted, along with colleagues, national and international. Program Coordinators for Computer, IT and Media Technology education in Sweden meet annually (since 1994) to discuss questions they share on content, structure and quality. International comparisons, albeit not yet in the form of formal benchmarking, are made when Program Coordinators and other responsible parties participate in international evaluations of research and education (Denmark, Ireland, Norway, Finland, and Estonia), in which panel members from all over the world take part. These discussions often touch on questions essential to education. At Media Technology, a comparative study has also been made with other similar programs in Sweden, Europe and the United States. This study has formed the basis for the changes being made in the program.

Encouraging students to participate in international exchange

The School encourages exchange students through scholarships, for instance, or information meetings and courses in foreign languages, which the School's own Language Unit offers to the whole of KTH. CSC has set up international majors in the D program: Chinese, Japanese, and European languages. Included in these majors is a sojourn abroad of at least one semester. Of those students who graduated in 2004 and 2005 from Computer Science and Media Technology, 40% had studied abroad.

Student performance and added value

Statistics regarding admissions are drawn up every year. A compilation of examinations and results at course level and program level is readily available from KTH's activity information system (VIS). We have participated in designing a special report in VIS that produces the data needed in a course analysis. We are exerting pressure on the VIS managers to complete an advanced program analysis report in the same system.

A major problem, with respect to the graduation numbers, is that our engineering students are so attractive on the labor market that they are offered jobs even before they have graduated. In 2008, of the graduating computer engineers, 75% already had full-time jobs within their field when they submit their application to graduate and the rest found jobs shortly after. The effect of this is also that undergraduates do not complete their studies. Two of our teachers contact undergraduates who are close to graduation and try to help and encourage them to finish the final remaining assignments and exams.

The 2007 career questionnaire showed that all graduates from both of our

Master of Science in Engineering programs had employment one year after graduating, almost all of them had permanent positions, and a smaller proportion than on other programs were employed by large companies. More than half of the computer engineers were computer consultants. The graduates considered that their education was very relevant to their daily work; this was especially noticeable for Media.

The School aims to give the students much more than knowledge of the field and subject skills. Our educational objectives include ethics, sustainable development, teamwork, and oral and written (communication) skills. A first-year course in communication has been part of the D program since 1995 and in the Media Technology program since it began. We engaged our own Associate Professor in Communication to be able to offer these courses. Our Master's programs include a mandatory course in Scientific Theory and Research Methodology, and several of our new Master's programs must contain yet another humanities course, for example, a foreign language or a course in Culture. Our popular course General Cultural Knowledge provides students with a broad cultural basis and trains their ability to write argumentative articles on cultural topics.

Our aim is also to give particularly gifted and diligent students the opportunity of improvement at a high level. We offer a course in Problem Solving and Programming under Pressure, in which particularly skilled programmers are drilled and given the chance to become even better at quickly writing correct programs. The course also prepares them to take part in programming contests. For many years, the School has had skilled student teams, who have won, among other competitions, the Nordic Collegiate Programming Contest every year since 2003 and reached the final of the World Championship for seven of the last eight years. Twice we hosted the Northern European Championships in Programming, and in April 2009 we will host the World Championships with participants from all over the world – a gigantic event with hundreds of competitors! The programming contest activities also influence the normal activities. The computer judge Kattis, built to automatically judge programs sent in to competitions, has been further developed into an automatic correcting system which is used in several of our ordinary courses. The system improves learning by giving instantaneous feedback free from embarrassment, and by scrutinizing the programs more carefully than a teacher might do. The time for advising may therefore decrease, and the teacher can use the time to improve understanding instead of checking solutions. We have recently employed a PhD student in Computer Science Didactics who will develop Kattis as a pedagogical tool in our regular programs.

Teaching and examination

The types of instruction and examination are specified in the syllabuses. Detailed rules and grading criteria are given in the course description, a document to be found on all courses and handed out during the first class. It is available on the course home page.

At an early stage, the School designed criterion-referenced and formative types

of examination. As early as 2006, the Chief Director of Studies himself defined a pure criterion-related examination for a course, using innovative methods which are also cheap. This was then documented and distributed at HSV's 2007 Quality Conference, at KTH's Development Conference in 2008, at pedagogical seminars at the School, at KTH Learning Lab, and at higher education institutions in Uppsala and Borås, inspiring other teachers to devise similar examinations with written reports, oral presentations and peer correction.

The School has organized seminars for teachers on how to define learning outcomes for courses in accordance with the Bologna and CDIO model, and time has also been set aside in the staffing plans for revising course aims and learning activities in line with the model.

The School generally has criterion-referenced examinations, but their actual form varies greatly from course to course. All courses have measurable goals and a specified aim in the syllabus. Many teachers introduce new types of teaching and examination. An increasing number of courses have more oral examination, and traditional written exams are becoming more and more unusual. During the last year, the traditional written test has been substituted by other types of examination in five courses.

Group size at lectures varies between 10 and 200 students, typically the large groups for basic-level courses and the smaller ones for advanced courses. Much of the tuition is given in the form of practice sessions in groups of 20–30 students. In the computer lab sessions for the first- and second-year students, we provide one supervisor for every 12–15 students. The degree project is carried out individually with one supervisor per student.

Some examples of teaching and examination methods

The Programming Techniques course has a long history, characterized by incremental development. Since the course is given three times each year, the development can be faster than for usual courses. New elements are developed, tested, evaluated and improved continuously. This, together with the fact that the teacher team has high ambitions and consists of both young and experienced teachers who have taught the course for a period of 20 years, has led to refined and adapted teaching and examination as the environment has changed, both with regard to engineering programs and the discipline itself. Furthermore, the course is given in three versions: as a regular course, as a distance course, and as a Problem Learning course.
The most important learning element in the course is the individual programming assignment. As early as the mid-80s we started to develop applied assignments from different areas and of varying difficulty. The assignments have been improved and increased in number through the years. Today there are more than 60 assignments graded by difficulty. Each student in the class works on a different assignment. The student has to write a design outline, inspect a classmate's program, be inspected by a classmate, and present the final version of the program to a teaching assistant for criticism and grading. The programs are also compared to all previous solutions to discourage copying of programs. Our experience with the individual assignment

is very good. Students who have managed to solve the assignment have gained the proficiency and self-assurance to carry out limited programming tasks in later courses and in professional life.
We have developed a similar element in the Numerical Methods course for six programs where the students study more advanced mathematics. Each student chooses a relatively large assignment from a set of about 50 applied numerical problems. The student presents the solution both as a written report and in a talk to an audience of a teacher and a dozen classmates who have chosen different problems. Unlike in most other courses, most of the audience is not familiar with the problem. The teacher gives feedback, and grades both the oral and the written presentations. We are not aware of any similarly organized course in numerical methods anywhere in the world. At many universities the numerical methods course leads an obscure life, but our course often gets estimation from alumni as the most enjoyable and valuable course in the curriculum.

The school uses oral examination in many courses, even in the first two years with more than 100 students. Traditionally, oral examination is said to be impossible to use in large groups. But our courses in programming, computer science and numerical methods almost always use computer assignments orally examined at the computer by a teaching assistant.

Most of the examination of the school is formative and given during the course. Feedback is usually given immediately at oral presentations. In several of the courses there is a written exam given in the middle of the course. Research has shown that continuous examination with fast feedback is an important key to improved learning. The program testing system Kattis mentioned above is another example of this.

Our factors of educational success

1. Very high level of academic competence

The teachers' subject knowledge, research qualifications and pedagogical skills are the reason for our programs and courses being relevant, topical and instructive.

2. Clear division of responsibility

Staff member in charge of undergraduate education – program management group – Directors of Studies – subject-representative professors – teachers – administration. The division of responsibility clearly indicates who is responsible for what. Moreover, everyone in the organization has someone else to turn to if needed.

After the staffing meeting, the course leader has total responsibility for running the course. This gives the teacher a great deal of freedom, but within given limits. Teaching teams provide coordination, support and backup for courses offered many times a year and taught by different teachers.

3. Good information and support systems

In-house teacher web pages, regular letters from the Directors of Studies every

semester, weekly information from the GA in the School newsletter *Numero*, course web pages, a student website and a program website. Information meetings and exhibitions to help student choose their majors, along with the School's Family Day, are held every year. All of this together, this keeps personnel and students informed. Answers to practically all questions are accessible on the School website. The teachers' work is supported and facilitated by the School's administrative system, designed in-house for registering results, timesheet reporting, project presentation booking, helpdesk queuing and questionnaire answering.

4. The course development cycle

The course is run → course evaluation → course analysis → staffing meeting → course development → new version of the course is run.

This cycle has a very strong quality-driving function.

5. Positive attitude to and fearlessness of new types of teaching and examination

Alternative examinations, labs, oral presentations, computer-based examinations, peer correction, etc. The School's teachers have a long tradition of trying out new ways. This improves learning, motivates the students, and thereby increases throughput.

6. Pedagogical development and personal development

Time for personal development and what the development should contain are also decided at the annual staffing meeting. This helps the teacher to find time for this development and carry it out. The Director of Studies has the possibility to influence this development so that it benefits the School. Most teachers have attended courses in teaching and learning. The School organizes its own pedagogical seminars and runs a number of pedagogical projects (for instance, the computer judge Kattis, diagnostic web-based testing systems, educational use of podcasting).

7. Particularly successful teachers

The School has many prizewinning teachers (in 2008, for example, we won two of four teaching prizes from KTH, Teacher of the Year from the Students' Union, and a STINT scholarship; in 2009, we have already won two STINT scholarships). We encourage teachers and teaching assistants by awarding our own prizes. The prizewinning teachers are motivated to continue the good work and spread quality to other courses and teachers.

8. Programs and courses with clear learning outcomes

The educational aims of the programs are carefully formulated in consultation between the program management group, KTH, students and industry. The program aims have evolved over the years, but the changes are not major ones. The aims act as a guiding light when the program or courses are revised. The course aims show students (before, during and after the course), teachers and future employers what the course has given (or will give) the student.

Sharing results with other departments and institutions

There are numerous examples where we have shared material and systems with others.

- Nada's Code of Honor (which we drew up ourselves, based on Stanford's Code of Honor) has been adopted by KTH's School for Information and Communication Technology (ICT) and most of it is now used by KTH centrally. Other universities and colleges have also borrowed it.
- The Department of mathematics has begun to use our staffing system.
- Viggo Kann has given talks at several educational conferences and has been invited to present the same material for the Directors of Study at Uppsala University Faculty of Science and Technology and for teachers at the University College in Borås. Olle Bälter has talked in Luleå and Uppsala and been invited to speak at the STINT conference in Umeå.
- Our idea "Advanced Individual Course" has first spread from computer science to the other subjects at the School, and later to several other Schools.
- Several course books, lecture notes and lab exercises written by our teachers are used at other universities and colleges.
- Through teacher exchanges, we have influenced universities in Tashkent, Erlangen, Freiburg, Beijing and to some extent Amherst and Williams College.
- The School participates annually in subject conferences in Numerical Analysis and Computer Science, in MDI and Language Technology. The exchange is always rewarding in both directions.

Changes and areas for improvement

Apart from the continual quality work, the School presently has several major changes in education in progress.

- Four new Master's programs and a new Bachelor's program will be set up by fall 2010. This is a stage in the division of the Master of Science in Engineering programs into a Bachelor's and a Master's part.
- The types of examination will once more be reviewed and traditional examination substituted by learning exams and more economical forms of examination. We are phasing out the ever more expensive written exams.
- Improvement of learning environments and computer environment. Classrooms and student space are being reviewed and adjusted.

In the longer term, we will be working on the following areas of improvement, among others:

- Gender distribution: We have a significant underrepresentation of women, particularly among the students.
- Throughput, both in certain courses and throughout the whole education.
- The time students devote to their studies: We would like to change the culture so that the students give top priority to university work
- The teachers' work situation: Despite the meticulous approach to staffing, there are teachers who sometimes feel pressured and those who find it difficult to focus on their own development. We try to find ways to prevent stress and support hard-pressed teachers. We are investigating the possibility of sabbaticals – extended periods of leave from teaching on a 75% salary.