Higher education institution: Linnaeus University
Third-cycle subject area: Computer and Information Science
Licentiate degree: Yes
Doctoral degree: Yes

1 Overview

Following the areas listed in UKÄ's guidance and template documents, this self-evaluation begins with an overview of the doctoral education's administrative and organizational conditions. It then discusses the research education environment, its resources, and the subject area. It follows an assessment of the design of the education and the teaching and learning conditions and outcomes. Then we illuminate the working life perspective. Although the doctoral student and the gender equality perspectives are taken already in the self-assessment parts of the previous sections, these perspectives are discussed in detail towards the end of this document. The self-assessment concludes with concrete areas of improvement.

External governance and policy documents are referred to throughout the self-assessment. The analysis of the doctoral perspective heavily depends on the anonymous doctoral student survey, Doktorandbarometern, conducted in 2016 that is linked as well.

The self-assessment refers to different quality assurance systems and instances established at Linnaeus University (LnU), at faculty and departmental level and outside the university in the scientific community. Central instruments for the quality assurance at LnU are the annually revised Individual Study Plans (ISP) and an activity-outcome matrix mapping activities of doctoral education to the goals of the Higher Education Ordinance and the general study plan (ASP). The ISP and the matrix are planning tools for the main supervisor and the doctoral student; the matrix additional assists all formal quality assessment instances in following up on the progression and the goal achievement of the individual doctoral education.

2 Governance and Organization

The principle rights for third-cycle education were granted when the educational institution became Växjö University in 1999. The major event since then was the merger with Kalmar University College (Högskolan i Kalmar) in 2010. The merger lead to Linnaeus University (LnU) and to an environment with 6 professors, 16 senior researchers, and 16 doctoral students. Currently there are 7 professors, 1 professor emeritus, 36 senior researchers, 10 post docs, and 30 doctoral students. This makes it one of the largest third-cycle education environments at LnU.

The general study plan (ASP) spans three subjects: *Computer Science*, *Media Technology*, and *Informatics*. The ASP was created in 2012, when the name of the third-cycle education subject area changed from "Computer Science" to "Computer and Information Science" that better reflects the three subjects. Regarding content and structure of the education, very little changed from the previous ASP to the current one; for everyone involved in the research environment this change had no impact, and all the existing doctoral students have transferred to the new ASP. In February 2016, the ASP was revised and now includes a subject description.

The graduate program includes the doctorate coursework of 90 credits and a scientific thesis (doctoral) 150 credits. The licentiate degree program includes coursework of 60 credits and a licentiate thesis of 60 credits. The coursework consists of a compulsory course (4 credits) and elective courses.

The third-cycle subject area Computer and Information Science is a part of the Faculty of Technology (FTK). The doctoral students are administratively part of one of three departments: Computer Science, Media Technology, and Informatics. They perform all departmental duties within their department. Each department has a head of department and a head of subject. Head of subjects are full professors.

The third-cycle education at LnU is regulated by the "Local regulations for education at third-cycle level"[1]. These regulations define the different roles and their responsibility, how doctoral students are funded and recruited, and how the thesis (and licentiate thesis) defences are organized. They also regulate the template documents for the general syllabus for third-cycle programmes (ASP) and the individual study plans (ISP). The ISP template has been subject to revisions in recent years to better connect the goals formulated for the third-cycle education to the different research education activities.

The third-cycle education is further regulated at faculty level. These regulations and administrative processes are described in "Handläggningsprocesser för utbildning på forskarnivå".[2]

According to the delegation of authority, all decisions relating to the third-cycle education at the faculty are made by the faculty board or the dean of the faculty. Administratively, the third-cycle education is managed by the director of third-cycle studies at the faculty,[3] who is assisted by a research secretary, and a faculty administrator.

At faculty level, several instruments for quality assurance of third-cycle education complement each other and together guarantee a high-quality environment and education. They are listed below.

ISP and activity-outcomes matrix. The ISP is defined before a doctoral student is enrolled in the third-cycle education. It contains a plan of activities for the coming period, a follow-up of activities for the previous period as well as a follow-up of the supervision process, both from the doctoral student's and the main supervisor's perspective. The ISP is complemented by an outcome matrix, that is used to map activities during the third-cycle studies, such as courses or thesis work, to the outcomes described by the Higher Education Ordinance and the ASP. The matrix is maintained by both the supervisors and the doctoral student, and is used to track and assess progress and outcome. In connection with the annual revision of the ISP, the doctoral student and the supervisors have the opportunity to discuss the progress of the studies together with the director of third-cycle studies.

The third-cycle programmes board (FUR). Many tasks relating to the third-cycle education, such as the revision of the ASP or ISP follow-ups, are delegated to FUR. Since 2017, FUR consists of all heads of subject at faculty, the director of third-cycle studies (chairman), the research secretary, the faculty administrator, and a doctoral student representative. FUR meets once a month and discusses ongoing issues of third-cycle education processes, ISP follow-ups, quality assurance in general, and challenges of specific doctoral students. It also decides actions if issues cannot be resolved by the supervising team or at departmental level.

Quality dialog between department and faculty. These regular dialogs between the head of department and the dean are instruments of general quality assurance at LnU. For instance, the Department of Computer Science has developed strategic goals for 2020 including the development of third-cycle education, which are aligned with the university's and faculty's strategies and monitored in these dialogues. The third-cycle education is affected by several of these goals. The department has developed an operational strategy to achieve the strategic goals, which includes several action points

[1] https://lnu.se/contentassets/22ca5224ca604cb7b7e3158bade6040c/local-regulations-for-education-at-third-cycle-level-140922.pdf

[2] https://lnu.se/contentassets/5a6dfb0c3b3b4aa3872a91b33c350311/handlaggningsprocesser-forskarutbildning-140422.pdf

[3] https://medarbetare.lnu.se/contentassets/885c4e4d5c504ede975f05eb8d66c9d4/reviderad-funktionsbeskrivning_studierektor-20160822.pdf

with measurable indicators that are checked and updated yearly. These action points are part of the department's yearly activity plan, which is discussed with the Faculty of Technology in these faculty-department dialogs. These dialogs follow up on the action points from previous years and consider several aspects for the plan ahead, such as resources and strategic support from the faculty and the university. The departments of Media Technology and Informatics have similar documents and processes for quality assurance.

Evaluation of researchers and research groups. FUR evaluates the research performance of all researchers and research groups annually. Additionally, there is an external evaluation of researchers and research groups every three years. The allocation of resources for research in general and the ability to employ doctoral students strongly depends on the outcome of these evaluations. Resources for running research educations are guaranteed regardless of the evaluations but, on the long run, only excellent and successful senior researchers become supervisors of many doctoral students.

Quality Assurance Council and doctoral student survey. At the university level, the main quality assurance instrument is the Quality Assurance Council and their recurring doctoral student survey, *Doktorandbarometern*.[4]

The latest survey was conducted in Spring 2016; questions were sent to all enrolled doctoral students at LnU. It investigates several aspects of the third-cycle education, and many of the results are presented and reflected upon in this self-assessment.

3 Environment, Resources, and Area

3.1 Third-cycle Subject Area

At Linnaeus University, the field and course of study referred to as Computer and Information Science covers a wide spectrum of approaches and activities within the subjects of *Computer Science*, *Media Technology*, and *Informatics*. A graduate degree program in Computer and Information Science at Linnaeus University may contain applied, empirical and theoretical studies, specific to the subject of studies. Doctoral students normally choose their subject in conjunction with the commencement of their graduate program. The third-circle subject area is defined in the ASP. The subjects are described below.

In the subject of *Computer Science*, concepts, languages, programming methods and tools are developed and analyzed for addressing efficient large-scale software development and data scientific problems in specific application areas, both from a theoretical and practical perspective.

The subject of *Media Technology* includes a variety of approaches within the field such as design and development of interactive systems, Web and mobile development, as well as advanced human-computer interaction techniques, just to name a few. Within this subject, methods, tools and various technical solutions are developed and analyzed, for the effective development, implementation and evaluation of media technical systems. The focus also lies on current problems within specific application areas, both from a theoretical and practical perspective.

Informatics develops knowledge about people's design and use of information technology in individual and organizational contexts as well as the society in general. These relationships are studied empirically and contribute to the theoretical, methodological, and conceptual development of knowledge. The research studies the interaction of people and information technology with an interdisciplinary or multidisciplinary perspective. Proven theories, concepts and methods are used within both old and new areas of application, in the study of working life and everyday existence. Relationships

[4] http://tinyurl.com/gtrxx52

between people and information technology are altered as a consequence of developments in technology, something which also has implications for the organization of work processes and the everyday lives of people in general. New methods are also developed and applied for the study of these new phenomena.

The research within these subjects of Computer and Information Science is organized in the following complementary and partially overlapping research groups, each led by a professor who guides the scientific work in the corresponding research field.

- *Visual Analytics* focuses on analytical reasoning facilitated by interactive visual interfaces.
- *Software Technology* focuses on the areas of Software and Information Quality, Scalable Computing, and Software Ecosystems.
- *Self-Adaptive Systems* focuses on Self-Adaptation and the Future Internet.
- *Learning Technologies* focuses on the design, development and implementation of mobile and Web 2.0 applications to promote innovative usage scenarios to support various human activities and performance in industrial and educational settings.
- *Advanced Human Computer Interaction* focuses on the design and implementation of systems supporting novel ways of interaction with simulations and computational models, with an emphasis upon support for shared (social) interaction.
- *Information Management* covers organization and coordination of the structures, processes, and resources for information use, including digital technology.
- *Digital Business* focuses on the innovative use of digital technology for the development of new business models with sustainable economic value creation.
- *Design of Interactive Artifacts and Services* focuses on design as an integrated part of different areas and contexts of digital technology use, to support human activity and experience in working and everyday life.

Each doctoral student, conducts her/his work in one of the research groups described above under the guidance of a supervisor from this group. There are cases when the focus of research and orientation comprises more than one research fields. In these cases, senior researchers of different groups collaborate and doctoral students are co-supervised. Two recent examples of this approach are the doctoral theses defended by Gil de La Iglesa (2015) and Vogel (2015) co-supervised from senior researchers in Self-Adaptive Systems and Advanced Human Computer Interaction.

3.2 Staff

3.2.1 Supervisors and Teachers' Overall Competence

In Computer Science, the team of supervisors consists of 1 professor emeritus, 3 full professors, with additionally 3 full professors acting as supervisors but employed at other universities, 1 associate professor, and 13 assistant professors (4 are currently evaluated for promotion to associate professor). These 20 potential supervisors are currently responsible for 13 doctoral students. 1 full professor and 2 associate/assistant professor positions in security, embedded systems, and Web and Cloud computing are under evaluation and will be appointed during 2017. At the same time, there are 4 open doctoral positions.

In Media Technology, the team of supervisors consists of 1 full professor employed at the department, 1 full professor employed at another department at LnU and additionally 2 full professors employed at other universities, 2 associate professors, and 5 assistant professors. These 8 supervisors are

responsible for 9 doctoral students. A recruitment for a professor of Teaching and Learning with Digital Technologies in Schools has been posted and will be an addition to the group. Deadline for applying is 21st of March 2017 and the plan is that the person will be on site by January 2018.

In Informatics, the team of supervisors currently consists of 3 full professors, 1 associate professor, and 6 assistant professors of which 2 are based at the School of Economics. These 10 persons are directly involved in the supervision of the 8 doctoral students and usually collaborate in joint research project. Other members of the department are involved in research activities, such as seminars, and/or act as opponents/discussants for doctoral students' seminars. These potential supervisors are 1 affiliated professor, 2 associate professors, and 6 assistant professors, including 2 interim positions.

The third-cycle education is tightly coupled to research. All supervisors are active researchers in their respective subject areas, which normally relates to the doctoral student's thesis topic. As discussed, research resources, i.e., internal and external funding of research, are coupled to the performance of senior researchers and doctoral students. However, the active work for a continued organic growth of research activities and resources aims for keeping the ratio of supervisors and doctoral students relatively constant even in the future (approximately one-to-one).

3.2.2 Allocation and Change of Supervisor

The supervisors and the examiner are allocated when an applicant for a doctoral position is enrolled as a doctoral student. The main supervisor is usually determined from the external grant or the faculty funding used to fund the position.

It is quite common for doctoral students to make changes to the supervisor team during their studies. According to Doktorandbarometern, 25% has done so. Such changes have often been motivated by junior supervisors acquiring formal supervisor competence (e.g., becoming associate professors) rather than by problems in the supervision itself. Another reason is that the doctoral student changes his or her research directions slightly and need different or additional competence in the supervision team, or that a supervisor leaves the department. Since doctoral students are embedded in research groups with usually more than one senior researcher, such changes are handled in dialog with the involved.

3.2.3 Professional Development of Supervisors

Senior lecturers/assistant professors are embedded in research groups together with full and associate professors, where they develop their scientific, pedagogic, and leadership competences by learning from examples and in practice.

Each associate and assistant professors is guaranteed at least 20% of full time faculty funding (in addition to external research grants) and full professors are guaranteed at least 25% of full time faculty funding allocated to further develop their competences. This competence development time is used for research, and pedagogic and leadership development. Moreover, supervisors use their competence development time to monitor scientific and societal trends and challenges that touch on their area of expertise. Finally, it is used for additional the responsibilities of full professors to participate in the self-administration of LnU, e.g., to act as a head of subject.

Members of the research groups often collaborate with societal and industrial partners via externally funded projects. This allows for alternative ways to acquire knowledge and further develop analytical skills to tackle and solve societal and industrial related problems.

Finally, associate professors are granted 20,000 SEK and full professors are granted 50,000 SEK to cover additional operational expenses, e.g., for conference attendance.

3.2.4 Efforts to Ensure Quality of Supervision

The supervisory team for each doctoral student consists of a main supervisor, one or two co-supervisors, and an examiner. To guarantee adequate supervision time, each main supervisor is guaranteed faculty funding corresponding to at least 5% of full-time if they supervise one doctoral student and at least 8% if they supervise two or more. The main supervisor can reallocate some or all of these funds or other research and competence development funds to the co-supervisor(s).

The main supervisor should at least be an associate professor, have completed an academic course related to "Supervision in Postgraduate Programmes", and be employed at LnU unless there are specific reasons to deviate from this rule. In some cases, an assistant professor can act as main supervisor as long as an associate or full professor is part of the team, and "supervises" the assistant professor. External supervisor complement the internal supervisor teams when needed.

The team of examiners, who are responsible for giving credits in the program consists of professors or associate professors. An examiner should not be part of the team of supervisors, since their role is different; the examiner follows up the doctoral student's progression and relates it to the Qualifications Ordinance. Earlier and only special cases, e.g., as when there is a lack of competent researchers in a field, the examiner can also act as a co-supervisor. These exceptions are not necessary for the doctoral students enrolled in recent years. It is also recommended that the examiner belongs to a different research area than the doctoral student and supervisors, to avoid bias.

As a formal requirement of FTK, the full funding for a doctoral student must be guaranteed before the position is announced. The funding should be documented and approved by FUR before the position can be announced. An initial ISP must be completed prior to the enrollment of a new doctoral student. Both the financing plan and the ISP are submitted to FUR that reviews the plans and together with the academic qualifications of the suggested supervisors and examiner, their ability, time and resources for managing supervision in relation to their other tasks.

Consecutive revisions of the ISPs are usually prepared jointly by the supervisor(s), the examiner, and the doctoral student. They contain comments and feedback on the process of both supervisor(s) and doctoral student. ISPs are updated annually and approved by FUR. This way, problems in the supervision process are identified and addressed promptly. Any such problem is discussed with all parties involved. Actions can include adjustments in the supervision process, changes in the supervisor team, and (in extreme cases) revocation of third-cycle education resources.

The supervisor teams meet regularly with the doctoral students, to quickly address scientific and supervision issues. The frequency of supervisory meetings depends on the doctoral student's stage in the educational process. For instance, when the doctoral student is writing his or her thesis, supervisory meeting can be twice per week, while in the beginning and/or when taking courses, the meetings usually are once per month. Frequency of meetings also varies greatly between different supervisors, and whether the doctoral student is involved in externally funded projects with regular deliverables. The supervision meetings often involve all (co-)supervisors since these meetings are an opportunity to learn from other supervisors and to become better aligned in the judgments of the doctoral student. The examiner should only attend the yearly follow-up meetings where the doctoral student's progress is discussed as well as the doctoral student's seminars, i.e., research planning, mid-, pre- and examination seminars.

3.2.5 Self-assessment of Staff

The Computer and Information Science third-cycle education rests on the competence of the supervisors. The current supervisor pool includes 7 professors (with 3 more full professors under recruitment),

5 associate professors, and 14 assistant professors. This competence has constantly improved. Several former assistant professors have been promoted to associate professors. There are overlapping and complementary skills of supervisors in each individual doctoral project. Hence, doctoral education projects do not stand and fall with a specific supervisor.

The staff's commitment to the third-cycle education is very high, since it is an integral part of the actual research in our subjects. The research areas cover a substantial range of Computer Science, Media Technology, and Informatics where our researchers have specialized competence, e.g., in visualization, software technology, digital business, and self-adaptive systems. We deliberately choose to not focus on other areas of our subjects, e.g., theoretical computer science, language technology, and e-democracy, and consequently will not supervise doctoral projects in these areas. The scientific skills are, however, currently strategically developed in research areas related to our core competences, e.g., in security and embedded systems, in design of interactive artifacts and services.

The methodological and pedagogical competence is also broad and specialized to the three subjects. Andreas Kerren, Professor of Computer Science, was honored with an award as an "outstanding doctoral student supervisor and pedagogue" at LnU in 2014.

There is space for improvement in the collaboration of the three different subjects. For instance, Informatics is strong in Participatory Design (PD) as a use-oriented approach, with the use of ethnographic studies and participative methods while Computer Science and Media Technology are strong on designing experiments. We address this challenge within "Data-Intensive Sciences and Applications" (DISA, http://lnu.se/disa), a Linnaeus University excellence center on Big Data and data sciences. DISA started in January 2017 and is one of the six excellence research centers at LnU. It was planned by and built around our three subjects. A graduate school connected to DISA will lead to more doctoral projects being co-supervised across the subject boundaries.

Doktorandbarometern elicited doctoral students' opinions on our third-cycle program recently in 2016. For Computer and Information Science the respondent rate was 50%. The overall impression stated in the summary of the report is that Computer and Information Science stands out in a positive way compared to the rest of the doctoral education subjects at LnU, especially, related to supervisors' competence and the supervision processes. The results also indicate that the frequent discussions regarding doctoral students' future career are highly appreciated. Most respondents give our program a high overall score and 100% of them would recommend it to others.

Several doctoral students provided feedback that the form and questions of the ISPs should be improved, and that departmental tasks, such as teaching, should better planned.

In the recent Doktorandbarometern, we can see that the vast majority of doctoral students are satisfied with the supervision they receive. When asked how well would you say the supervision is when it comes to: Choice of doctoral thesis subject, 93% answered Good, Theoretical questions, 93% answered Good, Methodological questions, 100% answered Good, and Constructive criticism, 86% answered Good.

3.3 Third-cycle Program Environment

3.3.1 Third-cycle education width and depth

Senior researchers/supervisors might belong to more than one research group and members of different subjects and research areas collaborate in joint projects, e.g., in a Knowledge Foundation Synergy project on "Software Technology for Self-Adaptive Systems" or in DISA. However, the major part of research and, hence, third-cycle education, is conducted within the specific research fields and the

groups representing them. For the sake of clarity in priorities, each doctoral student belongs to only one group determined by the thesis project topic.

Research is performed by developing and evaluating experimental systems, conducting empirical work, reading and discussing research papers, writing common papers and preparing other presentations of results, discussions in seminars, etc. The participation of doctoral students in these research activities, with gradual increase in independence and responsibility, e.g., first in an observing then in a participating and eventually in a leading role, guarantees *depth* and progress of the research education. It is common that the interests and initiatives of doctoral students in the later stages of their research education open up for novel research questions and even novel directions of their research groups. For instance, without the initiative of Erik Österlund (now with Oracle), the successful research in Garbage Collection would not have started; without Dr. Antonina Danylenko (now with IKEA) we would not have applied our data structures from program analysis to artificial intelligence problems; and the research by Dr. Miranda Kajtazi (now at Lund University) on information security expanded our focus to include cyber security of big data, cloud computing, and their applications.

Complementary courses outside the own research area and interacting with other researchers, industry, and society guarantee the *width* of the education.

3.3.2 Networking and Interaction with Society

Research Schools and Research Education Networks: Since 2002, Computer Science has been affiliated to the Graduate School in Computer Science (CUGS) in Linköping. Some of our previous doctoral students graduated from this school, e.g., Dr. Morgan Ericsson who leads the Software and Information Quality group today. All CUGS courses are open for our doctoral students. Senior researchers also contribute to four CUGS graduate courses: Advanced compiler construction (2002, 2004, 2008, 2010, 2012, 2014), Advanced parallel programming (2003, 2007), Multicore computing (2009, 2011, 2013), Machine Learning — Introduction and Application for Automated Performance Tuning (2012).

Doctoral students from Media Technology have been frequently attending courses and workshops connected to different European graduate schools networks in the field of learning technologies and Advanced HCI (e.g., the Kaleidoscope EU network).

All doctoral students and their supervisors in Informatics are part of the national graduate school in Management and IT (MIT). MIT organizes a conference for all participants twice per year. Most doctoral students actively participate, and supervisors and alumni also attend. Within the MIT Research School there are 30 credits mandatory courses as well as electives available to the doctoral students.

All doctoral students and supervisors in Informatics are encouraged to participate in the annual Scandinavian Conference Information Systems Research in Scandinavia (IRIS). The conference includes traditional conference presentations with senior researcher and working group sessions where each submitted work is devoted at least one hour. Thus, doctoral students get extensive feedback on their research by Scandinavian and international senior researchers and by other doctoral students. This conference is good starting point for students in building Scandinavian and international networks as well as getting knowledge about other research topics, thus, contributing to the width of the subject area in the program.

Industry Network: In 2011, the Department of Computer Science at LnU and other actors in the public and private sectors in Småland founded the Information Engineering Center (IEC, http://lnu.se/iec). Its main goals are competence development, networking, and knowledge transfer between LnU, companies, and public organizations in the region. Doctoral students play an active role in the IEC activities. For instance, one instrument to kick-off common research and innovation between academia and companies/public organizations is the IEC's seed activity; a smaller research and

prototyping activity that could lead to larger project proposals and externally funded research projects. Doctoral students have been intensively involved in such activities when they were in line with their research topics.

Most of the research activities are funded by and conducted in collaboration with industry partners in applied research projects. Partner companies include Danfoss, Eon, Ericsson, Hughes Power Systems, IBM, IKEA, Sigma Technology, Vattenfall, Wexjödisk, Yaskawa, etc., i.e., the full spectrum of smaller and larger companies with IT as their core or an important part of their respective businesses. The doctoral students participate in these applied projects and meet the external partners from industry and the public sector.

Additionally, doctoral students in Informatics form partnerships with companies and organizations for their empirical data collection, e.g., with IBM, CCC, PostNord, university libraries, newspaper businesses, insurance companies, banks and schools. Results are then fed back to these organizations and at times may lead to a joint publication with organization representatives.

Academic Networks: All senior researchers have strong national and international networks from which the doctoral students directly benefit. 79% (resp. 50%) of the doctoral students state in Doktorandbarometern that they have good access to international networks (compared with the national surveys). At times this leads to collaborations between doctoral students from our university and a partner institute. Over the years, joint collaborations of our doctoral students have been established with doctoral students of Groningen University (The Netherlands), York University (UK), KU Leuven (Belgium), Grenoble Institute of Technology (France), Martin Luther University Halle-Wittenberg (Germany), Karlsruhe Institute of Technology (Germany), University of Essen-Duisburg (Germany), University of Business and Technology (Kosovo), Oulu University (Finland), Valladolid University (Spain), National Central University (Taiwan), and University of British Columbia (Canada).

Every doctoral student presents their research results at national and international conferences; expenses and participation is always funded by the respective departments or by the respective research projects. As mentioned previously, the Informatics doctoral students meet at MIT Research School seminars and at the Scandinavian Conference of Information Systems, which give durable academic networks.

A very positive development in the last years is the fact that doctoral students have received several best paper awards at international scientific conferences: ICALT 2009 (Spain), mLearn 2009 (USA), WMUTE 2010 (Taiwan), ICCE 2011 (Thailand), ASE 2014 (USA), and ICCE 2016 (India), which increase visibility of their research and, which is also a witness of the quality of our research education.

The doctoral students are also actively involved in conference and workshop organization. A recent example is the annual international conference Dilemmas in Human Practice, organized at LnU in Autumn 2015. This way the doctoral students come in contact with the broader scientific community and also with international experts in their own research field, besides getting exposed to conference organizing—a likely future activity particularly if they are to remain in academia.

Doctoral students have also been invited to Dagstuhl Seminars, where world-leading experts meet to discuss specific topics. A crucial advantage of such activities is that they often result in conference papers and/or journal articles together with these experts. Such experience and contacts are invaluable for their future career.

Finally, we encourage our doctoral students to search for and apply to international doctoral courses of their interest, within budget limits, and also to Doctoral Consortia related to well-known conferences. Two doctoral students, one for Computer Science and one from Media Technology just got accepted to the Young Researchers Forum at ICSA 2017.[5] Such activities have shown earlier that

[5] http://icsa-conferences.org/2017/call-for-papers/young-researchers-forum/

they contribute to the doctoral students' academic network, both with industry, senior researchers, and with other doctoral students.

Double degrees with partner universities: We currently do not offer double degrees in third-cycle education. However, several students have a joint doctoral supervision with other partner universities. Currently, one student has a joint supervision with Groningen University (The Netherlands), two others have a joint supervision with KU Leuven (Belgium). In the past, one doctoral student already received degrees from both LnU and the Technical University of Kaiserslautern (Germany). We have gained very positive experiences with joint supervision and we plan to establish similar doctoral student settings in the future. We are currently part of a pilot project at LnU to offer double-degrees together with KU Leuven.

3.3.3 Seminars in the Environment

Research In Computer Science (RICS) is seminar series, recurring every month on Wednesdays, organized by the Computer Science department. RICS features talks from national and international guest researchers as well as from doctoral students. The seminars are intended among other things to provide doctoral students with opportunities to discuss research ideas with a broader audience of researchers or to present conference talks and to get feedback prior to the actual event.

Media Technology organizes a similar monthly research seminar where their doctoral students present results and get feedback.

Informatics Research Seminars are recurring on Thursdays once per month. The head of subject plans the seminars every semester. Doctoral students and senior researchers as well as national and international guest researchers are invited.

While the seminar series are managed by a department or research group, they are announced to and open for all doctoral students and senior researchers. The seminars are intended both to share research work among everyone in the environment and to other doctoral students, and to provide doctoral students with opportunities to discuss their respective research with a broader audience outside of their supervisory team. It is generally voluntary to present in the seminar series, but we require students to hold research proposal seminars, licentiate pre-seminars (or mid-seminars for doctoral students that do not do a licentiate thesis), and doctoral defense pre-seminars. We also recommend doctoral students to hold seminars to prepare for conference presentations. In addition, for Informatics, doctoral students and supervisors attend the MIT graduate school conference twice per year, where doctoral students present their research and progress, and review and comment on other doctoral students' research.

3.3.4 Doctoral Student Group Composition

In total, we have 30 doctoral students in Computer and Information Science (one of these started Jan 1, 2017). A full list of the doctoral students can be found in Table 1a. Two of the doctoral students have successfully defended their licentiate theses (See Table 1b). While it is recommended, many students skip the licentiate thesis. According to Ladok, an additional seven are 50% or more done, and eight are 80% or more done. An additional student has defended her licentiate thesis during 2017 and one more has reached 50%.

Gender balance: While the number of doctoral students has increased significantly, their distribution has not changed significantly over the last 15 years. A majority of the students is male (approximately 2/3). The gender balance is good in Informatics, but much lower in Computer Science (about 15%).

The dominance of male doctoral students is a challenge. Since the beginning of third-cycle education at LnU, we have applied affirmative action for female students if the qualification between candidates was comparable. This has not affected the gender distribution significantly. We mitigate this challenge by engaging our research and doctoral students in multidisciplinary and cross disciplinary projects with subjects that have the opposite gender distribution challenge (e.g., Humanities, Social Sciences). Additionally, the gender (un)balance is similar in the respective subjects' first- and second-cycle education why we see actions are needed in earlier educational phases and with a wider societal perspective.

Prior education: In Computer Science and Informatics, it is common that the students hold a master's degree in that subject. In Media Technology, most students have a master's degree in another IT-field, for example Computer Science. A little more than half of the students (16/30) did their first- and/or second-cycle education at LnU (including Växjö University or Kalmar University). Informatics has the most students continuing to a third-cycle education (7/8), while approximately only 40% of the doctoral students in Computer Science has a first- or second-cycle degree from LnU and only approximately 20% of the doctoral students in Media Technology.

The homogeneous level of prior educations simplifies the planning of research educations. However, we also welcome input from other research disciplines via our multidisciplinary research projects.

Co-location with supervisors: In Computer Science and Media Technology, about half the students are not co-located with their supervisor. This is in part due to LnU's two campuses, but also due to supervisors with multiple affiliations. Not being co-located with the main supervisor can be a challenge. Since LnU has two main campuses, in Växjö and Kalmar, we have established general ways of efficient remote collaboration in education, research and research education. Supervisors and doctoral students travel regularly and visit each other. As for seminars, we use Polycom, Adobe Connect or Skype to enable distance participation. In addition, we have some remotely located supervisors who spend a part of their time at LnU on an individual basis (from 5% to 20%). Doctoral students of these supervisors spend a relevant part of their time at the host institution of the supervisor (from 20% to almost full time).

Other aspects of doctoral student group composition: Most of the students are between 20 and 40 years old, but about 20% of the students are older than 40. The majority of the students is not Swedish. Almost all students have a master's degree.

English is the main language in our field. LnU offers Swedish courses that are taken by the international doctoral students and are commonly accepted as part of the third-cycle education curriculum by the examiners.

The activity of each doctoral student does vary from 0% to 100%. In the total composition of students there are several factors affecting the activity level. Reasons for low activity are often due to parental leave, sick leave or exceeding departmental tasks. Since some doctoral students do part-time work this also affect the activity level.

3.3.5 Supervisors Group Composition

The full list of supervisors, including external, and how many students they supervisor are available in Table 2. The full list of researchers is available in Table 3. Some of these other researchers have previously supervised students or supervise students at other universities.

The gender distribution challenge discussed for doctoral students also apply to the supervisors. For example, a majority of the supervisors is male (approximately 5/6). Just like in the doctoral student composition, Informatics has a gender balance, while Computer Science has 10% female supervisors and Media Technology has none.

Most of the supervisors are between 30 and 50 years old, and the rest are older. About half of the supervisors are non-Swedish, but many of the non-native supervisors are able to speak Swedish. Almost all supervisors have a doctoral degree in an IT-related field. There are 10 post docs and research assistants in the environment.

3.3.6 Systematic Monitoring of Third-cycle Education Environment

Several instruments for quality assurance of third-cycle education complement each other and together guarantee a high quality of our research environment and our research education. In addition to what is mentioned in *Governance and Organization*, we highlight the following quality assurance instances. The systematic monitoring is also further described in *Design, Teaching/Learning, and Outcomes*.

- Supervisors, responsible for the scientific quality of research questions addressed and the progress of the doctoral student.
- External reviewers of conferences and journals, responsible for the significance, originality and technical correctness of scientific results.
- Audience in internal research seminars and at conferences, responsible developing the ability to defend the research results.
- Examiner, responsible for approving the scientific quality of doctoral courses and studies.
- Opponent at Licentiate, tests the achievements at the 50% landmark.
- Opponent at pre-final research seminars, tests that the thesis is ready to be presented at the dissertation seminar.
- Opponent of dissertation seminar, tests if the doctoral candidate can defend the research results with an expert in the field.
- Grading board of the dissertation seminar, discusses and finally approves (or disapproves) the quality of a thesis as a third-cycle education level achievement.

3.3.7 Self-assessment

Third-cycle education is characterized by scientific depth and progression along the course of studies. This is assured by the tight coupling of research and research education. Networking with national and international academic partners and collaboration with industry and the public sector provide a broad spectrum of skills and knowledge beyond the actual research topics of the doctoral students.

However, the spectrum of standard third-cycle courses offered regularly at LnU could be broadened. Therefore, as part of the Linnaeus University Center DISA, we currently build a graduate school in Big Data technologies with a core of 7 doctoral students that are funded by DISA and enrolled at (almost) the same time. It will be complemented with other doctoral students funded by the faculty, or external projects. Each research group participating in DISA will offer at least one advanced level courses on, e.g., High-Performance Computing, Machine Learning, and Visual Analytics. Since DISA is a cross-faculty center, the range of third-cycle courses will even include subjects introducing to Computational Social Science, Data Analysis in Astrophysics, and Digital Humanities.

There are different seminar series in the three subjects which fulfill the purpose of stimulating scientific discussions in the research subjects beyond the individual research groups. However, the

participation of teaching staff has not been ideal. A high work load is probably the explanation to a relatively low participation in doctoral students' seminars by teachers who are not directly connected to any of the supervisory teams. Additionally, the interest for presenting own research has been low. Therefore, we need to address this by identifying incentives for the participation of teachers.

A further field for improvement is organizing seminars and discussions involving doctoral students and seniors between the three subjects. Also, there is space for improvements in gathering information about available third-cycle courses at university level and making them easy to find.

The diverse and international background of the doctoral student and supervisor groups in our research environment is considered an asset rather than a challenge. It has considerably contributed to the international alignment and success of our research. The dominance of male doctoral students and supervisors in Computer Science and Media Technology is a challenge and has been discussed already.

Our quality assurance systems monitor the third-cycle education environment systematically as a whole and are set up to guarantee high quality of this education. They also see the doctoral students as individuals and aim for a creative and healthy work and study climate for students and senior researchers. Issues are detected early and resolved, if possible, in consensus with all involved parties. Where this is not possible, the students' interests have high priority.

4 Design, Teaching/Learning, and Outcomes

There are many activities that are part of a third-cycle education of our subjects including the following:

- Taking courses
- Attending and presenting at seminars
- Writing papers and articles
- Attending and presenting at scientific workshops and conferences
- Planning research and writing research proposals
- Departmental tasks
- Writing a thesis
- Defending a thesis

These activities to contribute to a third-cycle education design as well as the assessment of progress and outcomes. The activities form the basis for the outcome matrix attached to the ISP as discussed in Section 2 (*Governance and Organization*), where each distinct activity is mapped to outcomes in the Higher Education Ordinance and the ASP.

The remainder of this section outlines how and what activities are mapped to which outcomes in general. Note that, since the education is individual and there is only one mandatory course, the actual activities (including the courses) mapped to a specific outcome will differ between doctoral students.

The outcome matrix is maintained by the doctoral students and their supervisors, and it is followed up on a yearly basis by FUR. It is our main instrument to track a student's progress in terms of the outcomes.

4.1 Knowledge and Understanding

For the doctoral degree, a doctoral student must:

(a) show broad knowledge in and a systematic understanding of the particular field of research and their subject in general, as well as an in-depth and genuine specialist knowledge within a defined part of the field of research; and
(b) show familiarity with scientific methodology in general, and with the specific research area methods in particular.

Broad and in-depth knowledge of the subject is acquired via third-cycle courses. Another way to acquire a broad understanding is from the environment. Each doctoral student is part of a research group, and as described in Section 3 (*Environment, Resources and Area*), the research groups within the third-cycle subject area cover a wide range of different domains, research focus, and research methods. The doctoral students are part of many collaborations between groups and external projects with industry, societal or academic partners. This exposes the doctoral students to a broad perspective, which allows them to form a broad and systematic understanding of their subjects and research fields.

Another way to acquire both broad and in-depth knowledge is through teaching. Most doctoral students spend 20% of their time in various courses that are related to, but often not exactly identical to their research topic. Teaching helps the doctoral students develop a deeper knowledge of a field since they have to structure and present it so that others can understand and learn.

The foundations of the scientific method are included in the compulsory "Philosophy of Science and Ethics" course. LnU offers other courses that cover aspects of the scientific method, for example statistical methods. All doctoral students in Informatics are part of the MIT graduate school, which includes compulsory courses on both qualitative and quantitative methodologies. Many doctoral students also follow courses offered by other universities, attend summer schools, or take part in Massive Open Online Courses (MOOC). All students are provided with funding (40,000 SEK/year) that can be used to attend courses or summer schools; doctoral students enrolled in the MIT graduate school get additional funding (50,000 SEK/year; 90,000 SEK in total).

The seminar series, as well as scientific conferences and workshops, help build broad and in-depth knowledge and familiarity with scientific methods in practice. These expose doctoral students to other researchers' use of methods, which may be different from their own.

Many of the senior researchers review papers and articles for conferences and journals, and often involve doctoral students as part of these tasks. This gives the doctoral students an opportunity to reflect on method use and documentation and to discuss it with fellow students and senior researchers (who co-review the paper or article). Some research groups also have reading circles that are open to all senior researchers and doctoral students, where they read a paper, and then meet and discuss it. These activities are often converted into recurring courses.

Most of these activities have some formal assessment, for example, courses have some kind of examination, paper reviews written by doctoral students are reviewed by the senior researcher, and so on. In cases of seminars, and conference and project participation, we rely on observation and discussion to assess the outcomes.

4.2 Competence and Skills

For the doctoral degree, a doctoral student must:

(a) demonstrate the capacity for scholarly analysis and synthesis as well as to review and assess new and complex phenomena, issues and situations autonomously and critically;
(b) demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work;
(c) demonstrate through a dissertation, the ability to make a significant contribution to the formation of knowledge through his or her own research;
(d) demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialog with the academic community and society in general;
(e) demonstrate the ability to identify the need for further knowledge; and
(f) demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity.

The doctoral student is the project manager for their thesis project. At the start of the project, the supervisor team are very involved in planning and management, but their involvement is reduced over time and their role changes from supervision to advice-giving. A general rule is that once a doctoral student is about half-way done, they should be able to manage their thesis project.

We mainly address the outcomes listed above through active supervision. The team of supervisors and the doctoral students work together on problems, often within a project with external parties, and the supervisors teach the doctoral student how to, for example, plan an experiment, find related work, make ethical judgments, etc.

We strongly encourage doctoral students to publish scientific papers and to do a licentiate thesis, since this is a good way for the doctoral student to learn (a)–(e) and for the supervisor team to monitor their progress. A student that publishes a paper is expected to both attend the conference and to present the findings. They are encouraged to do a trial presentation as part of the seminar series to get feedback. We expect students to actively participate in internal seminars and offer feedback, and to actively participate at conferences and workshops by asking questions or discussing results with other researchers to address (d).

We also encourage students to participate in outreach activities such as *Forskarfredag* and *Forskar-Grand Prix* as well as industry networks and events, such as Software Technology Exchange Workshop (STEW) to address (f). Several doctoral students have participated in, e.g., *Forskar-Grand Prix*, with good results; they have been nominated to the national finals in Stockholm and one student gave the second best presentation there. Departmental tasks such as teaching also address (f).

The ability of a doctoral student to plan and manage their thesis project is regularly assessed. A project often has multiple deadlines and milestones per year that are set by the student and the supervisors, e.g., paper deadlines or deliverables in projects. The ISP is used to plan the project and is followed up on a yearly basis by FUR. The ability to discuss and present research results is assessed through observation at seminars and conferences, and formally assessed during the licentiate and doctoral theses defenses. We use external opponents for the licentiate seminars to prepare students to for thesis defense. Similarly, (a)–(e) are assessed by scientific publications (and their reviews) as well as the licentiate and doctoral theses.

4.3 Judgment and Approach

For the Degree of Doctor the third-cycle student shall:

(a) demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics; and
(b) demonstrate specialized insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used.

The compulsory course "Philosophy of Science and Ethics" presents a broad picture of research ethics. General ethical considerations are also discussed and dealt with in supervision meetings. The ethical considerations are especially addressed at the seminars when the thesis is examined (planning, mid and final seminars). In the ISP, an ethical assessment of the work done and planned is required. Specific ethical issues depend largely on the thesis topic. For example, in cases where the research relies on human subjects, ethical issues must be discussed in more detail. Even if a doctoral student's research work that is fundamental and far from a direct application contexts, the student needs to provide arguments for why those issues do not apply.

Ethics aspects are also discussed when reading or reviewing other scientific publications.

We rely on courses to show an in-depth insight into the possibilities of science and its limitations, its role in society, and the individual's personal responsibility for how it is used. For example, specific courses on, e.g., complexity theory, statistics, simulation technology, modeling and abstraction, software analysis, perspective on science and research, help form an understanding of possibilities and limitations. Similarly, participation in projects where research results are applied to real-world problems can show both possibilities and limitations, and form the basis for such discussions.

Finally, licentiate and doctoral defenses address questions and comments related to the limitations of the work, its impact on society, and so on.

Apart from the thesis defense, there is no formal assessment of these outcomes. The supervisor teams observe the students and their progress, and help address any ethical issues.

4.4 How do we ensure that students complete their studies in the allotted time?

As partially discussed before, the resources for doctoral studies must be available before any employment of a doctoral student and they cannot be revoked easily, e.g., as a consequence of negative research evaluation of the supervisors involved.

Due to the very close research collaboration between supervisors and doctoral students, the supervisors have a clear understanding about the progress and can react early in case of delays.

Also, the activity-outcomes matrix gives an overview of the achievements of the doctoral student, which makes it easier to see approximately where in the process of reaching different goals the doctoral student is.

There is a great flexibility between third-cycle education (usually 80%) and other activities (usually 20% teaching). This is used to keep doctoral students busy in periods with little progression in the research education, e.g., at the beginning of studies when the right approach to the research topic has not been found or towards the end, when the doctoral students wait for the results from a journal/conference or the thesis revision processes needed to fulfill the formal requirements of a dissertation. On the other hand, when the doctoral student is close to finishing the thesis writings, we plan that the departmental tasks do not interfere and slow down the writing process. If things do not work according to plans within the scheduled time, solutions are found with the interest of the doctoral student as a starting point. Further, in exceptional cases, extra study time may be allocated.

Both doctoral student and supervisors can report issues in the individual study plans and deviations from the original plans are tracked there as well. Since each ISP is revised annually, issues between supervisors and doctoral students are at least discovered then. This leads in general to individual discussions with the persons involved in order to understand the root cause of the issues and to moderated group discussions in order to resolve the problems, e.g., the introduction of extra supervisor help or even the change of supervisors. In these discussions, it is possible to involve the director of third-cycle education and the research secretary.

ISPs with minor changes and without major issues reported are approved by FUR. Otherwise, FUR initiates a process to find a solution. The head of the respective subject, who is by default a member of FUR, owns the process and discussions with supervisors and doctoral student are triggered. Potential measures, e.g., the extension of supervisor group, the change of the main supervisor, or a tighter follow up regime, are documented in the ISP by the main supervisor before it is resubmitted for approval by FUR.

If the progress is, after all measures and adjustments, still insufficient for achieving the final goal of a doctoral thesis, the expectations can be lowered to Licentiate thesis as the final goal. In extreme cases, the employment of the doctoral student is not extended. If a doctoral student has not made any substantial progress in eight years, even the resources for conducting the doctoral studies, such as, e.g., office space and access to supervisor competence, can theoretically be withdrawn (this never happened since LnU was formed).

4.5 How do we assure the quality of theses?

All doctoral theses are based on work that was checked for quality by having it successfully published in peer-reviewed journals and conferences. As a strong recommendation for defending a monograph thesis, the material should have appeared in at least one journal article and at least three conference papers. For a compilation thesis, the strong recommendation is two-three journal articles and at least two-three conference papers. The exact number can vary depending on the quality of the journals and conferences, and the length and depth of the submission.

Besides a sufficient number of peer-reviewed publications, formal requirements also include the ASP activities and outcomes for doctoral studies at our faculty as discussed under ISP. It is worth noting again that the roles of the supervisors and the examiner are separated: while the supervisor guides the student towards the doctoral degree, the examiner checks and approves the formal requirements for allowing a doctoral thesis to advance to the dissertation seminar. During the process this is done by approving the planned and later passed courses.

The final seminar is the ultimate filter before the dissertation seminar. The seminar and the discussion is led by an internal or external opponent who is not the examiner and who is not part of the supervision team. Informatics always has an external opponent, and sometimes an additional internal as well.

Based in the outcome of the seminar, the examiner and the supervisors team together with the internal/external opponent discuss and decide that either:

(i) the candidate is ready for the final public defense seminar,
(ii) the dissertation requires minor changes before the candidate can defend (which can be handled by the main supervisor), or
(iii) the dissertation requires major changes, possibly based on additional research, before the candidate can defend.

In case (iii), more time and resources might be needed before the thesis can reach the quality to be promoted to the dissertation seminar. Then, the head of the respective subject and the head of the respective department get involved. They discuss with the supervisors and the student if and how the work could be completed. The head of department is responsible for the documentation of the discussion and its result. The main supervisor is responsible for those decisions to be filed in the ISP. The doctoral student may then with the approval of the supervisor go for a new final seminar.

The date of public defense is determined when the thesis quality is judged to meet the quality criteria. The revised dissertation requires approval from the examiner. When all the criteria are met, it still requires a formal approval by FUR (due to the local regulations for education at third-cycle level) independent of supervisors, examiners, and internal/external opponent, before a PhD thesis advances to the dissertation seminar.

4.6 Self-assessment

In recent years, extensive work has been carried out to ensure that postgraduate education is of high quality. This included a quality system where responsibilities, (sub-)goals and processes are regulated.

The major part of the research education is conducted in the actual research groups with increasing responsibility of the doctoral student for the research activities in these groups. These activities are complemented with courses from the graduate schools and networks and individual courses helping students develop the necessary depth in their knowledge of computer and information sciences and with a compulsory course on scientific methods. The development of a broader portfolio of our own optional standard third-cycle education courses is currently subject of intense development work within the frame of our DISA graduate school.

The doctoral students graduating from our program fulfill in our opinion very well the educational outcomes of documenting actionable knowledge and understanding of the research subjects and their scientific methods. Doktorandbarometern asked several questions regarding the outcomes. 73% of the students agree that the third-cycle studies have improved their ability to perform tasks within a given time frame. The vast majority of students (87%) indicate that they presented and discussed research findings nationally or internationally. Most (60%) doctoral students feel that they become intellectually independent researchers. The ethical assessment permeates many parts of the third-cycle education program. However, it shows that only 50% of the doctoral students feel comfortable concerning making ethical judgments. One possible explanation is that 25% of the respondents is in the beginning of their studies and mostly rely on supervisors. Nonetheless, it is evident that we need to put in effort to strengthen their knowledge and self-assurance as to make ethical judgments as they continue with their studies. Many (80%) also say they have developed insights into the possibilities and limitations of science. The doctoral students are asked to assess the third-cycle education program and the majority (80%) expressed that they have developed insight into the possibilities and limitations of science. Most (93%) also think that the third-cycle education program has given them the opportunity to contribute to the learning of others. All doctoral students specifically value the seminar culture, experiencing that the discussions as constructive and engaging.

The ISPs clearly plan for and document progression. Therefore, ISP documents have defined and iteratively adapted and improved of several versions in the last ten years. The latest ISP version plans the means of how each (sub-)goal should be achieved in the next year and assesses the degree of achievement of the (sub-)goals of the previous. There is, however, space for improvement regarding the adoption of ISPs by students and their supervisors as a planning and documentation tool in between the annual report dates. It is important to consider the ISP documentation process from several perspectives so that it becomes a valuable planning instrument for the doctoral students and their supervisors.

As it is now, it is often regarded as a kind of required documentation for administrative purposes. We had several information meetings and discussions about the ISP template and based on that there have been adjustments. The ISP template has been revised on several occasions and we are now working to explore the possibilities of a digital ISP. This in order to facilitate the work, and to customize the template for the needs that doctoral students, the supervisors and the administration have.

Reviewers give feedback at all stages of the third-cycle education process, with their reviews of the student's scientific papers, applications for fellowships, traveling funding, research proposals, and at the Licentiate and doctoral defense seminars including pre-seminars. This guarantees that a doctoral student completing our program has been accepted by the research community. Conversely, it is not possible to complete our program without positive feedback and acceptance from the research community.

Participation in internal seminars and at national and international conferences as well as publications in peer-reviewed conference proceedings and journals is mandatory and have a funding guarantee: either by the faculty, the department, external sources or the research project/group that the doctoral student is member of. Several papers with a doctoral student as the main author have won "Best Paper Awards" at international conferences, and many doctoral students collaborate on publications with doctoral students and senior researchers based in other national and international academic institutions that they met at e.g., conferences and seminars, or corporate people which they have become acquainted with through their empirical research. We see the fact that such collaborations have emerged as an indication of well performed presentation of own research, that has gained interest for further interaction and collaboration.

The doctoral students are put in several contexts which involve planning and carrying out tasks within given time frames. The different steps of producing scientific results and publishing these, eventually in a doctoral thesis, are central. In general, a doctoral student finishes on time, which shows that they are able to reach the goals of our third-cycle education program within the allocated budget. The throughput statistics that we have access to show that the total study time for most doctoral students do not exceed the planned time. The average time of study for doctoral students is 12 semesters (including departmental tasks, parental leave, etc.), but the net time of study is four years on average. In cases where the study time exceeded the stipulated, the reasons varied from personal problems to difficulties matching work outside of academia to their studies.

Due to more, and ever increasing, complex requirements of academic careers and the high needs for qualified IT experts in industry and the public sector, doctoral students face more complex challenges during and in parallel to their studies. When the planned schedule is not followed this often is due to the increased complexity of doctoral studies and career planning besides and after these studies, more seldom due to personal reasons. In case of personal reasons, these relate often to illness or planned leave, such as parental leave. The student is then compensated for this absent period so such reasons do not affect the total effective time for which resources are allocated.

While our processes work well in spotting and addressing heavy deviations from the plans, smaller delays that usually have good reasons but eventually sum up are harder to counteract. Handling this issue requires responsible doctoral students and insightful and reflecting supervisors and members of FUR. We also see that a careful doctoral selection process and more time and incentives for supervisors and board members is the way forward to address this issue.

The third-cycle education program brings together senior researchers and supervisors with doctoral students from different fields of Computer Science, Informatics, and Media Technology. Ethical and attitude questions are broadened up and discussed in official seminars but also in informal discussions. This way, our doctoral students develop their ability to become critical intellectually independent researchers. The open and friendly atmosphere contributes to this learning outcome.

5 Working Life Perspective

5.1 Relevance of the Education to the Changing Work Sector

As discussed before, most research activities involving our researchers and doctoral students are applied. They are funded by and conducted under participation of industry partners in applied research projects. The doctoral students participate in these applied projects and meet the external partners from industry and the public sector. This way they understand and learn to meet the real-world requirements for the short-term applicability of results, agile planning, short delivery cycles etc. The feedback from external parties are for some projects organized in, so called, consultation meetings three-four times per year to update the partner company about activities and progress and to ensure that our program is relevant and up to date for their interest.

More experienced doctoral students are encouraged to even take the lead in IEC seed activities with industry and the public sector (also described before).

The main problem is actually that doctoral students in IT subjects have job offers from academia and industry before their doctoral exam. Regardless of favorable the job market situation in the IT industry, this also shows the high relevance of our third-cycle education. This is guaranteed even in the future due to our supervisors being well connected in IT industry. This way, they sense trends in industry and receive concrete job offers for industry positions targeting their doctoral students.

Supervisors are also well connected in academia and in their international scientific communities and sense research trends and receive concrete job offers for post doc or junior faculty positions targeting their doctoral students.

Longer stays and studies in national and international partner research groups prepare many of our doctoral students for a professional life in academia after their third-cycle studies. This is the most common job market, particularly, for doctoral students in Informatics. Therefore, all our doctoral students are encouraged to take courses on pedagogy for higher education and teacher training courses, get involved in funding applications, engage in administrative boards representing doctoral students, take part in organizing conferences, seminars and workshops, act as reviewers, etc. Likewise, collaboration in applied research projects with industry or even an employment at companies in parallel to third-cycle studies—that some doctoral students prefer over teaching obligations—prepare for a professional life in in industry after third-cycle studies.

5.2 Alumni

The departments of Computer Science and Media Technology have their own registers of alumni PhD students. For the department of Informatics, the MIT graduate school that all their students are affiliated to maintains a common register of alumni. A general doctoral association at Linnaeus University with an organized alumni network is about to be created. Alumni are invited to the MIT graduate school yearly seminars, often offered funding grants to be able to attend.

All our seminar series regularly feature presentations of our former doctoral students. By these events, current doctoral students and seniors get the possibility to keep contact with alumni and get tips and feedback on their own research.

Each supervisor has close contact with previous doctoral students and consider them for additional collaboration projects and guest lectures/research seminars. The most common question in the opposite direction from the former doctoral student to the former supervisor regards suitable candidates for recruitment.

Some alumni are nowadays colleagues at our departments of the computer and information sciences at Linnaeus University or at other universities. For instance, Dr.Ilir Jusufi is now assistant professor in Media Technology after his PhD studies in Computer Science and a post doc visit at UC Davis.

5.3 Departmental Duties

Most students have certain departmental duties alongside graduate studies. Activities outside research include teaching, administration, working in companies. The amount of these activities is 20% (rule) up to a maximum of 50% (exception).

Almost all doctoral students have teaching obligations between 20% rarely up to 50% of their workload. All graduate students employed by the university are offered this opportunity. This way the graduate program also prepares for a later lecturer position. The doctoral students support our Master's and Bachelor's programs, in lab courses and seminars and (co-)supervise Master's and Bachelor's students. Ideally, though not always possible, these teaching obligations are connected to the research subject and the corresponding research courses. For instance, a doctoral student in program analysis or garbage collection is ideally responsible for the Master's level courses on applied program analysis and compiler construction, checks the programming assignments, and supervises corresponding undergraduate thesis projects.

Moreover, not all elective third-cycle courses for 86 credits must be directly related to the research subject and/or the dissertation. The examiner can also approve e.g., Swedish or English language courses or other academic courses. Also, the examiner can approve courses related to developing the pedagogical skills. Both, language and pedagogical skills, are highly relevant for good performance in most departmental tasks.

5.4 Systematic Performance Evaluation

In connection with the annual revision of the ISP, the departmental tasks are followed up as well. This way, these tasks can be aligned with the needs of the doctoral student and research subject, e.g., concerning time allocation during the year.

As a part of the staff, the doctoral student also has the annual performance talk with his/her department head. Due to the Local regulations for third-cycle education the doctoral student need to fill in if he/she had appraisals or not with their manager in the ISP. The research administration is not engaged in this, but ensures it is implemented or not. When it comes to carrier guiding in the ISP, we refer to LnU career in the template.

5.5 Self-assessment

Third-cycle education in Computer and Information Science works well as preparation for a working life in industry as well as in academia. Due to our applied research directions and common projects with industry, our doctoral students come in contact early with industry requirements on knowledge and skills and ways of working in industry. Moreover, the ASP aims in many respects at developing generic skills, which make our graduates employable outside academia. Doctoral students working in industry in parallel to their studies usually have a hard time to finish their studies in time. However, there is a trade-off between such delays and the benefits of such a parallel employment, e.g., smooth transition to a working life after the studies and more practical relevance in the research approaches

and results. We think therefore that extra effort and delays could be accepted if doctoral students are well-informed about these challenges and risks.

Besides the relevance and the quality of our research, departmental tasks are an essential element in the preparation for a working life in academia. Based on our monitoring, the workload in departmental tasks is perceived as quite high, especially, in the light of high time and performance pressure due to scheduled courses and demanding students. It seems important to achieve a better balance and matching between departmental tasks and third-cycle education. This appears to be the most critical point from our own evaluation.

One area that can be developed is alumni activities. While we have registers of our alumni and regular dialog with them, the alumni relations should be organized more formally. It would be useful to develop activities more systematically, e.g., to continuously collect the alumni perspective on strategic decisions and to develop the brand.

6 Doctoral Student Perspective

6.1 Involvement of Doctoral Students in Their Own Education and Overall Research Environment

In general, supervisors support doctoral students in their development as independent researchers but becoming an independent researcher is very much a personal maturation process. In this supervisory process, supervisors learn from their doctoral students as much as the doctoral students learn from them. Close collaboration and communication with the doctoral students positively influences the learning process.

The planning of third-cycle studies is organized jointly by the doctoral student and the supervising team. Doctoral students participate in many formal and informal decision processes: they are partners in research groups and projects, there is dialog and joint planning.

However, eventually, usually after the Licentiate thesis, the doctoral student takes full responsibility for their thesis project. Changes in the doctoral thesis topic and goals due to doctoral students' increasing knowledge and change of interests are common rather than an exception. Any such changes in the supervision process are formalized in the ISPs and, which then are discussed in the annual ISP meetings.

They are also responsible for the agenda at the supervisor team meetings recurring more frequently. They influence which items are of highest importance at the moment for discussing and feedback. Normally, the agenda involves reporting on activities since the previous meeting, planning activities before the next supervisory meeting, and discussion additional issues such as interesting courses to attend, conferences, departmental tasks, physical workplace issues etc.

The working situation for our doctoral students is overall good. Students have offices with ergonomic furniture and access to modern hardware/software infrastructure, e.g., each student gets a new computer at the beginning of their studies, which can be replaced after a number of years if needed. Due to space limitations, some doctoral students have to share offices, which can be difficult at times when a student is in a writing, reading, or reviewing process and does not want to be disturbed. Students determine their working time and their office hours by and large only restricted by classes, meetings, and other appointments. Student mobility is encouraged, e.g., funded visits at partner universities, when these fit the students' needs.

The doctoral students at occasions have their own meetings, both of social character and for supporting each other, sharing knowledge and experience in doing research. There have been discussions

of organizing in social media networks e.g., a LinkedIn group, to have more structured contacts and information sharing, also with PhD alumni.

Each semester the director of third-cycle studies, the faculty administrator and the research secretary invite new doctoral students to a meeting, and present the administration who works with the third-cycle education, give general information, responsibilities and rights, and discuss any issues. The HR-department has its own meetings several times per semester where information on personnel-related issues is presented, and doctoral students can participate.

6.2 Systematic Performance Evaluation

In the ISP, the doctoral student gives personalized feedback about the supervisor, the supervisory process, and the third-cycle education. They can also provide anonymous feedback in the Doktorandbarometern. Moreover, there is doctoral student representation in FUR (one representative) and on the faculty board (two representatives). This way attention is given to doctoral students' needs in leadership and all relevant formal processes.

In addition, the head of the Informatics department has annual meetings with the doctoral students to learn about their working situation, workplace environment, etc. Supervisors do not attend these meetings, in order to give space to the doctoral students to openly express their views. In addition, if there are any issues, the faculty organization provides support, as does the HR-department.

According to the Doktorandbarometern, 75% of the doctoral students state they know who to turn to when they have questions about their education, and 64% if any issues arise. Currently two of our doctoral students are on partial sick leave. Rehabilitation plans are defined and followed up in meetings involving each doctoral student, the head of the department and a consultant from HR-department.

6.3 Self-Assessment

There exists an open and inclusive communication climate in our research environment in general and including the third-circle education. This is also acknowledged by all of our doctoral students in Doktorandbarometern. The doctoral students' views on various issues are always taken into consideration. Doctoral students also have two representatives in the faculty board, which leads to the students' views and wishes to be seen and discussed in a formal setting. As far as possible, decisions and measures for positive changes for the doctoral students are implemented.

The combination of formal and informal influence of doctoral students is important. It works well for influencing content and processes of the students' coursework and research tasks.

Evaluation shows that doctoral students are by and large positive about their education and the environment it is conducted in. Departmental tasks and parallel work in industry are perceived as stressful and are matters of future improvements. The provided resources are largely equivalent for each doctoral student and meet their needs.

7 Gender Equality Perspective

7.1 Gender Equality Perspective Integrated in the Programme Design and Activities

In Computer Science and Media Technology subjects, male students are over-represented and, consequently, so are they also among the doctoral students and supervisors. With similar qualification, we take affirmative action to employ female doctoral students and senior researchers. The situation is more balanced when looking at Informatics.

Swedish language and culture courses for international doctoral students can be part of the third-cycle education, if so desired. LnU organizes similar courses for non-Swedish supervisors. This way recruitment of international doctoral students and supervisors are supported especially from countries with a more balanced gender distribution in the Computer Science subjects, e.g., in Eastern Europe and Asia.

Our Linnaeus University excellence center DISA is a chance to multidisciplinary collaboration with research subjects that have the opposite challenge of gender balance. This paves way for achieving a more balanced gender distribution in these multidisciplinary research groups.

Although we believe that the research education subjects as such are gender neutral, challenges might occur due to differences in interaction and communication. Whether these are formed by gender or by personality is hard to say. Mitigation of possible issues is an ongoing challenge. What we can do is to strive towards gender balance in supervisory teams and research groups.

On a larger scale, the IT industry and Computer Science/Media Technology research groups constantly seek qualified researchers. Attracting more female doctoral students is one way of addressing this issue. This, however, is a societal issue.

A suggestion for addressing this challenge is forming role models. If females are more visible, this should attract more females to the area. This might be an explanation why the Informatics subject has a more gender balanced staff and doctoral student composition; two of the three professors are female, as well as one of the two associate professors.

7.2 Systematic Performance Evaluation

We get the statistics about the gender balance and, hence, the awareness, via the HR department, the Doktorandbarometer, and, for undergraduate students via LnU's admission office. We follow up on these statistics in the faculty board.

It is always checked that equality prevails (if possible) in connection with formal processes and boards, e.g., the composition of supervisor teams, dissertations and examination committees, as well as, reviewer groups for promotions and employments. Additionally, if a female candidate applies for promotion or for a position, at least one reviewer must be female.

7.3 Self-assessment

Female associate professors and professors in Computer Science, Informatics and Media Technology are congested as a result of our striving on equal representation in all boards, bodies and commissions, not only at our university but in Sweden in general. This might have the counterproductive effect of delaying, e.g., recruitment and promotion processes of female candidates. Being caught up in administrative boards takes time from research meriting. Given the recruitment basis in Sweden and internationally, a completely equal distribution of doctoral students, supervisor and examiner groups in our research education subject is not realistic even in the near future.

The number of female associate professors and professors and thus potential principal supervisor and examiners needs to be expanded. There is a university program, designed to support female researchers' qualifications, and these and similar efforts need to be intensified.

8 Challenges and future tasks to improve the quality of our third-cycle education

Research education within Computer and Information Science at Linnaeus university started in the early 2000s. During the last 17 years, it has grown and developed to become a sustainable research environment consisting of more than 35 senior researchers involved in research and supervision activities and 30 doctoral students.

We have identified a number of distinct issues and challenges in this report that should be addressed to further improve the quality of our research education. Below we enumerate the most important of these and provide and outline improvements to address and remediate those.

Development of a common series of research seminars for all doctoral students independent of subject and department (Computer Science, Media Technology and Informatics). The current series of research seminars is organized individually for the subjects. To better promote interaction between doctoral students and supervisors across the subjects, and to support collaborative knowledge building, a new structure for common seminars will be developed. An additional goal of this series of research seminars will be to give all doctoral students a better feeling of identity in relation to their third-cycle education program. The head of subjects together with the director of third-cycle studies and two doctoral student representatives will work on this activity. These actions will start during the academic year 2017–2018.

Development of a core module of compulsory courses in the program to provide a common foundation to all doctoral students. Three new courses will be developed addressing the following aspects:

1. Research methods in Computer and Information Science
2. Evaluation, Assessment, and Validation Techniques
3. Doctoral thesis writing

The DISA graduate school will contribute with additional data science technology and application third-cycle courses that will be open for all doctoral students of our subject area. The DISA board is addressing these issues during 2017.

Conceptualize, develop and implement a strategic plan to increase the number of female doctoral students to join our research education program in the near future. Our formal evaluation and quality assurance systems follow up on the activities addressing these questions, goal achievement in all its aspects, particularly on ability to holistic thinking and making judgments on societal good, but it is not easy to assess and our approach could be improved.