Universitetskanslersämbetets

utbildningsutvärderingar

Självvärdering

Lärosäte: KTH
Forskarutbildningsämne: Datalogi
Licentiatexamen: ja
Doktorsexamen: ja

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Date:
10 March 2017

Aspektområde: område, miljö och resurser

Aspekt 1: Forskarutbildningsämne

Bedömningsgrund:
Avgränsningen av forskarutbildningsämnet och dess koppling till den vetenskapliga grunden och beprövad erfarenhet är välmotiverad och adekvat. Forskarutbildningsämnets relation till området för forskarutbildning är adekvat (för de lärosäten som har examensrätt för område för forskarutbildning).

Doctoral programmes were introduced at KTH in 2011 and have since then been the environment within which third cycle education is given. Generally speaking, each school is the host of 1-3 programmes, where each programme comprises 1-3 subjects and optionally a small number of specializations or tracks. On the central level at KTH, *prodekanus* leads the third cycle education and conducts and coordinates activities relating to KTH rules and regulations, the coordination of common courses and the coordination of other educational activities such as seminars, quality processes such as FUS (more on this below), etc.

The *School of Computer Science and Communication* (CSC) at KTH has currently two doctoral programmes, *Mediated Communication* and *Computer Science*. The latter of these offers two subject areas, *Speech and Music Communication* and *Computer Science*. The present document concerns the latter subject area only; however, all described processes apply to both subject areas, and in most cases also to both doctoral programmes.

The Area. The area of *Computer Science* can be understood at two levels. In a very broad and foundational sense, as we formulate it in our Subject Area Study Plan (ASP), it is the science that attempts to answer the question of what is computable by means of a physical device, and find general principles and fundamental limitations of computability. As a science, it provides the foundation for the formulation of methods for the construction of software and other representations of computation. It is the starting point for the formulation of various application areas. In a narrower sense, we focus our doctoral programme on the application areas that are of strategic importance for the CSC school, in particular such areas as secure computation platforms, robot technology, computer vision, computational biology, language technology, and high performance computing and visualization. These application areas manifest themselves as the *four specializations* of the Computer Science subject area of our Doctoral Programme:

1. Theoretical Computer Science (TCS)
2. Robotics, Perception, and Learning (RPL)
3. Computational Biology (CB)
4. High Performance Computing and Visualization (HPCViz)

which correspond (approximately) to the departments of our School (see the ASP). Concretely, in the context of our Computer Science subject area we understand *breadth* as corresponding to a particular specialization, and *depth* as the specific topic of a given thesis.

Breadth and Depth. Breadth in our subject area is provided primarily through the courses offered within the four specializations, covering the corresponding sub-areas of Computer Science. Additional breadth is provided through courses across the specializations, and through fundamental courses such as *SF1910 Applied Statistics*. The requirement of a

minimum of 60 ECTS course credits guarantees that width is obtained. The diversity of research, journal clubs, seminar series, etc., within our departments, which constitutes the environment where our doctoral students conduct their studies and research, further fosters our students in terms of width. Depth is achieved primarily through the individual study of the scientific literature and the state-of-the-art that is needed to formulate the research goal of the thesis, identify possible approaches to addressing it, and relate the obtained results to the existing work. Since significant weight is given at our School to peer-reviewed publications for forming the backbone of a thesis, and publishing requires knowledge of and accounting for the state-of-the-art, and since the thesis is reviewed by a thesis committee, addressing depth of study is virtually guaranteed in practice in our doctoral education. Breadth could also be viewed as covering further complementary domains of Computer Science; however, from the practical point of view of the need for teaching faculty to have the required expertise, we currently do not see how to realize such a view. In terms of interest from doctoral students to take courses from departments other than their own, we have seen an increase over the last few years following a school-wide effort to create cross-departmental research projects and cross-departmental research-level courses linking to those research projects. We can also note that the annual development talks introduced a few years ago have resulted in an increased awareness among the doctoral students of aspects pertaining to needs for the future career beyond completion of the thesis. As a result, doctoral students are more interested in taking courses in leadership, project management and patent/IPR, although still at a low percentage.

Aspektområde: område, miljö och resurser

Aspekt 2: Personal

Bedömningsgrunder:

A. Antalet handledare och deras sammantagna kompetens är adekvat och står i proportion till utbildningens innehåll och genomförande.

B. Handledarnas sammantagna kompetens och kompetensutveckling följs systematiskt upp i syfte att främja hög kvalitet i utbildningen. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

Core Competences. Doctoral studies in the subject area of Computer Science are conducted at our CSC school in specializations (see previous aspect) that correspond to the core competences of the departments. In this way it is guaranteed that the available research body has a stable critical mass and competence required to teach courses and supervise doctoral studies within the specializations of the subject area. We have currently 77 faculty members supervising 81 doctoral students, 29 of which as main supervisors (see Table 1a and Table 2), plus 28 faculty members and postdocs involved in the research-level education within the subject area (see Table 3).

As the current practice is to hire doctoral students on projects for which funding has been secured by the prospective supervisor (see more on this topic below), the problem of insufficient supervisory personnel rarely ever exists at CSC. Furthermore, the selection and development of the individual research topic of the student is closely related to the competence area of the supervisor. And as an additional precaution, the Director of Third Cycle Education (sv. *forskarutbildningsansvarig*, FA) is careful *not* to approve supervision that appears inadequate in terms of either existing funding or expertise in the topic of the thesis.

Cumulative Competence. Making sure that the cumulative competence of the departments follows the important developments and trends in the research community and the society at large is the responsibility of the leadership of the School and the departments, and is to a large extent driven through recruitment. In this way existing competences are consolidated, and new competences developed, directly affecting the supervisory and teaching resources for doctoral studies. The international composition of the CSC faculty is both a result of and the cause for the continuous renewal of competence in accordance with the scientific and societal developments.

Scientific Competence Development. The individual scientific competence development of the supervisors is to a large degree shaped by the existing research funding schemes (see more on this below). A certain (but rather limited) portion of the Faculty Funding (*FoFU*) may go to cover personal research time of faculty members, which can be used for scientific self-development. However, there are no written policies or regulations for this at present, and we identify this as a potential area for development. Thus, the individual scientific competence development of the supervisors is currently driven mostly through projects: the project proposals that one is writing and submitting (since the funding agencies issue calls for specific research topics which are considered of strategic importance for society) and the projects one is participating in (since they offer a means of contact with the research

community). As a complement to the above, one concrete forum for competence development at CSC are our regular *Joint professor and young faculty lunches*, where we discuss various topics related to career development. At the KTH level, seminars to develop the faculty (sv. *kvalitetsseminarier*) have been arranged for many years now and cover a wide range of topics for the faculty.

Pedagogical Competence Development. The individual pedagogical competence development of supervisors is mainly taken up by means of courses and seminars. A certain (but again limited) portion of the Funding for Basic Education (GRU) may go to cover pedagogical self-development of faculty members. Further, there are numerous *pedagogical courses* maintained by the Department of Learning, some of which are mandatory for all teachers and supervisors at KTH; examples are the mandatory course *LH231V Teaching and Learning in Higher Education,* and *LH207V Doctoral Supervision*, which is a formal requirement for becoming a *docent*. In addition, KTH and the CSC school organise regular pedagogical, supervisory and quality-related *seminars* (such as the course *I-Supervise*), and the Supervisor's Day (sv. *handledardagen, 2012*) that focusses on various topics related to doctoral student recruitment and supervision.

Leadership Competence Development. The mandatory course *LH207V Doctoral Supervision* mentioned above constitutes the fundamental training of supervisors. There is, however, an increasing number of junior and mid-level faculty offered leadership courses of various kinds, a trend starting around the late 90's. Today a range of courses is offered and a fair fraction of the faculty have taken one or several of these. As an example, during 2014, 8 and 2015-16, 18 lecturers and professors (out of a total of 50) took either *Ledarskap 1* or *Ledarskap 2*. Our School has also been running junior faculty (sv. *biträdande lektor*, *lektor*) lunches every 6-8 weeks over the past several years, to provide a multitude of aspects of training to our faculty. This means that doctoral students are supervised by persons increasingly aware of project management and leadership aspects. In a similar vein, the FAs are provided by KTH centrally with workshops and lectures on a wide range of aspects pertaining to university management (annually 1-2 events).

The acquired competence, however, would be more effectively used if linked to adequate *mandate*. FA has no mandate concerning financial or human resource matters, since these reside completely in the line organization. PA of the doctoral programme has no formal mandate whatsoever, and needs to operate based on what is offered. By virtue of the strong regulations pertaining to doctoral students, FA and PA have ultimately very limited means of leadership should a doctoral student not respond to discussions. Balancing regulations and mandate is important and undeniably non-trivial but also highly pertaining to quality.

Industrial Impact. Regarding the industrial impact of research, it is considered as a task of the supervisors to establish relevant industrial contacts, and to apply for project funding involving industrial partners. Specific support for industrial collaboration is occasionally provided through our so-called *strategic partnerships* (for CSC these include Ericsson, Scania and SAAB, among others), for instance within initiatives such as the *KLOSS AkUt* initiative funded through VINNOVA, and the so-called *Impact 2.0* initiative at the KTH level.

Quality Assurance: Three Pillars. Even if more relevant for the aspects discussed below, it may be meaningful to describe early on the process of quality assurance of studies within our Doctoral Programme. It is based on what we refer to as the *three pillars*, which are: (1)

individual study plans (ISPs), (2) yearly *meetings* of each doctoral student with a *supervisory group*, where discussions are held based on a written *progress report* submitted by the student, and (3) *promotion seminars* held in conjunction with advancement along the progression steps, described in a separate Doctoral Ladder document (stipend holders and industrial PhDs are not subject to progression steps, but are still required to hold promotion seminars). These monitoring mechanisms, summarized in this document and described in detail in our Programme Description document, have been introduced with the intention of providing transparency and protection for both the student and the supervisor. With the support of the Head of the respective department, the Director of Third Cycle Education (FA), and the PhD Council, these mechanisms allow to uncover early on potential problems in the doctoral study or supervision processes, and take corresponding rectifying measures. Pertaining to the aspect discussed here, it is mostly the second pillar that is of relevance, since the meetings with the supervisory groups provide a channel of feedback both to the Programme Coordinator (sv. *programansvarig*, PA) and to the supervisors on the quality of teaching and supervision, and the general attractiveness of the research topics. Another channel of monitoring is the annual *faculty performance review* (sv. *utvecklingssamtal*), carried out for each supervisor and each doctoral student who so wishes, of which the supervision activity is a very important component and for which FA is invited to give feedback on supervisors' performance.

Should the supervisor or the doctoral student feel that feedback or discussions do not result in changes that have been deemed necessary, they can escalate the topic to the head of department, programme PA, FA or School vice dean (who is dean of faculty), a choice depending on the nature of the problem. Most topics are resolved at one of these levels, FA only receiving 3-4 requests annually. However, in a small number of cases (1-2 annually), a problem persists. If the problem is on the student's side we have in practice very limited possibilities for action when discussions do not lead to a solution, since HF stipulates that students are warranted 48 full time months, and since KTH typically rules against any request for withdrawal of resources in favour of the student. Should the problem be on the supervisor's side, these (quite rare) cases are discussed jointly with the Head of School, head of the Human Resources department (HR), union representatives, and FA, and when it comes to this point we also see very little effect in terms of resolution. Again, these cases are quite rare, but they may nevertheless create an uncertainty among the staff and students which may generate smaller but more frequent problems as well as a distrust in the system.

Supervisor Change. As a measure to handle certain unforeseen situations it is possible, and a formal right of every doctoral student, to change supervisors following an established procedure. In the majority of the cases, the doctoral student and the main supervisor themselves find a new candidate supervisor and thereafter approach FA with a suggestion agreed upon between present supervisor, new supervisor and doctoral student. With more than 80 active doctoral students, we have a few such changes each year, showing that we are operating in a system where this is accepted and handled adequately. As such a change may have serious implications for both the student and the supervisor, however, we strongly rely on the monitoring and evaluation mechanisms already described above, including the annual supervisory group meetings and annual development meetings with the Head of Department (HD). Still, if a student approaches FA with a request for change of supervisor (we have 1-2 such cases per year), we set up a series of meetings, the student and FA, the supervisor and FA, all 3 parties, HD and FA, etc., all depending on the details of the concrete case. Ultimately, FA and HD discuss the alternatives, and in the end FA makes the decision of new

supervisor, while HD makes the financial (or resource allocation) decisions. Whenever needed, FA also contacts the Human Resources department (HR) and initiates contacts between the student and HR. HR in turn, may initiate contacts with the health care provider if seen useful. FA may also provide the student with contacts to the student organisation or union representatives.

Research Funding. Finally, to fully understand the aspects of personnel and the general research environment, one has to take into account the specifics of the current research funding model that has established itself throughout most of Sweden, and in particular at CSC, as it defines the premises under which we operate. Its most characteristic aspect is that there is little direct funding dedicated to cover the time that our faculty spends on research and supervision. The majority of research is funded *externally*, and most of the external funding comes from national and international funding agencies in the form of *projects*. Due to the full cost model, a substantial fraction of the faculty funding is used to cover overhead in projects financed by EU and national private foundations. While KTH and the School can on one hand feel privileged to obtain these grants and thereby increase our overall volume of work, this has a number of implications on how research, supervision and doctoral studies are organized and conducted. *On the positive side*, doctoral students are only hired if there is funding. Since the funding sources are extremely competitive, we can observe a rather low fraction of doctoral students per supervisor (around 2-3 in average at CSC), which may be considered good for the students as they can get sufficient supervision attention. Further, the thesis work has an already predefined focus as given by the particular project on which the student is hired, with a stipulated industrial relevance and scientific impact of the expected project outcomes. In the case of larger (and international) project consortia the project also provides a stimulating environment that can give a meaningful context to the research task at hand, which can be of great motivational value for the doctoral student. Furthermore, since project funding is usually granted on the basis of the merits and expertise of the applicant(s), the competence of the supervisor in the research field of a given thesis topic is additionally assured. *On the negative side*, the duration of projects (2-3 years) is typically shorter than the duration of doctoral studies (4-5 years), which can lead to disruptions in funding or change of direction of research for the doctoral student. Further, such a funding scheme limits the academic freedom to follow one's own scientific curiosity and can be an obstacle for students who want to formulate and pursue their own research problems. Students have often to deliver concrete items within a given project, and sometimes even artifacts that do not directly contribute towards a thesis (such as implementing GUIs and producing manuals for tools), which effectively limits their own choices. Still further, projects funded by agencies such as VR typically are sufficient to cover the research time of the doctoral student only and not the time of the supervisor. In certain cases the result can be that supervisors work on other projects (for which there is funding, and thus work to do) and can only afford to monitor the work of their doctoral students, rather than actively collaborate with them. Thus, from the viewpoint of warranting that every student and every supervisor get appropriate time and continuity to create the best education and outcome, we see challenges.

Aspektområde: Område, miljö och resurser

Aspekt 3: Forskarutbildningsmiljö

Bedömningsgrunder:

A. Utbildningen och forskningen vid lärosätet har en sådan kvalitet och omfattning att utbildning på forskarnivå kan bedrivas på en hög vetenskaplig nivå och med goda utbildningsmässiga förutsättningar i övrigt. Relevant samverkan sker med det omgivande samhället.

B. Forskarutbildningsmiljön följs systematiskt upp för att säkerställa hög kvalitet. Resultatet av uppföljningen omsätts vid behov i kvalitetsutvecklande åtgärder och återkoppling sker till relevanta intressenter.

RAE. The *Research Assessment Exercises* (RAE) of 2008 and 2012 evaluated our research environment. The conclusions of these were used in our *Kvalitetsredovisning* 2015. We can thus view the current evaluation as a continuation of an ongoing evaluation process, but now with focus on research education.

Research Groups. Research at the CSC school is conducted in research groups within the departments. We have a number of strong research groups led by leading researchers in their respective fields, as witnessed by a number of distinguished prizes and awards (see also the Lists of Publications), who are capable of attracting considerable external funding, allowing doctoral and postdoctoral students to be hired. One could mention our research in robotics, algorithm analysis, data visualization, and security, among several others. These strong research groups are also active in providing courses at the research level. The list of students (81) and list of faculty (77) within the subject can be found in Table 1a and Table 2, respectively.

Research Networks. As already explained, since research is mostly funded through projects, many of which are at the European level, doctoral students funded on such projects (and also to some extent the other doctoral students) are naturally included in stimulating and motivating research networks. These are complemented by a number of interdisciplinary research and *competence centres* such as *NADA* (KTH and SU), *SeRC*, *INCF*, *SciLifeLab* (KTH, SU, KI, UU), and *Stockholm Brain Institute* (KI and SU) as well as international PhD programmes like *EuroSPIN*, an Erasmus Mundus-funded programme that has connected CSC with departments in Edinburgh, Freiburg, and Bangalore (in this programme, admitted doctoral students have two advisors from two different member universities, and spend time at both universities; the whole PhD time is thus truly international). For those (less frequent) cases where funding for a given PhD position is insufficient to cover trips, there are funding opportunities for attending conferences (when a paper is to be presented) both at the KTH and the school level. Also, there is funding at the KTH level for short research visits at other universities. Our doctoral programme encourages such visits at established universities (see the Programme Description). During 2016, the average number of travels outside Sweden was 1.98 per doctoral student (source VIA Agencia). As concrete examples we can mention the relatively recent visits of doctoral students to *Carnegie Mellon University* in Pittsburgh and to the *University of Illinois* at Urbana-Champaign. Another excellent source of knowledge acquisition and early networking are the various *summer schools* (and the less frequent winter schools) to which we send our doctoral students. As a

prominent example we can mention the yearly *NATO Summer School in Marktoberdorf* in the field of the Theory and Practice of Programming, which has been attended by many of the doctoral students from the Department of Theoretical Computer Science (TCS). Similarly, the *OIST Computational Neuroscience Course* in Okinawa is regularly attended by doctoral students from the Department of Computational Science and Technology (CST). Participation in summer and winter schools is usually accounted for as learning and is awarded a certain number of credits. Studies at other universities and in particular in joint programmes are, however, not without challenges. It can mean a larger diversity of projects to conduct and more regulations to follow, thereby limiting access to certain courses or the time spent on the respective project. Internationalization holds many promises, but for those who would need to make decisions, the mandate may be limited.

Industrial Networks. As for the industrial networks, these are made available to the doctoral students through the various strategic partnerships and initiatives described above in the context of the Personnel aspect. Some doctoral students (currently they are 6) are directly engaged with Industry in the form of *Industrial PhDs*, meaning that they typically work half-time in industry and conduct doctoral studies in the remaining time. In other cases we have doctoral students that are employed in the regular fashion, but use the industrial contacts of their supervisors to collaborate with (and on occasion also to do part of their research at) the industrial partner's site. Furthermore, in some of the EU, VINNOVA and Formas projects, an integral part is work with the industrial partners. However, as we also point out later (see aspect Career Perspective), we see a clear potential for improvement in educating our doctoral students on how to carry out industrially relevant and applicable research.

Composition of Doctoral Students. The composition of doctoral students in the Computer Science subject area is rather diverse. As a substantial number of doctoral students in our subject area are *international students*, their integration is rather smooth, and is further facilitated by various welcome meetings and the *Doctoral retreat* organized biannually by our Doctoral Programme. Even if certain cultural clashes may be unavoidable, the CSC school organization and the Doctoral Programme in specific make a concerted effort to include all students, and there has not been any reported case of conflicts on the basis of cultural differences or clashes. *Industrial PhDs* employed at 50% face the difficulty of maintaining a steady study rhythm. Combining the work at the company with prescribed activities as a doctoral student can be complicated and these students may not be able to fully utilize the resources available from the doctoral programme. *Stipend holders* (we have currently 17) face other difficulties, as they fall outside of the standard Swedish system of employment. In particular, it can be problematic to reimburse such students for travel expenses, or supplement their income if the stipend is much lower than the usual salary level of doctoral students. In the cases of *parenting* during the time of doctoral studies our doctoral students have been able to make arrangements with their supervisors and use parental leave; however, stipend holders may have rules on how the stipend is used, even though some protection is guaranteed by *Kammarkollegiets försäkring*. Finally, our endeavours for equity are governed by strict rules and zero-tolerance towards any sort of discrimination or harassment (see more on this in aspect Equity Perspective).

Composition of Faculty. The composition of faculty is such that it has not given rise to any major difficulties for the supervision of doctoral students. Our supervising faculty is typically employed full-time at our School (with currently just 2 exceptions, see Table 2), and apart

from occasional short-term sabbaticals abroad, faculty members are fully available for supervision. Parental leaves of supervisors have also been handled adequately at CSC. In cases of this kind we rely on the co-supervisors to step in and make sure that there are no major disruptions in the progress of doctoral studies. We also rely on the co-supervisors in the very rare cases of conflict between doctoral student and main supervisor. One negative aspect of the composition of faculty which is worth mentioning, however, is the relatively low fraction of female main supervisors (currently 14%), as they serve as important role models for doctoral students.

Thesis Work. Thesis work is monitored throughout the whole period of doctoral studies by means of the three pillars of quality explained in the context of the previous aspect. The *individual study plan* (ISP) is used for planning the work on a yearly basis. It is agreed upon between doctoral student and supervisor, and is checked and approved by the Director of Third Cycle Education (FA). In the annual follow-up meeting with a *supervisory group*, consisting typically of two faculty members excluding the supervisor and co-supervisors, the thesis work can be discussed with independent observers whose goal is to check whether the student's research is progressing and planned in an adequate fashion, and that the doctoral student is satisfied with their studies, research and supervision. Progress is additionally monitored through the *seminars* given in conjunction with the promotion along the doctoral progression steps (as already mentioned, stipend holders and industrial PhDs are not subject to progression steps, but are still required to hold promotion seminars). In particular, the 30% seminar should present a meaningful research proposal for the thesis, the 50% seminar should serve as a midterm evaluation and for planning, and the 80% seminar should outline the structure of the actual thesis. *Thesis quality* is to be assured by the supervisors, and is additionally and independently checked by means of an *internal review*, performed by a faculty member not directly involved in the work or supervision of the doctoral student.

Quality Assurance. The proper flow of doctoral studies is monitored and its quality is assured by the same process based on ISPs, meetings with supervisory groups, and the progression step seminars. Additional points of feedback for the doctoral students on any aspect of their studies are the Council of the Doctoral Programme led by the Programme Coordinator (PA) where each department has a doctoral student representative (the council meets 4 times per year and doctoral students therefore have a regular forum for discussions), the PhD Council (entirely run by the students), the Director of Third Cycle Education (FA), for example during the annual FA department visit, the Head of department (either annually during the development talk, or by request), the Human Resources administrator, and the *ledningsgrupp* of the School.

Consider for instance the progression up the salary ladder. In advance of this, a new ISP is sent in. If FA finds reason to ask for more information, a motivation for the raise, this is done. Analogously, in the annual update of the ISP, FA can ask why a student has not been raised on the ladder or why results are not reported since last year. As a further example, when FA gets a question from a supervisor on a student who is not performing adequately, most often the supervisor, the student and co-supervisors as well as other senior staff members have been involved in discussions. Then, FA initiates a series of meetings with the student, student and supervisor, supervisor and head of department. Along with these meetings, the ISP is updated and made more specific. Depending on the nature of the problem, motivational activities like lab visits or summer schools are used, extra

co-supervisors are added, or coaching in e.g. writing is added. Also the supervisor may be encouraged to find alternative projects, which fit the student better, or improve in terms of e.g. meeting management and communication (see also above, Aspect 2, paragraph Quality Assurance). Thus, by establishing a predictive and transparent system, many issues can be prevented.

Moreover, various types of *questionnaires* are sent out every year to gather additional feedback from doctoral students, faculty and alumni, such as the *doktorandspegeln* for doctoral students (analyzed by FA and discussed with the PhD student council) and the *medarbetarundersökning* for all employees (2016, 2014, 2012, analyzed separately by HR and FA, and discussed with the PhD student council, the School *Lilla ledningsgruppen*, School *Ledningsgrupp*, and at the department level; actions based on the survey are lead by HR and include implementation plans separately for each department). KTH further follows up by conducting alumni surveys among former doctoral students "*Doktoranduppföljning*" (latest conducted 2013, before that 2009, analyzed by KTH centrally, by each FA, and discussed with doctoral programme PAs as well as on the KTH level at the FA-meetings). All surveys and major actions taken based on these are presented at the School Information meetings for all co-workers.

We are currently working on setting up a system for *course quality control* for research-level courses, following the way this is handled in the undergraduate education by means of student questionnaires and course analyses. This is currently mostly informal, relying on implicit mechanisms or incentives from the doctoral students (who have representation in the doctoral programme board), the School *ledningsgrupp*, the student dialogue morning meetings (monthly informal meetings to pick up what is currently discussed among students), and the KTH FA-group. However, a more structured process, as in basic education, has its merits to get all courses surveyed. In light of the changed yearly department planning of PhD courses (see Aspect 4B on coordinated departmental organization), we intend to include the course analysis as one of the mechanisms in this process. With regard to course quality control, it is worth mentioning that courses are given with substantial self-interest by the faculty involved, to utilize one's own and the students' time and effort to gain as much as possible, thereby constituting a feedback mechanism.

ISPs. To enable a more systematic organisation of the work involving the ISP, KTH recently introduced an electronic ISP (eISP) adopted from the one used by the University of Gothenburg. There will be many benefits from the system, enabling the doctoral student and the supervisor to use the ISP in a more integrated way on a day-to-day basis, by virtue of its easy access and support for updates of preliminary (working) copies. eISP will also enable monitoring of ISPs by a larger group of persons, on KTH-central level, by the Head of School and the head of department, etc., thus providing insight and transparency. In the future, study time, course credits, financing, etc., will all be registered and accumulated, providing further monitoring for transparency and quality purposes. Before this system was introduced, our School used during 2015-2016 an active-PDF ISP combined with the e-mail errand handling system RT to handle the ISP process. The main benefits were better tracking of ISP updates and communication in RT and better usability for doctoral students and supervisors by the functionality offered by the active PDF document. In parallel to this, KTH introduced in 2015 web access to doctoral students and their supervisors on parts of the LADOK records. Students and supervisors could thereby on-line check course credits and basic information on ISPs (e.g. the date registered). Also these measures served to improve

the third cycle education by providing the student and supervisor with means of accessing their own status data.

Regarding the ISPs that were sampled in this evaluation**,** please note that the ISPs for each person do not appear in chronological order (our apologies about this). Also note that due to the shift to the electronic system eISP, some departments have had their month of the annual ISP update moved. This means that some ISPs expected for November or December 2016 may be missing as they are delivered either in January or in February 2017. We also have a general concern regarding ISPs sampled this way. Neither the Director of Third Cycle Education (FA) nor the Human Resource department (HR) can share any information they have on our doctoral students that may be confidential. It is thus possible that we are fully aware of individual cases and situations for an individual that affect (among several things) their ISP, but will be unable to communicate this to you. There is thus a potential risk that you may be viewing and evaluating partial information. With only 16 ISPs selected, this number may vary substantially from subject to subject in your evaluation, and some subjects will by statistical necessity have none and some quite a number. Please bear this in mind.

Co-supervision. An area which we feel to be in need of improvement is the way we engage faculty in the capacity of co-supervisors. In the TCS department, for instance, it is a policy to include a co-supervisor from the very beginning of studies of a doctoral student. The purpose of this has been to provide a measure of stability to the supervision process. However, this mechanism has mostly been used in emergency situations. Instead, we feel that co-supervisors need to have a more formal role in the day-to-day supervision process. We identify this as an area for further development, and plan to start discussions with the aim of formulating a *policy on co-supervision*.

Aspektområde: Utformning, genomförande, resultat

Aspekt 4: Måluppfyllelse – kunskap och förståelse

Bedömningsgrunder:

A. Utbildningen säkerställer genom utformning, genomförande och examination att doktoranderna, när examen utfärdas, visar bred kunskap och förståelse både inom forskarutbildningsämnet och för vetenskaplig metodik inom forskarutbildningsämnet.

B. Systematisk uppföljning görs av utbildningens utformning och genomförande i syfte att säkerställa måluppfyllelsen. Resultaten av uppföljning omsätts i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

Following the formulation of the *Higher Education Ordinance*, Annex 2 (Qualifications), doctoral students in the Computer Science subject area gather scientific insights and acquire specialised knowledge in the field of their study through their *daily research practice under the supervision* of the academic staff at CSC (see Aspect 1). Analogously, within the realm of competence and skills, the students familiarise themselves and use appropriate research methods to conduct their research investigations. The way our third cycle education is organised to address this and the following two aspects is described in detail in our Subject Area Study Plan (ASP).

Research Development. A key role in supporting and controlling a student's research development is fulfilled by the supervisor. Additionally, the student's progress in the process of deepening domain specific knowledge, and proficiency in selecting as well as applying research methods is formally controlled at CSC by the aforementioned *three pillars of the quality assurance* (see Aspect 2). The goals of doctoral education within the domain of knowledge and understanding are aligned with the learning outcomes explicitly addressed in the students' ISPs. At this point we would like to mention that up to 2015, KTH was using its own formulations of Goals derived from the national text. Thus, in the ISPs available to you, you may find older ISPs referring to these older formulations. An early marker of the students' progress is their familiarity with the literature relevant to the subject of their scientific investigation and the state-of-the-art context of their research. The students' knowledge in this regard is verified by means of a written report, discussed in detail with the supervisor and examined on a separate occasion with the corresponding supervisory group, and as part of the evaluation process coupled to the first of the *promotion seminars* (a so-called *30%-progression-step* seminar), discussions covering among others aspects of judgement and approach. The subsequent promotion seminars that mark *50%* (equivalent to Licentiate defence) and *80% of the estimated advancement in the doctoral study* towards the degree completion should usually take place, respectively, at the end of the second and in the beginning of the fourth year of studies. The evaluation that accompanies these seminars and strict requirements reflected in assessment criteria can vary across the CSC departments. *For example*, at the Department of Computational Science and Technology (CST) a group of three members of academic staff, sometimes including an external reviewer, is appointed to evaluate each seminar. Following the seminar, the group meets both the student and the supervisor to ask follow-up questions and, in consequence, share their comments regarding the student's progress. All the promotion seminars are advertised a couple of weeks in advance in the news magazine circulated in the School and on the designated webpage. In the aforementioned department, *for instance*, supervisors are

supposed to inform a person responsible for organising regular seminars about the upcoming need to schedule a progression seminar for their students. The person in charge of seminars makes the reservation, advertises the event through the departmental and School's communication channels and requests participation from other members of staff such that a group of reviewers, mentioned earlier, is formed. Naturally, any conflict of interests precludes a person from serving as a reviewer.

Monitoring of Progress. The three-pillar framework (see Aspect 2) for following up the students' development, which is focussed on testing students' knowledge and understanding in the field of their research along with their competence in utilising research methods, provides the scope for effective monitoring of the doctoral study progress. In this way it helps to minimise the risk for students not completing their degrees within an intended period of time. In addition, the promotion seminars coupled with follow-up evaluations, yearly meetings with a supervisory group and regular examinations of the ISPs (annually and at every change of the salary step) are intended to complement students' self-regulating practice. In particular, the learning outcomes of research-level education (as stipulated by HEO) are discussed and assessed jointly by the supervisor(s) and the student yearly, when writing the new ISP. The topic of quality assurance of theses was discussed above (see Aspect 3).

Scientific Publication. Although there are no universal publication norms, doctoral students in the Computer Science study programme are also obliged to publish their work in suitable and adequate journals and attend conferences, workshops, and symposia in the realm of their research field, where they receive feedback relevant to their methodological approaches, specialised knowledge and systematic understanding of the study area. This is usually done under close supervision of the respective supervisor(s) and, if necessary, in collaboration with external partners complementing the CSC supervisors' research expertise. It is worth noting that there are no universal publication norms across different fields within the Computer Science study programme due to considerable differences in publishing culture. Finally, the thesis written by each doctoral student constitutes the evidence for them having obtained sufficient level of scientific understanding and knowledge as well as having mastered suitable research methods in their field. The thesis is subject to solid scientific and methodological scrutiny by the external opponent and evaluated by the examination board to ensure the fulfillment of the respective learning outcomes.

Research Courses. With respect to the breadth of knowledge, we note that the four specializations of our doctoral programme are quite broad and students are exposed to a wide array of topics. They are offered multiple opportunities to gain broader understanding of the field. In the first place, they are obliged to participate in both second- and third-cycle courses given on a regular basis by all the departments in the School. Relevant information about the courses is maintained on a designated webpage. The requirement for doctoral students is to obtain 60 credit points accounted for by courses (with at least 45 credit points at the research level, and at most 10 credit points at the basic level). The breadth of expertise in Computer Science is in this context guaranteed by the scope of research conducted at CSC and often expanded by the expertise of guest professors willing to organise courses on single occasions, such as for instance the intensive course on *Actor languages and actor models* in the fall of 2013, and the intensive course on *Probabilistic verification and synthesis* in the fall of 2015, both given by top scientists in their respective fields.

Currently, the Programme Coordinator (PA) with the support of the Programme Council is introducing a *new process* for the coordinated departmental organisation of the third-cycle course curriculum at CSC, described in a separate document. As a result, the intention is to update the curriculum on a yearly basis to ensure *a good balance between specialised and more general scientific content*. The responsibility for course maintenance, including financial aspects, is distributed among the departments and coordinated by the doctoral Programme Council. As a result, new courses are being developed or will be proposed, and older courses will be refined in the ongoing dialogue with doctoral students. This effort is aimed at ensuring continuity and regularity in providing core courses, determined individually for each specialization, as well as creating opportunities for students to more deeply delve into a selected set of topics. *Core courses* are intended to present the foundational and state-of-the-art knowledge of central relevance to the subject sub-area corresponding to the given specialization. For example, *DD3445 Complexity Theory* is a core research level course in the Theoretical Computer Science (TCS) specialization. *Shell courses* on the other hand are subject to more dynamic changes and can be adapted to current needs driven by new developments or trends within the subject sub-area. Representative examples are the research level course *DD3457 Program Semantics and Analysis* in the TCS specialization, *DD3356 System Integration and Robotics* in the Computer Vision and Robotics specialization, *DD3424 Graduate Course in Artificial Neural Networks and Other Learning Systems* in the Computational Biology specialization and *DD3370 Scientific Software Development Toolbox* in the High-Performance Computing and Visualisation specialization. All research level courses are to be evaluated according to the rules of the School, which implies that *course evaluations* are published following each course round.

Doctoral students can complement their competence in the study area by attending courses at other Swedish universities (mainly Stockholm University and Karolinska Institutet, but also Uppsala University). Furthermore, students are encouraged to visit both national and international workshops and research schools within the wide realm of their doctoral education. As an example of how this expectancy is communicated, the digital eISP has dedicated fields where these kinds of activities can be reported. We estimate that the majority of CSC doctoral students have 10% of their course credits (minimum 60 ECTS) from summer schools or research schools (unfortunately, the exact number is difficult to obtain from LADOK due to the way credit points are entered). Moreover, it is a common practice that students join the courses which within the scope provide training in specific research methods with hands-on components (e.g., *Advanced Scientific Programming in Python*). The course selection and decisions about attending external workshops or research schools are made by the doctoral students with the support and supervision of their academic supervisors at CSC. Each student in the Doctoral Programme in Computer Science is also obliged to participate in a mandatory course, *D3301 Research - Theory, Method, Practice*, offered on a yearly basis by the School. This course addresses generic aspects of conducting research with emphasis on research methodology. Moreover, during the years 2013-2014, a small number of doctoral students who were recently admitted to PhD studies (time window 3-9 months) were given an opportunity to participate in the introduction course *iPhD*, focussed on self-leadership, conducted by the KTH Transport Platform. Evaluations by doctoral students and participating staff were very positive. To make this mandatory for all doctoral students, we had two limiting factors: providing staff to run the course (in a mentoring-type role) and financing the course in the form of a three-day internship.

The acquisition of specialised research insights and gathering knowledge in the broad field of Computer Science are further facilitated by a variety of *research seminars*, *reading groups* and *journal clubs* organised by each department at CSC. Students are urged to take part in these events and display an active attitude by engaging in a critical academic discussion. Supervisors are responsible for encouraging their students' participation. Given the pressure on students to finalise their doctoral education within 4 years, we admit that there is a challenge to attract students to seminars outside the scope of their PhD projects. It is necessary, however, to inform and remind doctoral students of the need and value of extending and widening their scientific perspectives.

Additional Measures. The learning outcomes relate to *working knowledge*, factual competence, operational judgement, etc. We believe that some of these goals are better fulfilled by other activities than courses. Thus, rather than organizing a small number of mandatory courses whose *intended learning outcomes* (ILO) match the ones of the Swedish higher ordinance to guarantee that every student fulfills all the required ILOs, we have chosen a more diverse approach. We expect that some aspects of *working ability* are more effectively acquired when executed by a student in the context of real-world circumstances (project, task, question, etc.). This conjecture is at the heart of project work assignments and many daily activities in a department mentioned earlier such as journal clubs, project meetings, joint grant writing, and seminar series. Their assessment is cohesively conducted within the three-pillar framework, as described above.

Finally, even if the programme is designed to rely on the performance of multiple individuals (supervisory group, progression seminar committees, doctoral board), the overall quality of the programme depends on each supervisor. One way to improve the quality of doctoral education is via communication from those in charge of quality processes. Such communication could entail rules, regulations, policies and process descriptions of the doctoral education, and our experience is that we reach most but not all staff. In this respect, existing mandate for FA and PA to make possible effective communication with *all* faculty is in need of strengthening.

Aspektområde: Utformning, genomförande, resultat

Aspekt 5: Måluppfyllelse – färdighet och förmåga

Bedömningsgrunder:

A. Utbildningen säkerställer genom utformning, genomförande och examination att doktoranderna, när examen utfärdas, visar förmåga att planera och med adekvata metoder bedriva forskning och andra kvalificerade uppgifter inom givna tidsramar samt såväl i nationella som internationella sammanhang muntligt och skriftligt med auktoritet kan presentera och diskutera forskning och forskningsresultat i dialog med vetenskapssamhället och samhället i övrigt. Doktoranderna ska också visa förutsättningar för att såväl inom forskning och utbildning som i andra kvalificerade professionella sammanhang bidra till samhällets utveckling och stödja andras lärande.

B. Systematisk uppföljning görs av utbildningen för att säkerställa att utbildningens utformning och genomförande är av hög kvalitet och att doktoranderna uppnår målen. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

KTH performed an internal evaluation of its PhD education 2014-2015 entitled *Forskarutbildningssatsning* (FUS). The entire report can be found here. It was composed of three parts: SWOT Analysis (Strengths, Weaknesses, Opportunities, Threats), quality processes, and doctoral programme organization. A list of points of improvements was presented, although without clarifying what mandate would be provided to obtain the improvement. Feedback was provided to each school and each doctoral programme. As one of its outcomes, all PhD courses are now (at CSC completed 2016) available via the electronic system KOPPS (*Kurs- och programkatalogen*), also used in basic education. Furthermore, all subject area study plans (ASP) of the doctoral programme are now in KOPPS, and each doctoral student is linked to one particular subject area study plan (work performed during 2015-2016, previous updates including a minor update 2013 and a new document 2011). There is also an updated process on how subject area study plans are revised. According to the annual KTH report (sv. *årsredovisning*), the study time was 4.3 years for obtaining the PhD and 2.6 and 2.7 years for obtaining the licentiate degree (women and men respectively). Thus, in terms of study time, we follow closely the national regulation of 4 full time years.

Research Management Skills. The educational structure, execution and examination are described above (see Aspect 4, Three-pillar framework as well as Daily research practice). Please find below further discussion on particular aspects asked for here. The nature of doctoral studies in the School implies the need for students to demonstrate their research management skills. In particular, doctoral students in the Computer Science programme have to plan their projects and report these plans providing specific schedules in their ISPs, which are monitored and discussed with the supervisor(s). The responsibility given to the students to manage their research gradually grows throughout the study period, which should be reflected in the ISP and systematically examined as part of the aforementioned three-pillar mechanism for quality control (see Aspect 2). Doctoral research funded by the EU Framework Programme grants has proven challenging in this regard since the resulting projects tend to be scrupulously organized by the principal investigators, who end up as doctoral supervisors. In these cases, the common practice is to leave students as much room as possible for planning and driving their research activities within already given project

frameworks. Alternatively, other opportunities to demonstrate such research management skills are offered to students. *For example*, students are encouraged to engage in a project outside the scope of the original project funded by the EU grant, especially given the shorter lifetime of the EU projects than the duration of doctoral studies. All in all, the development of competence to manage one's own research and build an independent line of research that can potentially attract funding is a challenging component of doctoral education. There have been occasional opportunities for students to organise seminar sessions with experienced researchers who have coached on how to manage one's own research and establish independent research groups. Still, it appears that there is room for enhancing the doctoral programme by, for example, providing training to students on how to write their own research grants. This is partly implemented as part of the aforementioned general course *DD3301 Research - Theory, Method, Practice*. In addition, more systematic guidance and structured support could be offered to students in relation to the commercialisation potential of their work.

Knowledge Dissemination. An inseparable part of doctoral education in the Computer Science programme is knowledge dissemination. Students are obliged to take an active role in presenting their research via different academic channels. It is expected that they orally discuss their research findings at national and international conferences, and publish their work in high impact (international) journals. There are no strict quantitative criteria but ISPs should convincingly report that students have engaged in these typical academic activities. In order to prepare students for sharing their results within their research community, they are urged to give presentations at their departmental seminar sessions. This practice is coupled with the promotion seminars so that each student is offered multiple opportunities to communicate their research in front of their CSC colleagues (see Aspect 4). Supervisors play a role of considerable importance in monitoring and encouraging students' engagement in such activities. A good deal of research published by doctoral students in the Computer Science programme at CSC receives international recognition and attracts citations in the research literature. In addition, some of these contributions have been particularly appreciated at top conferences in respective fields of Computer Science as they have won multiple best paper awards (in excess of ten over the last five years), which is a strong indicator of the high quality of research conducted by the first-author students. To improve technical aspects of communication skills, whether with respect to the written or oral modality, doctoral students are encouraged, for instance during annual supervisory group meetings, to join targeted courses and workshops, regularly organised by the KTH School of Education and Communication in Engineering Science. The course *DS3102 Writing Scientific Articles* can serve as a prime example in this regard. Participation in summer schools, which commonly are international, further provides opportunities to discuss and present one's own work to a scientific audience. Summer schools, as well as international conferences (see above) are among the main reasons for international travel (CSC had 1.98 international travels per doctoral student during 2016, source VIA Egencia). Over the study period, an average of 4 written contributions are produced, thus providing continuous training in written communication as well as feedback from the supervisor and potentially also from reviewers. In the end, each student writes and defends her or his own thesis, which assures that writing and presentation skills reach a high and appropriate level of quality.

Impact of Research. With respect to the impact on society of research produced within the Computer Science subject area, doctoral students at CSC have varying experience depending on their projects. *For example*, students working towards their doctoral degree

within projects funded by the EU Framework Programmes tend to be offered a broader perspective of their contribution beyond merely scientific value. Similarly, a significant number of students are involved in projects with industrial partners and receive therefore more opportunities to get engaged in a dialogue with partners outside the realm of academia. An increasingly common practice is to involve doctoral students in the supervision of Master's thesis projects, which are commonly conducted in collaboration with companies. This creates opportunities for doctoral students to interact with industrial partners. In a broader societal context, beyond research commercialisation aspects, not all students in the doctoral programme are sufficiently exposed to *outreach tasks* undertaken by the School. Only a relatively small subset of students have been involved over the last few years in outreach initiatives such as public lectures, open house visits, museum exhibitions or interviews for press media among others. Although these tasks are mostly undertaken by doctoral supervisors as academic members of staff, they serve as role models and hence help instill societal awareness and attitudes into their students.

All in all, it is felt that there is a need for a more systematic approach to shaping students' attitudes and helping them understand the relevance of their *contribution to society* and environment outside the realms of academia. First of all, it is emphasised that there is a need to provide training to students in the Computer Science programme in how to effectively communicate the content of research to a non-academic audience. Contributing to popular science newsletters or informing about research advances in a *popular science* style could constitute good practice for doctoral students. There are opportunities to receive specialised training in this regard, for example by participating in the course *LS3107 Communicating Research beyond the Academy*, organised by the Language Unit at the KTH School of Education and Communication in Engineering Science. Another opportunity to engage in outreach activities could be better involvement in *pedagogical initiatives* sporadically undertaken outside academia. The idea of reaching out to secondary school pupils to supervise group projects and provide them with an opportunity to interact with doctoral students who are active scientists was under discussion. However, it did not sufficiently resonate with interest on both sides. At the same time, it should be emphasised that doctoral students in the Computer Science programme are prepared to engage in teaching activities and support learning in various forms. They receive *pedagogical training* by attending dedicated courses, *LH3000 Basic Communication and Teaching* and *LH231V Teaching and Learning in Higher Education*, and develop competence to facilitate and support learning by serving as *teaching assistants* mostly in second-cycle courses.

In conclusion, CSC doctoral students in the Computer Science subject area have to develop and demonstrate throughout their studies competence in managing and planning their own research. This process is continuously supported by the supervisor and regularly monitored as part of the three-pillar quality control process (see Aspect 2). Additional support towards this goal in the doctoral education could be implemented by offering extra training opportunities for students to practice writing their own research grants or to receive guidance on commercialisation of research. With respect to knowledge dissemination in the academic context, each doctoral student is obliged to publish their research findings in high impact journals and to make contributions to conferences. Throughout their studies, doctoral students have to perform oral presentations on multiple occasions at the School as well as conferences, workshops, summer schools, etc. These are formal requirements examined by means of the aforementioned quality control mechanism and continuously monitored by the supervisor. Finally, with respect to outreach activities that allow students

to contribute to or engage in a dialogue with society outside the strictly academic context, it is recognised that *more systematic measures could be taken*. Although there are opportunities that some students seize, as discussed above, there is *not enough incentive* for all the students to get involved. It is desirable that students in the programme be strongly encouraged to reflect on the development of their skills and their potential to contribute to society and open for a dialogue facilitating the communication of research implications for society, popularisation of science beyond the academic community or supporting learning in various forms. Promoting students' efforts to build up this potential and the verification of this capacity for professional involvement outside the academic context (complementarily to their commitments to the scientific academic community) in a systematic way poses a challenge that has to be addressed within the doctoral programme. Our annual development talks constitute one attempt to address this, but students have a natural tendency to focus more on short-term goals which can present an obstacle to the development of these types of skills.

Aspektområde: Utformning, genomförande, resultat

Aspekt 6: Måluppfyllelse – värderingsförmåga och förhållningssätt

Bedömningsgrunder:

A. Utbildningen säkerställer genom utformning, genomförande och examination att doktoranderna, när examen utfärdas ska visa intellektuell självständighet, och vetenskaplig redlighet/forskningsmässig redlighet samt förmåga att göra forskningsetiska bedömningar. Doktoranden ska också ha nått fördjupad insikt om vetenskapens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används.

B. Systematisk uppföljning görs av utbildningen för att säkerställa att utbildningens utformning och genomförande är av hög kvalitet och att doktoranderna uppnår målen. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

Intellectual independence is one of the key learning outcomes specified for the doctoral degree. Independence and *ability to reason critically* are among the key aspects assessed by the examination committee of the dissertation. Through the progression seminars, doctoral students are provided with feedback on their own performance. It often poses a challenge for supervisors to ensure that their students develop a sufficient level of autonomy in their research. It is common that gradually in the course of doctoral research, students are offered more opportunities to manage their projects by formulating research questions, defining the scope of their investigations and identifying suitable methodological approaches. Students also attend conferences, where they demonstrate their work as first authors and engage in critical academic discussions to defend and promote their research. Further, students gradually get involved in the practice of *peer reviewing* of papers, which offers them an opportunity to make professional judgements in the capacity of experts in their area giving them a sense of being a fully-fledged member in their research community. The coaching of a student's independence rests mainly on the supervisor(s).

Ethical Aspects. Students are made aware of the ethical aspects involved in conducting research as part of their doctoral education. Each thesis is also read by a faculty member other than the supervisor before formal plans for the defence can take place. Moreover, on preparation for the defense, every thesis is scrutinised for evidence of plagiarism with the use of dedicated software. Also, each member of the thesis committee as well as the opponent is examined in terms of conflict of interest. These formal processes also show doctoral students standards of ethics of the education. Ethical aspects are particularly exposed in the aforementioned mandatory course *DD3301 Research - Theory, Method, Practice*. In this course the participants are requested to reflect on generic ethical problems in research as well as ethical questions specific to their field of research. Moreover, during the bi-annual doctoral programme retreats, ethical topics are among the topics included. Doctoral students are also inevitably exposed to discussions about ethical aspects in their scientific discipline as members of their respective research communities. It is common for instance that journals have ethical guidelines, and before submission the student therefore needs to consider those. In the same spirit, doctoral students are made aware and asked to reflect on the scope of possibilities and implications that their research field has both in the academic realm and for society. This *scientific consciousness* grows as students become increasingly immersed in their research communities via conference participations,

publishing efforts and peer review processes among others. Here, the academic culture to which CSC students are exposed in their respective departments and groups or laboratories through intensive daily interactions with academic staff, researcher assistants, post-doctoral researchers and peer students is also of great value. Formally, each doctoral student at CSC engages in relevant discussions already at an early stage of her or his doctoral education in the aforementioned course *DD3301*. An additional *programme integrating course* is currently under development, following the idea of its successful undergraduate version *DD2300*. The course will focus on cross-cutting issues such as the ones mentioned above, among other topics.

Furthermore, students are supposed to familiarise themselves with the relevant governmental and EU *legal regulations* as well as the *Code of Conduct* as an employee and researcher at KTH. For employees, this information has been provided at School and departmental meetings (sv. *arbetsplatsmöten*), most recently during 2016 when our School updated the document on values (sv. *värdegrund*). There is also a *Code of Honor* for undergraduate courses, and as undergraduate courses can be taken within the mandatory 60 credits, doctoral students become familiarised with these, too. The document is posted on the School web pages, so that every employee should get informed. Students are further obliged to regularly share their reflections on these issues in the context of their research practice in the ISPs, when commenting upon how the goals pertaining to ethics are met, which are subject to evaluation within the three-pillar framework for quality control (see Aspect 2). Occasionally, there are also targeted seminars organised for academic staff, research assistants and doctoral students, which serve as an opportunity to generically discuss problems of ethics, responsibility and risks as well as threats associated with science and research output in both an academic and broader societal context.

Arbetslivets perspektiv

Bedömningsgrunder:
A. Utbildningen är användbar och förbereder doktorander för ett föränderligt arbetsliv, såväl inom som utom akademien.

B. Utbildningens utformning och genomförande följs systematisk upp för att säkerställa att den är användbar och förbereder för arbetslivet. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

As formulated in the Programme Description document, the aim of the doctoral programme is to provide students with deep knowledge of their research subject (specialization within the area of Computer Science) and the ability to conduct independent research, development, education and inquiries within diverse parts of society. Additionally, the students should graduate with the ability to independently initiate, plan, and lead research work and have a high understanding and awareness of ethical aspects of their work. Thus the career emphasis is primarily directed to research-related activities in diverse areas of society. KTH regularly conduct surveys directed to former doctoral students (such as the alumni survey Doktoranduppföljning 2013, as described above in Aspect 3). The main areas of society in which research is carried out and in which our students obtain employment are found within industry (60%), including consultant companies (14%) and the establishment of start-ups and independent companies by the graduates, where research, development or management of such dominate. Further careers are in academia (35%, where education is also an important component) and research institutes (such as SICS, the *Swedish Institute of Computer Science*). An additional important career area for our graduates is found in governmental agencies concerned with research financing and policy making, international research contacts and research dissemination involving publishing and media. The tasks performed are research (48%), product development (10%), project management (5%), education (5%), investigations (4%), construction & design (4%) and project work (4%).

The main components that define the *ability to conduct research* and which are essential for a research career are specified in the ASP. These can be summarized by the following three main goals: 1. The formulation of a critical scientific question which can lead to new and important scientific findings in the area of specialization, 2. A command of the methods, measurements, experimental setups and equipment, and the data required, and 3. The ability to present scientific achievements clearly and convincingly both orally and in writing. While general aspects of these goals are covered by doctoral courses such as the philosophy of science, scientific method (*DD3301 Research - Theory, Method, Practice*) and scientific writing (*FDS3102 Writing Scientific Articles*), the main emphasis in the doctoral programme is on actually carrying out research which will lead to the publication of scientific articles in high quality conference proceedings and journals, and ultimately to the publication of outstanding dissertations. Furthermore, since our modern society builds on creating a sustainable society, KTH has decided that all programmes shall encompass activities within sustainability. At the School, we have the following courses encompassing sustainability, DM3506 ICT and sustainability. Contacts to and experience working for industry are obtained for instance within EU or VINNOVA projects having industrial partners, daily contact with industrial PhD students and affiliated or adjunct professors with primary employment in a company or faculty running start-ups, and contact when supervising MSc thesis conducted at a company.

The *doctoral position* is already one of employment and is seen as an *essential career step* in which the student is already an active and important member of a research team. It is through working in the research team within a project often funded by grants with connections to industry that the student is prepared for the specific, new and evolving aspects of scientific enquiry, methodology and presentation needed for a dynamic and changing career. The fact that the supervisors are also responsible for the progress and outcome of the project which funds the doctoral research ensures that the content of the doctoral programme and the knowledge obtained are relevant to the continuing career of the graduate. *Project experience* is highly relevant for careers both in Sweden and internationally as a large number of grants involve international consortia, primarily EU grants. A further important aspect of preparation through doctoral employment is the opportunity for participation in teaching, supervision (e.g. Master's thesis supervision), organizational tasks (e.g. taking and maintaining project meeting notes), and participation in information activities at CSC such as open house or visits by school classes. These opportunities are expressly described in the study plan as departmental duties and generally comprise 20% of the doctoral student's employment. Participation in the *organization* of workshops and conferences also serves to provide the doctoral student with skills in organization, time management and time planning. The participation of the doctoral student in *grant writing* further provides experience in planning and budgeting of projects.

There exist, moreover, several *concrete measures* to ensure the relevance of the programme to a continuing career. First of all, supervisors and the CSC departments make an effort to help in the career placement of doctoral students, staying in touch with them and following their career progress. This contact is both informal and formalized through alumni meetings, where industrial and other partner contacts are also invited, and alumni surveys in which various aspects of the doctoral programme can be discussed. The CSC school maintains a societal impact strategy involving a continuing dialogue with strategic partners from industry (including e.g. Ericsson, Scania and SAAB) in which strengths and weaknesses of the doctoral programme are assessed. *Feedback* from these dialogues are channeled back to the Doctoral Programme Council and disseminated primarily to supervisors at supervisory seminars organized by the Director of Third Cycle Education (FA). As described above, the outcome of the KTH alumni surveys "*Doktoranduppföljning*" are discussed at the KTH FA meetings, by FA at the School with doctoral programme PA and PhD student council representatives, as well as at the School *Ledningsgrupp*.

Additional Measures. Two areas which have recently been defined as areas in need of improvement are *leadership abilities* and *report writing*. Leadership training and a stronger emphasis on academic writing are now being given more prominence in the doctoral programme. Another potential area for improvement is formal instruction for doctoral students on how to carry out *industrially relevant and applicable research*; the exact forms for addressing this, however, while still following the 4-year education and its learning outcomes, are still to be agreed upon and worked out.

In summary, we can state that with good basic skills and knowledge of methods, there comes a security and flexibility which, along with leadership skills, project management and writing skills, should provide a good basis for fulfilling important roles for various types of employers. And fortunately enough, deep competence in Computer Science is currently very much in demand.

Doktoranders perspektiv

Bedömningsgrunder:
A. Utbildningen verkar för att doktoranderna tar en aktiv del i arbetet med att utveckla utbildningen och lärprocesser.

B. Utbildningen följs systematiskt upp för att säkerställa att doktorandinflytandet används i kvalitetssäkring och utveckling av utbildningen. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

Doctoral Student Influence. As the main goal of the doctoral programme is to provide students with the ability to conduct independent research, development and education, one of the most important aspects of ensuring the student's active role in this development is to guarantee that the student has a strong influence over the research activities pursued during the course of the programme. An active role and influence in formulating research questions, employing and developing methodologies, and presenting results at conferences and writing research papers and reports are essential to supporting student influence over the development of their own educational goals. The fact that the student is a member of a research and teaching team affiliated with a CSC department serves to involve the student in the development of pedagogical and learning processes. Student participation in teaching and departmental organization and work is also stipulated in the study plan for the subject area of Computer Science within the Doctoral Programme. Furthermore, many of the doctoral courses are structured in such a way that the content is dynamic and flexible with the doctoral students themselves having a strong influence on the course design and the choice of relevant research articles and reference literature in cooperation with the teachers and supervisors.

Doctoral Student Representation. In an even more formalized manner, participation of doctoral student representatives is ensured by representation in the CSC School Management Organisation and by representation on the Doctoral Programme Council. Each department at the CSC school has one doctoral representative in the council. Membership in the council is therefore equally distributed between supervisors and doctoral students. Student initiative is strong and important especially concerning joint student and supervisor activities such as the biannual retreat and breakfast and lunch seminars. The formulation of the Programme Description document has to a large extent been the product of student involvement and influence. Doctoral students are also represented in the School *ledningsgrupp*, in the School executive board (sv. *strategiska rådet*). Doctoral students also have KTH-level participation in several fora, for instance the *FA-gruppen* where the Directors of Third Cycle Education (FA) from all of KTH schools meet monthly. As a reflection, over the last few years, it has been increasingly hard to recruit doctoral students to all the positions they are given representation in. On the one hand, a low engagement could mean that the doctoral students are relatively satisfied. On the other hand, it might also be an effect of discussion during recent years on quality and timekeeping, thus reflecting an awareness of need for priority-making which has become perhaps missguided. We need to be aware that everything we do, including quality monitoring processes, affect the persons involved.

Working Environment. To ensure a good physical and social working environment, the three pillars of quality assurance (individual study plans, meetings with a supervisory group, and the promotion seminars) play a crucial role. The formulation and updating of the individual study plan comprises a dialogue between the student and the supervisors giving the student

influence over his or her own educational development. The supervisory group comprises a control body where the progress of the student and the working relationship between the student and the supervisors can be assessed and evaluated. The promotion seminars also comprise an additional control station where the progress of the student can also be assessed by the faculty and by other doctoral students.

Additional Measures. Several additional measures are also taken to ensure the participation of the doctoral students in a positive working environment. The biannual retreat where students and supervisors present their work and meet in a relaxed atmosphere is organized by the doctoral students. Introductory meeting (given 2-3 times annually) and breakfast seminars are organized to increase and foster doctoral student inclusion and interaction. Participation in the regular department workplace meetings is also important for ensuring a positive working environment. Finally, surveys specifically addressing doctoral students and general employee surveys are carried out on a regular basis as well as a final, post-graduation meeting with each doctoral student, typically by head of department. Feedback from these surveys and meetings are channeled back to the Doctoral Programme Council and disseminated primarily to supervisors at supervisory seminars organized by the Director of Third Cycle Education (FA). Results from this feedback have recently led to changes in the structure, design and availability of several doctoral courses.

Jämställdhetsperspektiv

Bedömningsgrunder:
A. Ett jämställdhetsperspektiv är integrerat i utbildningens utformning och genomförande.

B. Systematisk uppföljning görs för att säkerställa att utbildningens utformning och genomförande främjar jämställdhet. Resultaten av uppföljning omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

The perspective of *equity and equal opportunity* in all aspects of the Doctoral Programme is formally governed by strict rules and no-tolerance towards any sort of discriminatory action or harassment. The basic pedagogical courses at KTH also cover topics on equality and gender issues. A substantial number of doctoral students in the programme are international students representing a wide geographical and cultural diversity. However, a gender imbalance remains as one of the most challenging aspects of equity within the programme. As a result of a number of actions and measures taken both at the KTH and CSC levels and general changes in society, the gender balance is improving as an increasing proportion of women are entering the Doctoral Programme. These actions involve various measures directed to supervisors, teachers and students to increase the awareness of the mechanisms behind gender imbalance and to create an atmosphere of inclusion in the doctoral programme for all students.

One of the most important measures has been establishing various seminar series and courses at both the KTH and CSC levels for teachers and students. One example at the KTH-level is the required course in supervision which every faculty member must complete to attain qualification as main supervisor. In this course, gender has its own theme. KTH also recently (2016) had all faculty involved in recruitment complete a course involving aspects of gender and culture. Other examples at CSC include a seminar series for faculty taking place over two semesters (2007) with topics relating to equality, diversity and equal treatment; norm-critical courses for teachers and supervisors (2014); courses and seminars on recruiting doctoral students for supervisors (2012, 2013); and courses on gender and mentorship for faculty (e.g. Technologica, running around the years 2006-2007). The School Workplace Council includes aspects of gender as one of its key tasks. Within the activities initiated by the School Workplace Council, opportunities for the funding of activities to promote gender balance or address aspects of gender and equal treatment have been instituted.

With regard to *systematic follow-ups*, all surveys provide results and numbers for the two genders separately. Unfortunately, due to the small sample size, statistical interpretations need to be taken with caution. By far most of the questions are not significantly different between the genders. In some of the older surveys, it is possible that female doctoral students were somewhat less happy with their supervision and their studies when responding to a few particular questions. These results, in addition to the gender imbalance, emphasised the need for establishing the above mentioned courses for supervisors, teachers and faculty in general. In the most recent survey, there was no significant difference between genders. Still, as members of minority groups are in general in disadvantaged situations, continuous monitoring is needed.

A *promising trend* can be seen in the increasing number of women who have been admitted to the subject area of Computer Science within the Doctoral Programme. During the three-year

period 2010-2012, 5 of a total of 41 new students were women (12%), while during the three-year period 2014-2016, 13 of 47 new students were women (28%). At present (autumn term, 2016) 22% of the doctoral students currently enrolled in the subject area of Computer Science are women. The proportion of women graduates in the subject area has also been increasing. During the ten-year period of 1997-2006, only 4 of 47 graduates were women (9%) while during the ten-year period of 2007-2016, 11 of 77 graduates were women (14%). Continued action must be taken to increase the gender balance, and measures are discussed regularly in the Doctoral Programme Council.

Some of the additional measures that are being taken to increase equity within the Doctoral Programme include the KTH code of conduct for a sustainable working environment and female mentorship programmes (for instance Technologica). Doctoral students are encouraged to invite doctoral or post-doctoral students from other universities to hold guest seminars at KTH and thereby contribute to strengthening their research network including a greater number of female researchers. Top female candidates are now actively encouraged to apply for post-doctoral research positions to improve the gender balance and serve as role models for both female and male doctoral students. All of these measures will be systematically followed up and assessed at the regular meetings of the Doctoral Programme Council.