

Universitetskanslersämbetets utbildningsutvärderingar

Självvärdering forskarutbildning

Lärosäte	LULEÅ TEKNISKA UNIVERSITET
Forskarutbildningsämne	GRÄNSYTORS KEMI (CHEMISTRY OF INTERFACES)
Licentiatexamen	JA
Doktorexamen	JA

Bakgrundsinformation

De högskolor som har ett område för forskarutbildning, inom vilket ett forskarutbildningsämne som ska utvärderas ingår, beskriver det område ni har examenstillstånd inom och hur forskarutbildningsämnet förhåller sig till detta område.

Highlights

Research Subject: As stated in the description of the research subject Chemistry of Interfaces (Col) at Luleå University of Technology (LTU), "Chemistry of Interfaces deals with both experimental and theoretical aspects of the heterogeneous processes that occur at interfaces between liquid, solid and gas phases, as well as with the development of novel surface-sensitive analytical techniques for studying these processes at the molecular level." The research subject Col was established at LTU in late 2006, and since then twelve doctorate and nine licentiate theses have been defended.

Supervisory Resources: The subjects' supervisory resources have varied over the years as between two and four professors/associate professors are eligible per year to be principal supervisors and examiners of graduate students. The systematic strategic work at Col at developing the research and teaching competences among young faculty members has resulted in three more associate professorships in the research subject, thus, there are currently four in total. Researchers and post-doctoral research associates (PDRAs) are also actively involved in training and co-supervision of graduate students at Col.

Number of Graduate Students: Over the years, the number of active graduate/PhD students varied between one and five each year, depending on the external and strategic funding. From March 2019 until August 2020, there were no active PhD students at Col, which was a critical weakness. Since the funding situation has improved there is, however, now a positive development. One graduate student was enrolled for PhD studies in August 2020 and he is included in this assessment. Two more graduate students (one for a double PhD program), will join the Col group in 2021. The strategic ongoing work is to secure more external funds and to enrol more graduate students at Col.

General Study Plan (GSP) and Individual Study Plans (ISP): The formal document describing the main requirements for graduate studies in Col is the General Study Plan (GSP). Every PhD student is supervised by a minimum of two supervisors (the Principal and the Assistant supervisors) during their entire period of graduate study. The latter usually runs for four years (240 hp credits in total with a minimum of 60 hp for graduate courses and 180 hp for the PhD thesis work), but can be extended to a total of 4.5 – 5 years depending on the teaching duties (ca. 10-20% of time) of the graduate students in a variety of chemistry courses at LTU. Another important document for every PhD student is the Individual Study Plan (ISP), which is templated following the same criteria as outlined in the second part of this self-assessment document. The ISP is created and signed by all supervisors and

the graduate student upon her/his admission, and then followed up, updated and revised a minimum of once a year and before the Licentiate and PhD theses defences. The ISP is a “living” document that directs, controls and highlights the professional and personal development of the graduate student and his/her contribution to the progress of research project(s). The role of the ISP as a working tool for quality assessment of the graduate studies at Col is discussed in detail below.

Teaching at the Undergraduate and Graduate Levels: All faculty members and graduate students are involved in teaching of basic and project chemistry courses for engineering programs at LTU. The level of teaching duties for faculty members ranges from 15 to 80% and from 5 to 20% for graduate students. The graduate students hold tutorials, supervise undergraduates during their laboratory work and perform chemical shows for high-school pupils visiting the campus during “LTU open days”. These teaching activities are important to strengthen the graduate student’s own supervisory competence and to improve their pedagogical skills in teaching and transferring knowledge. The teaching duties also strengthen the postgraduate education by promoting in-depth learning of theories, as it is required to lead discussions in tutorials and answer on questions during the laboratory exercises. The acquired experience in teaching is regarded as a prerequisite for a successful graduate education and a future career of graduate students in academia.

Scientific Equipment and Laboratories at Col are “state-of-the-art”. This both strengthens and facilitates the laboratory research projects in which Col’s graduate students are actively involved. Graduate students are learning the theory, methodology and operation of the scientific instruments by attending specialised graduate courses. These courses are taught by experienced scientists from Col and other research subjects within the Division of Chemical Engineering (DCE). Graduate students at Col obtain their “driver’s licenses” to operate different scientific instruments through these courses. They are also given the responsibility of assisting other researchers and PDRAs at Col with measurements when needed. A common thread throughout the third level education in Col is progression in learning of new methodologies and scientific instruments by graduate students to achieve high-quality results in their research projects needed for Licentiate and PhD theses.

Historical Background

Before 2006 there were three research subjects in the Division of Inorganic Chemistry: Inorganic Chemistry, Analytical Chemistry and Physical Chemistry. Inorganic Chemistry and Physical Chemistry were given a new focus as Chemistry of Interfaces (Col) in 2006 and Oleg N. Antzutkin was recruited as chaired professor to lead the subject. The chair for Col has been held by Antzutkin since then. Following LTU’s policy in 2008-2012 to consolidate its research portfolio, the three named subjects were gradually “merged” into Col. Most PhD students registered in Inorganic Chemistry, Physical Chemistry and Analytical Chemistry before 2006 have, after receiving their Licentiate of Technology degrees, transferred to Col and defended their PhD theses in Col. Over the years, since the late 1990s, our success in attracting external funding has been shaping both the research focus and the enrolment and education of new graduate students, first to obtain their Licentiate of Technology and then their PhD degrees (see **Table 1**).

Table 1. PhD and Licentiates of Technology theses defended since the establishment of the research subject Chemistry of Interfaces at Luleå University of Technology in 2006. The last three PhD theses (in squares) are included in this evaluation (see also **Table 1b** in Appendix for details).

No.	Year	Degree	Name	Title of the thesis
1.	2006	PhD	Daniela Rusanova-Naydenova	An NMR Synopsis of the Coordination Chemistry of Copper(I) Dithiophosphate Clusters. (2006 Best PhD Thesis at LTU, “Bergforsk”)
2.	2006	PhD	Andreas Fredriksson	Kinetics of Collector <i>in-situ</i> Adsorption on Metal Sulphide Surfaces Studied by ATR-FTIR Spectroscopy
3.	2006	PhD	Dan Sandström	Solid State NMR Studies of Synthetic Mineral Surfaces
4.	2006	PhD	Mathias Jarlbring	Surface Reactions in Aqueous Suspensions of Fluorapatite and Iron Oxide
5.	2007	Licentiate	Payman Roonasi	Adsorption and Surface Reaction Properties of Synthesized Magnetite Nano-particles

6.	2008	Licentiate	Xiaofang Yang	Interactions Between Iron Oxides and Silicates
7.	2009	Licentiate	Faiz Ullah Shah	Boron Compounds as Additives to Lubricants: Synthesis, Characterization and Tribological Optimization
8.	2009	PhD	Payman Roonasi	Sorption Reactions Between Ionic Species and Magnetite in Aqueous Solution
9.	2010	Licentiate	Andrei Filippov	Synthesis and Aggregation Studies on Amyloid Oligomers of Alzheimer's A β Peptides
10.	2010	Licentiate	Rickard Jolsterå	Reactions at the Water-Mineral Interface of Olivine and Silicate Modified Maghemite
11.	2011	PhD	Xiaofang Yang	Interaction of Magnetite with Soluble Silicates and Bentonite: Implications for Wet Agglomeration of Magnetite Concentrate
12.	2011	PhD	Faiz Ullah Shah	Designed Boron Chemistry for Tribological Systems
13.	2012	Licentiate	Mamoun Taher	Novel Boron Compounds in Lubrication
14.	2012	PhD	Rickard Jolsterå	Surface Reactions of Magnetite and Maghemite with Dissolved and Added Ions in Process Water. (<i>Best PhD Thesis at LTU, "Bergforsk"</i>)
15.	2012	Licentiate	Alexander Goryan	Nuclear Magnetic Resonance Studies on Bentonite in Complex Mixed Systems
16.	2014	Licentiate	Vasantha Gowda	Combined Experimental and Theoretical Studies on Dithiocarbamate Complexes of Yttrium, Lanthanum, and Bismuth
17.	2015	PhD	Mamoun Taher	Orthoborate Ionic Liquids for Lubricated Interfaces
18.	2015	Licentiate	Mylène Trublet	Outline of Titanium(IV) based H ₂ SO ₄ Ion-exchangers: Kinetics and Sorption Models
19.	2016	PhD	Andrei Filippov	Self-diffusion and Microstructure of Some Ionic Liquids in Bulk and in Confinement
20.	2017	PhD	Vasantha Gowda	Experimental and Computational Magnetic Resonance Studies of Selected Rare Earth and Bismuth Complexes
21.	2018	PhD	Mylène Trublet	Titanium(IV) Phosphates: The Next Generation of Wastewater Sorbents

Long Established Research Areas

The Col's research profile has emerged from the traditional area of research on minerals and surface chemistry at the Division of Inorganic Chemistry led by Prof. Willis Forsling. The research of Forsling included external funding of 42 MSEK from The Swedish Foundation for Strategic Research (SSF) and industrial partners LKAB and Boliden organised within the Agricola Research Centre (ARC), which was established at LTU in the late 1990s. A large proportion of the ARC budget was allocated to salaries of young researchers and professors actively involved in supervision of graduate students. The ARC programme successfully resulted in ten PhD theses and degrees (five at the Division of Inorganic Chemistry). The research areas of mineral surface chemistry, organometallic chemistry and studies of adsorption/desorption processes from mineral surfaces were, therefore, naturally acquired by the Col group from the Division of Inorganic Chemistry and the ARC (**Fig. 1**, orange circles). These areas of research have been continuously supported by external and LTU internal grants ever since (see **Fig. 2**, orange circles) including:

- Hjalmar Lundbom Research Centre at LTU, 100 MSEK donation from LKAB 2004-2014
- VINNOVA and the mining industry (LKAB, New Boliden, Lundin Mining), the so-called ARC-2-MMS Centre at LTU in 2008-2013 (14.3 MSEK grant coordinated by Col)
- The Centre for Advanced Mining and Metallurgy (CAMM-1) at LTU funded by the Swedish State (80 MSEK, 2010-2015 and 80 MSEK, 2016-2020, partly funding work within Col)
- The Research Council Formas and New Boliden (3.4 MSEK, 2013-2017 and 3 MSEK, 2019-2021)

Despite our strong research traditions, which secure external funding, there are obvious risks for Col to "be trapped" in old research themes, which may lead to stagnation and application-oriented or a "R&D"-type research more suitable for industry. On the other hand, novel ideas may bring new,

exciting applications directly to our industrial partners, such as New Boliden and LKAB. As has been proven over time, Col's graduate students are "generators" of novel ideas, which have even led to patents.

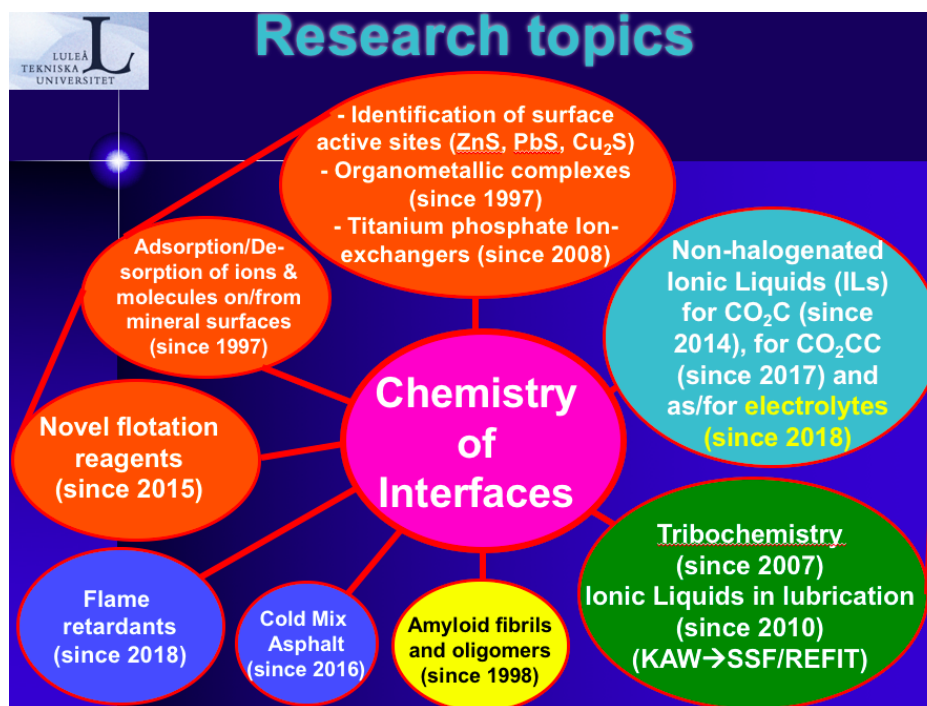


Figure 1. Research areas and projects run at Chemistry of Interfaces

Emerging Research Areas

After one year of sabbatical as a researcher at the National Institutes of Health, USA (July 1998 – June 1999), Antzutkin brought a new research field to LTU, supramolecular solid-state nuclear magnetic resonance spectroscopy and its application in the structural elucidation of Alzheimer's amyloid fibrils and oligomers (**Fig. 1**, yellow circle). This research was supported by external funds from NFR and later the Swedish Research Council (VR) and Kempe Foundations (**Fig. 2**). These research projects have generated more than 20 peer-reviewed articles in world-leading chemistry journals with impact factors of up to 15, such as *PNAS* and *ACIE*, among others. Research within this area resulted in a number of MSc theses (in collaboration with the Division of Physics at LTU) and one Licentiate of Technology at LTU (Andrei Filippov in 2010) (**Table 1**). The research findings in this and other related topics have been highly appreciated by the scientific community, resulting in many oral talks and posters at different national and international conferences. The publication in *ACIE*-2014 (in collaboration with Prof. Torleif Härd's and Prof. Niels Ch. Nielsen's groups and groups at the University of Warwick) on the structure of toxic oligomers of Alzheimer's amyloid-beta oligomers was especially well-received, with great interest also from the general public. The work was featured on TV and in newspaper reports in the Norrbotten County media. This is an example of high impact of research results obtained by a graduate student at Col both in the scientific community and in the wider society.

Another example of initiation and development of a completely new research area under the umbrella of Col are the research topics of "Tribochemistry" and "Ionic Liquids" (**Fig. 1**, green and light-blue circles). In 2007, Col initiated a fruitful collaboration with another research subject at LTU, Machine Elements, within the research area of tribochemistry — which studies lubrication and chemical processes between lubricated contact pairs. The initial exploratory work was done by a graduate student under shared supervision by Col and Machine Elements, and without any external funding. The results obtained were so encouraging that we submitted a patent application (approved in 2011) prior to a number of peer-reviewed publications in well-recognised chemical and tribological journals.

The graduate student has since successfully defended both a Licentiate and a PhD theses on the subject. This is an illustrative example of how enthusiastic graduate students can successfully serve as a driving force for research and innovation at Swedish universities. Later on, Col's research profile expanded to other applications of Ionic Liquids and Ionic Materials, such as non-flammable electrolytes for lithium-ion batteries (funded by The Swedish Energy Agency for the LTU-Chalmers consortium, 5.6 MSEK, 2019-2022). Our most recently recruited new PhD student, Mukhtiar Ahmed (**Table 1a** in Appendix), is funded to work on the project studying non-flammable electrolytes for lithium-ion batteries. One more PhD student is under recruitment in another related project recently funded by Formas, 2021-2024. This research area of the Col group is now extending further into other applications, such as the use of green ILs for carbon dioxide absorption and conversion into useful organic compounds, such as oxalic acid, which can be used in the synthesis of bis(oxalato)borate-based ionic liquids for tribological and electrochemical applications (**Figs. 1 and 2**, blue circles).

It is also worth mentioning the "flame retardants" project (**Figs. 1 and 2**, dark-blue circles). This project has its roots in a fruitful collaboration with La-Trobe University, Australia, on solid-state NMR studies of adsorption-desorption of organic substances on soils. Lately, phytic acid has been a research focus within the scope of this collaboration. While teaching undergraduate courses for the fire engineering programme at our department, Col's faculty members (Anna-Carin Larsson and Anuttam Patra) devised the ingenious idea to test phytic acid as a flame retardant. A few diploma students have been supervised by Col to test the idea. The results presented in the BSc and MSc diploma were very encouraging and created the basis for two new research projects funded by "Brandforsk". Thus, a new, emerging research area was recently established within the Col group. We hope to attain more funds to enable enrolment of graduate student(s) to work in this research area and further linking the graduate and undergraduate education at Col.

These examples highlight the major importance of so-called "free research" in Swedish academia, i.e., the use of internal faculty and strategic funding for pilot projects and that MSc and PhD students are actively involved in testing of new research ideas at Col. LTU has recently approved internal strategic funding (56 MSEK in total, 2020-2024) for two new strategic research areas (SRAs): CREATERNITY and SUN – Natural Resources for Sustainability Transitions. These SRAs will financially support new pilot projects at LTU, co-fund PhD students who will be enrolled in two PhD schools in these SRAs, organise workshops and other activities to stimulate the development cross-disciplinary collaborative projects and new strategic research infrastructures at LTU, and attract more external funding. The Col group is already actively involved in CREATERNITY and our recently admitted PhD student will be joining the CREATERNITY PhD activities, such as specific graduate-level courses in sustainable economy, green chemistry and energy, etc. This initiative will strengthen the quality of the PhD education in Col by facilitating and increasing direct communication with graduate students and researchers from other research subjects at LTU.

Research Projects at Col in Collaboration with Industry

In addition to our trustful partners in industry since 1990s, such as New Boliden and LKAB, Col is open to creating new contacts with industry, where topics in surface and interfacial chemistry may assist in solving technological problems. A "cold-mix asphalt" research project funded to Col by Formas within one of their strategic initiatives in 2016-2017 is a good example of how a research project can emerge from the needs of industrial partners (**Figs. 1 and 2**, dark-blue circles). In 2015, Col was contacted by the LTU-Business team, which then organised a workshop meeting with the industrial partners Nynas AB and NCC. The theme was "cold-mix asphalt" as a new energy-saving technology. However, problems with controlling the chemistry, the coalescence and setting of bitumen emulsions on the ballast material often occur depending on the nature of the ballast material used in the cold-mix asphalt. This topic is squarely within the research area of Col. In collaboration with the Division of Soil Mechanics at LTU, we received a grant from Formas Research Council for research on cold-mix asphalt and established a fruitful collaboration with the industrial partners Nynas AB (manufacturer of bitumen emulsions) and NCC and PEAB (road and paving construction companies). There is an ongoing dialogue between Col and the industrial partners regarding enrolment of an "industrial" graduate student, who could perform research in the named project. However, financial difficulties at Nynas due to reconstruction of the company in 2020, have postponed the original plans.

Unforeseen changes in company's economy and strategies create uncertainties in Col's plans for these types of contacts, which are useful for the graduate studies. It is still unclear to us how to deal with such weaknesses in the future concerning PhD education and industry partners.

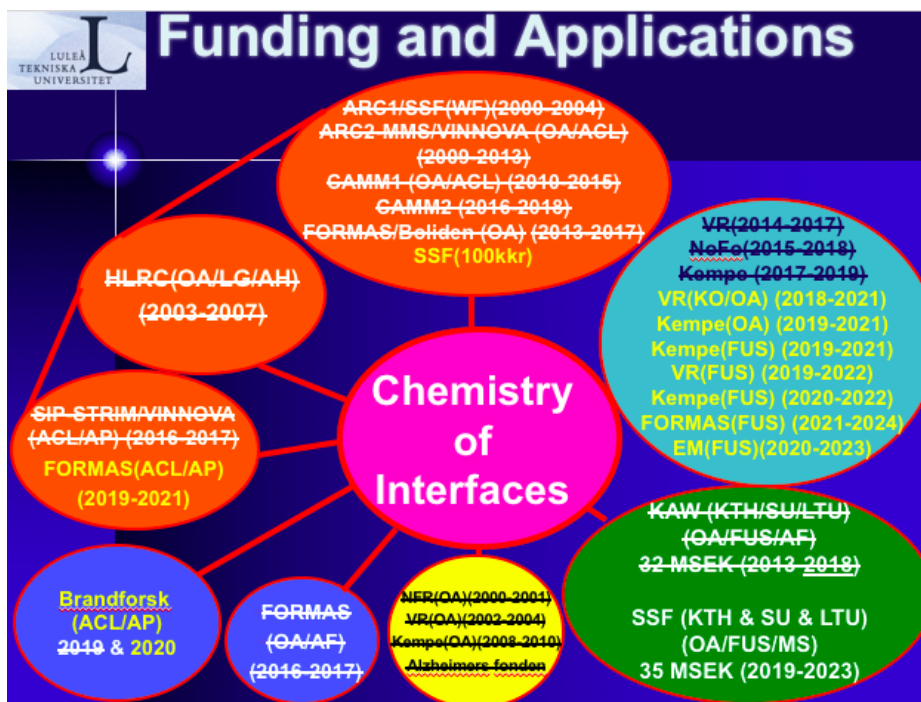


Figure 2. Research grants in the corresponding research areas (in Fig. 1). Crossed over text corresponds to completed and reported projects.

Förutsättningar

Personal

Bedömningsgrund:

Antalet handledare och lärare och deras sammantagna kompetens (vetenskapliga/konstnärliga, pedagogiska) är adekvat och står i proportion till utbildningens volym, innehåll och genomförande på kort och lång sikt.

The Col Group Composition Currently, the Col group consists of one (chair) professor (Oleg N. Antzutkin), three associate professors (Lars Gunneriusson, Anna-Carin Larsson and Faiz Ullah Shah), one university lecturer (Dr. Eva Gunneriusson), three researchers (Drs. Andrei Filippov, Anuttam Patra and Manishkumar Shimpi), three PDRAs (Drs. Inayat Ali Khan, Preeti Jain and Sourav Bhowmink) and one PhD student (Mr. Mukhtiar Ahmed) (see **Tables 2** and **3** in Appendices). One more PhD student, Ms. Pengpeng Fan, has received a PhD scholarship from the government of P.R. China to join the Col group for 1.5 years to earn a double PhD degree at both LTU and Nanjing University of Science and Technology. However, her travel to Sweden and enrolment at LTU have been postponed until spring 2021. One more PhD will be recruited in 2021 with recently (November 2020) received funding from the Swedish Research Council Formas (**Fig. 2**, blue circle).

All senior researchers (professor and associate professors) within Col have undergone formal training in PhD supervision through courses on research supervision and research education provided by Professional Services at LTU. These courses address themes such as rules and guidelines, gender

and diversity in postgraduate education, learning goals and individual study plans, ethics, supervisor role, relationship supervisor and doctoral student, tutoring, etc. PDRAs and researchers at Col actively participated in writing grant proposals to different funding agencies. If funded, these will form the basis for new academic positions at Col. There are also strategic internal funding programs at LTU supporting talented young researchers. Two of Col's associate professors (Anna-Carin Larsson and Faiz Ullah Shah) have built their academic careers via such strategic investments. Recruitment of a new chair professor will, in agreement with LTU's general policy, be initiated at least two years before the current chair's planned retirement (2030) to ensure a smooth transition.

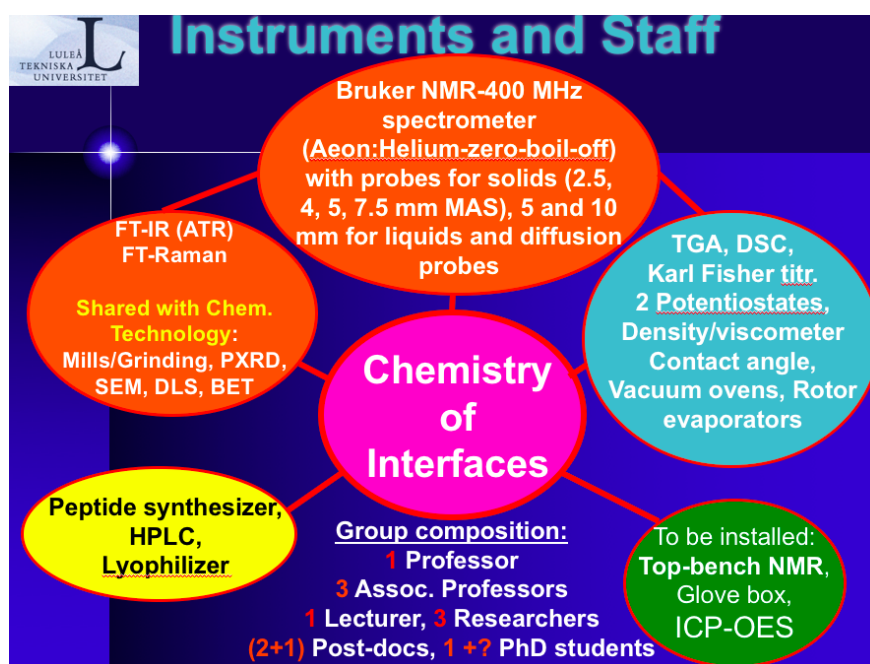


Figure 3. The Col group composition in November 2020 and scientific instruments from research grants won and operated by the Col group in laboratories at the DCE.

Supervisory Capacity The Col group has the workforce and combined competences suitable for supervision and mentor support of at least four PhD students, such that every professor and associate professor will serve as the principal supervisor for one PhD student and as the assistant supervisor for an additional PhD student. The supervisory capacity of the group is secured at a level of four professors/associate professors for the foreseeable future. By 2023, one of our associate professors will reach retirement age (see **Table 2** in Appendix). The other (three) professors/associate professors have 10 or more years before they reach retirement age. Two of the group's associate professors will soon apply for full professorship in Col. The number of active PDRAs with different and complementary competences in physical chemistry, electrochemistry, organic chemistry and chemistry of materials (see resumes below and **Table 3** in Appendix) is also ideal for co-supervision, consulting, mentoring and training of four-five PhD students. Each PDRA could be a mentor for at least one PhD student, assisting the main supervisors in research project design, coaching of the synthetic work, operating scientific equipment, analysing the results obtained and jointly writing research papers. Hence, it is clear for all colleagues that the Col group will need at least two-three more PhD students to achieve a favourable balance between the number of supervisors, PDRAs and PhD students. Our PhD students are appreciated as laboratory and teaching assistants in undergraduate courses for different engineering programmes and, hence, there is also a departmental and divisional interest in growing the number of graduate students within Col. The courses our graduate students are engaged in are General Chemistry, Physical Chemistry, Water Chemistry and Inorganic Chemistry. All senior researchers are actively writing and submitting grant proposals to

Swedish Research Councils, agencies and foundations in order to win additional external funding needed for recruitment of new PhD students.

Weaknesses and Challenges An obvious weakness in our research environment is the current low number of PhD students, not only within Col, but also within the whole Division of Chemical Engineering (DCE). However, the situation is improving with additional graduate students being enrolled during 2020-2021. One of the main challenges is the fact that we must keep a “critical mass” of competences in the research environment, by maintaining a reasonable large group of staff, while also securing funding for PhD students. The salaries of academic faculty members at LTU are partly covered by the university, with the extent of coverage related to their level of engagement in undergraduate teaching. Consequently, each faculty member must secure external funding to cover his/her research costs and part of his/her employment costs, which is a challenge that must be dealt with before securing funding for PhD students. Another challenge is the cost associated with hosting advanced research instrumentation. A substantial proportion of the faculty support received by Col is used for payment of laboratory premises and service agreements for scientific instruments, reducing the possibility of the subject to self-fund PhD students. Therefore, in addition to the financial support for PhD positions provided by the university, which covers ca. 40% of the required amount, two grants are usually needed to cover the costs for one supervisor and a PhD student. After economic challenges in 2017-2018, the Col group has managed to stabilise the group’s economy and secured salaries for all current faculty members until at least 2023-2024. We are now actively working on securing additional external funding primarily to enable recruitment of new PhD students.

The Col Group Competences Below are research biographies of all current members of the Col group including their experience in supervision and mentorship of PhD students. In recruitment of PDRAs and PhD students, we consider their competences and track-records with respect to suitability for specific research projects currently running at Col. We also consider the complementary skills needed for synergy within the research environment and mentorship of PhD students within Col, as well as in other research subjects at the DCE.

Faculty Members Eligible to Supervise PhD students (Prof. and Assoc. Prof.)

Oleg N. Antzutkin (OA) is Professor and Chair in Chemistry of Interfaces since 2006. OA is also, since 2015, an Honorary Professor at the University of Warwick, UK. In 2020 he was listed among the top 2% of the world’s leading scientists.[#] OA received his Licentiate of Technology in 1992 in the field of structure and dynamics of radicals trapped in freon matrices as studied by ESR spectroscopy and optically detected (OD) ESR, and a PhD in Physical Chemistry in 1996 on methodological and theoretical developments in magic-angle-spinning solid-state nuclear magnetic resonance (NMR) spectroscopy under the supervision of Prof. Malcolm H. Levitt at Stockholm University. Directly after his PhD, OA obtained a university lecturer position at LTU where he established a solid-state NMR laboratory. Between July 1998 and July 1999, OA spent a one-year sabbatical at the National Institutes of Health, USA (host Dr. Robert Tycko). The five papers generated from this period have been cited more than 2900 times (ISI Web of Science, 2020-11-24). OA’s main areas of research experience are methodology development of surface-sensitive solid-state NMR and their application in biomolecular systems (amyloid fibrils and toxic oligomers), as well as chemistry of interfaces and coordination chemistry, studies on phosphates, flotation reagents and polymers adsorbed on mineral surfaces. Since 2007, his research has also focused on synthesis, tribological and spectroscopic studies of novel, efficient and environmentally friendly boron compounds as ionic liquids and as additives to lubricants. OA has published about 200 articles in peer-reviewed scientific journals, a few book chapters, been granted nine national and international patents, and received a number of prizes, such as Kungliga Skytteanska Samfundets prize to a young researcher (in 2001) and “Hugo

[#]Antzutkin’s C-score = 3.536004815, 183 papers (1990-2020), ranked 647 (totally 57598), Inorganic and Nuclear Chemistry. (refs: <https://journals.plos.org/plosbiology/article/file?id=10.1371/journal.pbio.3000918&type=printable>
https://drive.google.com/file/d/1bUJrvurVVbBxSI9eFZRSHFif7tt30-5U/view?fbclid=IwAR0B6QQzrahBrFJltD6J7-Ln_zn2kuJ-Sz2YQPHn_5KVC3ANNMTInW_ufus)

Theorellpriset” of the Swedish Biophysical Society (in 2004). OA is currently the work-package leader and a member of the steering group for the REFIT project funded by the Swedish Foundation for Strategic Research (SSF) (2019-2023, 35 MSEK). The REFIT project is a collaboration between LTU, KTH and Stockholm University and a continuation of the highly prestigious I-LEAP project previously funded by the Knut and Alice Wallenberg Foundation (2013-2018). As a principal supervisor OA has successfully supervised nine PhD (one at the University of Warwick) and 10 Licentiate of Technology students and over the last 23 years taught 65 undergraduate and graduate courses in physical and general chemistry, spectroscopy, biophysics, etc. at LTU and abroad (University of South Australia).

Anna-Carin Larsson (ACL) is since 2015 an Associate Professor in Col. After defending her PhD in Physical Chemistry at LTU in 2004 (solid-state NMR, coordination chemistry, awarded the prize of “Best PhD Thesis at LTU” by “Bergforsk”), ACL worked as a researcher in the same field for one year before joining the Department of Education, LTU, for a lecturer position in Chemistry and Physics for teacher-students. ACL has an MEd degree in Chemistry and Philosophy and is also a certified teacher for upper secondary school. In 2007 she returned to Col as project leader in different mining research programmes, restarting her research career. ACL was promoted to associate professor in 2015 and is currently project leader for research projects funded by Formas (selective collectors for flotation) and Brandforsk (environmentally friendly flame retardants). ACL has been involved in the supervision of seven PhD students and has also supervised eight BSc and MSc thesis projects, mainly within fire chemistry. Over the years, ACL has been extensively involved in teaching including, among other things, as an examiner and lecturer in High School Chemistry for the preparatory year (teknisktbasår) since 2008 and for the introductory course for Chemical Engineering students (which include theory of science and research ethics). ACL has also developed a PhD course in Lab Safety (2015).

Lars Gunneriusson (LG) is since 2011 an Associate Professor in Col. After defending his PhD in inorganic chemistry at Umeå University in 1993, LG was employed as a university lecturer in inorganic chemistry at LTU. LG’s area of research is within adsorption processes and surface complexation modelling as well as in biohydrometallurgy. LG is the director for the Masters Programme in Sustainable Process and Chemical Engineering and is examiner and teacher in undergraduate courses in introductory, solid state, water and inorganic chemistry. LG has previously been a principal and an assistant supervisor of two PhD students. He has also been a principal supervisor for numerous Masters theses.

Faiz Ullah Shah (FUS) is since 2018 an Associate Professor in Col. He received his PhD from LTU in 2011 and since 2013 has been working as an independent researcher leading his own research team within Col. FUS has external experience working at the Department of Chemistry, Lund University Sweden and the Department of Chemistry, Monash University Australia. His research is focused on the synthesis, characterisation and interfacial behaviour of novel functional ionic liquids for various energy-related applications such as CO₂ capture and conversion to useful chemicals, friction and wear reduction and electrolytes for batteries and supercapacitors. Over the past seven years, he has received research grants of >17 MSEK as a main applicant and >9 MSEK as a co-applicant. FUS has published more than 50 research papers and obtained eight patents. He has supervised three postdoctoral researchers as a principal supervisor and one PhD student as an assistant supervisor. FUS’s current research team comprises one PhD student and two postdoctoral researchers. In addition, he supervises bachelors and masters students (mostly for the fire-engineering program) on a regular basis. FUS has been involved in teaching in many courses and remained an examiner for a new course “Batteries for a Sustainable Society: from Raw Materials to Battery Cell”. The latter course is taught in collaboration with Uppsala University and Northvolt.

Researchers and PDRAs as Mentors for PhD Students

Andrei Filippov (AF) is since 2008 a researcher in Col. AF is also a Leading Researcher of Research Laboratory of Magnetic Radio Spectroscopy and Quantum Electronics at the Kazan Federal University (Kazan, Russia) and Professor of the Department of Medical and Biological Physics at the Kazan State Medical University (Kazan, Russia). He obtained his PhD (Dynamics of molecules and phase transformations in polymer mixtures) at the Department of Molecular Physics of Kazan State University (1985-1988). In 2001, he moved to Sweden as a research fellow at the Department of Biophysical Chemistry, Umeå University. There, AF worked in the field of NMR diffusion study of lipid

membranes under the supervision of Prof. G. Lindblom (2001-2007). AF's main areas of research are molecular mobility in complex and heterogeneous systems, such as mixtures of polymers, molecular liquids in confinement (porous glasses, zeolites, and porous rocks), ionic liquids in bulk and in the confinement, surfactants and lipids suspensions, biomembranes, peptide-biomembrane systems. AF is also an expert in solid-phase synthesis of peptides, peptide purification and characterisation. AF has published 112 articles in peer-reviewed journals and books. AF has supervised three PhD students who received their doctoral degrees at Kazan Federal University. AF has been involved in teaching of courses in Physical Chemistry (LTU), Colloid Chemistry (LTU), General Chemistry (LTU), Medical Physics (Kazan Federal University) and Basics of NMR (Kazan State Medical University).

Manishkumar R. Shimpi (MRS) is currently a researcher in Col. MRS completed his PhD in 2010 at the National Chemical Laboratory, University of Pune, India, where he worked in the areas of development of supramolecular complexes and coordination assemblies by molecular recognition studies. MRS' competence covers chemical characterisation techniques, primarily X-ray diffraction supported by various spectroscopic and thermal techniques such as TGA, DSC, NMR, IR, Raman UV-Vis, etc. After completing his PhD, MRS was awarded a postdoctoral fellowship within the Erasmus Mundus External Cooperation Window India4EU project in Sweden in 2010. During his postdoctoral training, he gained experience handling nanomaterials and pharmaceutical solids under the supervision of Prof. Olof Ramström (KTH) and Prof. Sitaram Velaga (LTU). MRS joined Col as a PDRA in 2014. Presently, MRS is working in the REFIT project funded by SSF (2019-2023) with a focus on the synthesis of high-purity, non-halogenated orthoborate ionic liquids as advanced lubricants. Since 2017, MRS is also involved in teaching of undergraduate courses (tutorials in general chemistry) at LTU and in mentorship and supervision support of PhD students in FT-IR and Raman spectroscopy for the entire DCE. MRS also trains all other users of these instruments at LTU.

Anuttam Patra (AP) is a researcher at Col. After his BSc and MSc studies, AP was engaged in research projects with Prof. Santanu Bhattacharya at the Division of Chemical Sciences, Indian Institute of Science, Bangalore. In 2004, he moved to Australia to undertake his PhD with Laureate Prof. John Ralston and Dr. Rossen Sedev. AP received his PhD in Applied Science: Materials and Minerals [2004 –2011] from Ian Wark Research Institute, University of South Australia on "Design of pyrimidine-based photoresponsive surfaces and light induced wettability control". AP joined LTU in 2008. His present research interests involve development of novel mineral specific flotation reagents and environment friendly flame-retardants. AP is intensively involved in teaching in various undergraduate and postgraduate courses. He has supervised several undergraduate and postgraduate students (in exchange programs with Turkey) during their laboratory-based projects.

Inayat Ali Khan (IAK) is since 2019 a PDRA in Col under the supervision of Assoc. Prof. Faiz Ullah Shah. IKA received his MSc degree in Analytical Chemistry from University of Peshawar, Pakistan, and his MPhil degree and PhD (2017) in Analytical and Inorganic Chemistry from Quaid-i-Azam University, Islamabad, Pakistan. IAK carried out a part of his PhD research at the Department of Chemical and Biomolecular Engineering, National University of Singapore (NUS) in Prof. Dan Zhao's group. At NUS, he worked on a project entitled "MOFs as precursors for fuel cell catalysts". Before his postdoctoral fellowship in Sweden, IAK served at CIRBS, International Islamic University Islamabad (IIUI), Pakistan, as an Assistant Professor in Chemistry (2018-2019). IAK's research is focused on materials and electrolytes for electrochemical energy storage devices: batteries, supercapacitors and fuel cells. IAK has more than 20 peer-reviewed publications in high-impact journals with cumulative impact factor above 90, and more than 500 citations. IAK currently mentors the group's recently admitted PhD student and will be also co-supervising the PhD student that is to be recruited in early 2021.

Preeti Jain (PJ) is since 2019 a PDRA at Col under the supervision of Prof. Oleg N. Antzutkin. PJ completed a MSc degree in Physical Chemistry in 2012 at the Department of Chemistry, University of Rajasthan, India, and in 2017 a PhD degree in Physical Chemistry at CSIR-National Chemical Laboratory under the supervision of Dr. Anil Kumar in the field of ionic liquids, IR and Isothermal Titration Calorimetry (ITC) to elucidate physico-chemical properties of ionic liquids in binary mixtures with molecular solvents. As a PDRA at the Indian Institute of Science Education and Research, Bhopal, PJ worked on the electrochemical performance of alkyl sulfate-based ILs and in the field of

supercapacitors using ionic liquids as electrolytes. PJ has published seven articles in peer-reviewed journals and received a number of prizes such as the Best Poster Award at CSIR-NCL-2016, Gold Medal in MSc (Physical Chemistry) for securing the 1st position at the university in the Graduate Aptitude Test for Engineers (GATE) held in 2012. PJ is rigorously trained in using instruments such as Conductometer, Viscometer, UV-Vis Spectroscopy, IR, Raman and Potentiostats. At LTU, PJ has been building on her previous experience synthesising ionic liquids and materials and has received training in various techniques such as solid and liquid state NMR spectroscopy, BET, DSC and TGA. Currently, PJ is working on different ionic liquids as lubricants and electrolytes and on the different forms of the titanium phosphate materials as energy storage materials for supercapacitors. In India, PJ obtained experience supervising two MSc students. This experience is a good complement to her mentorship of PhD students at Col and the DCE.

Förutsättningar

Forskarutbildningsmiljö

Bedömningsgrund:

Forskningen/den konstnärliga forskningen vid lärosätet har en sådan kvalitet och omfattning att utbildning på forskarnivå kan bedrivas på en hög vetenskaplig/konstnärlig nivå och med goda utbildningsmässiga förutsättningar i övrigt. Relevant samverkan sker med det omgivande samhället både nationellt och internationellt.

The Research Environment and Col's Connection to Other Groups within LTU

The Division of Chemical Engineering (DCE) includes three research subjects, Chemistry of Interfaces, Chemical Technology and Biochemical Process Engineering. The research groups share common working space and laboratories and the atmosphere between the groups, as well as among the PhD students, can be described friendly and cooperative. There are currently five active PhD students at DCE, all participate in teaching of chemistry courses for a new Sustainable Process Engineering program at LTU. A common learning environment is facilitated through joint courses, shared lab space and joint regular seminars. Apart from being an active contribution of DCE to graduate studies and PhD schools at other departments at LTU, these courses also are a forum for PhD students at DCE to communicate with PhD students from other research subjects, to share research ideas and knowledge on methods, methodology and equipment available at other laboratories. Such new contacts, established during attendance of the graduate courses, may grow further to close collaboration during, and even after, the remaining period of doctoral studies.

Interactions with other PhD students and senior researchers within the department are also initiated and supported by CENE's Introduction School to third cycle studies (TCS). This introduction course is directed towards all new PhD students at the department (see appended study plan), and we ensure that all Col's PhD students participate. The CENE TCS Introduction School covers the first year of PhD studies starting with a kick-off day and offering short basic PhD courses, such as "Scientific writing and review", "Teaching and popular science presentation", "Research ethics, IPR and career planning", and "The power of methodology" (see appendix). At the end of their first year, the PhD students are required to pass the "Final seminar", where they orally present their research questions, methods, time and publications plan, risk analysis, ethical and equality considerations and make a poster about their project. An expert panel consisting of faculty members from other research subjects cross-examines the PhD students and a jury evaluates the posters. Apart from offering tools to help the new PhD students swiftly start their research work, the Introduction School serves also as a platform for meeting other students at the same stage of their TCS, which is especially helpful for small research environments such as Col. The Introduction School is highly appreciated by PhD students. Antzutkin from Col also shares teaching duties in the "Scientific writing and review" course.

As mentioned in the Background section, LTU has recently established two strategic research areas (SRAs), “CREATERNITY” and “SUN – Natural Resources for Sustainability Transitions”, which will include joint cross-disciplinary PhD schools from 2021. The Col group is actively involved in CREATERNITY and our recently admitted PhD student (and future PhD students) will be joining the CREATERNITY PhD school activities, such as specific PhD courses in sustainable economy, green chemistry and energy, etc. This will strengthen the quality of the PhD training in Col, both through the new range of courses available to our students and through the opportunities the school offers for PhD students to engage in new contacts and collaboration with researchers from other research subjects at LTU.

Col has long established collaborations with research subjects within other disciplines at LTU. One example is the collaboration within the field of tribology with Machine Elements, mentioned in the Background sections (see **Fig. 1**), which dates back to 2007. These internal collaborations broaden the students’ perspective on their research area as they naturally drive discussions with researchers from other fields. In addition, our collaboration in tribochemistry has expanded nationally (with KTH and Stockholm University) and even outside Sweden, thus giving further opportunities for Col’s PhD students to communicate with world-leading researchers (see below). Other examples are Col’s long-term collaborations with the research subjects Applied Geology (Prof. Christina Wanhainen) and Minerals Processing (Prof. Hanumantha Rao) within minerals chemistry. The latter collaborative projects were funded by VINNOVA, CAMM and (ongoing) Formas and New Boliden (see **Fig. 1**).

Weaknesses and Challenges There are currently ongoing discussions with the Department of Health Sciences at LTU, where Prof. Fredrik Nikolaeff from Uppsala University was recently appointed chair of Medical Technology. Nikolaeff is establishing a new laboratory for Alzheimer’s and cancer diagnostics research at LTU. The Col group has rented out laboratory space for Nikolaeff’s small group of three researchers and will help with sharing scientific instruments. We are planning to submit new joint research proposals to different funding agencies to revitalise this research area at LTU with the possibility of enrolling new PhD students in both research subjects. One of the reasons for Col engaging in new collaborative activities is that we are aware of that our research subject is small, which is an obvious weakness for both research and education at the graduate level. Interaction with other research subjects based on mutually favourable research backgrounds and track-records is vital for providing a high-quality and also a more robust research education environment. However, it takes time, resources and systematic efforts to establish new, fruitful and trustful collaborations.

National and International Academic Research Collaboration

Col is part of wide collaboration networks with researchers at other universities, both within Sweden and abroad. These collaborations extend to joint research seminars, research visits abroad for our PhD students, joint supervision of PhD students and supervision of PhD students for double degrees. Indeed, educating PhD students together with external collaborators at other universities for double degrees is an approach we have used, and continue to use, to widen the research environment for PhD students in Col. The subject has experience educating a PhD student (Vasantha Gowda, 2017, see **Table 1**) for a double degree with University of Oulu, Finland, and an agreement is in place for double degrees with Nanjing University of Science and Technology, P.R. China. The subject’s principal external research collaborations are outlined below. The origin and scientific focus of these collaborations are presented in more detail in the Background section.

Collaboration with The University of Warwick, UK One long-term collaboration at Col involves Prof. R. Dupree, Prof J.V. Hanna and Prof. Steven Brown at the Department of Physics, The University of Warwick (UoW), UK. Antzutkin has collaborated with the UoW group on solid-state NMR in the high magnetic fields since 2001, acting as visiting professor between 2008-2015 and as an Honorary Professor thereafter. This collaboration renders Col access to the state-of-the-art equipment (high-field solid-state NMR spectrometers, see below in the research infrastructure section) and connections with many outstanding researchers and graduate students at UoW. From 2012 to 2015, Antzutkin was also the principal supervisor of one PhD student at UoW (Robert T. Kelly), sharing supervision with Prof. Brown. This duty was a great experience that enabled him to learn about the graduate education system in the UK and compare it to the Swedish system. Kelly visited Col at LTU

a few times, performed peptide synthesis and purification and also communicated actively and exchanged ideas and knowledge with Col's PhD students. Kelly defended his PhD thesis (in solid monography) at UoW with excellence in 2015.

Collaboration with Monash and Deakin Universities, Australia In early 2010, Antzutkin met Prof. Maria Forsyth from Monash University, Australia, during one of his regular working visits at UoW. Forsyth is one of the world's leading scientists in the field of ionic liquids and their applications in electrochemistry. During discussions with Forsyth, an idea about orthoborate-based ionic liquids as future lubricants was born. This led to a three-month internship at Monash University for our PhD student Faiz Ullah Shah. During the internship at Monash, Shah learned the synthesis of orthoborate-based ionic liquids, their purification and characterisation using mass-spectrometry, NMR and other techniques. This internship was a "breakthrough" for Shah's PhD project, his future career in academia and in entrepreneurship. Furthermore, Shah's time at Monash opened up a new research area and future opportunities for the entire group: (i) the tribological performance of new classes of ionic liquids synthesised by Shah was outstanding and the group has received two grants from the Swedish Research Council; (ii) a fruitful collaboration has been established between LTU, KTH and Stockholm University and a large and prestigious grant (32 MSEK, 2013-2018) was awarded by the Knut and Alice Wallenberg Foundation for the "Ionic Liquids Enabling Advanced Performance, I-LEAP" project with Prof. Glavatskih as the PI at KTH and Prof. Antzutkin, Prof. Kloos, Prof. Rutland and Prof. Laaksonen as co-PIs in different work packages; (iii) two PhD theses have been defended at LTU within the "I-LEAP" project (Mamoun Taher [2015] and Andrei Filippov [2016], see **Table 1**); (iv) these novel classes of ILs have been patented (seven patents in total in Sweden, EU, USA, Russia, Japan, Canada, and China); (v) new, big grants have been awarded in a highly competitive process with other consortia within Swedish academia for research on ILs in lubrication ("REFIT" project funded by SSF for the KTH-LTU-SU consortium, 35 MSEK, 2019-2023). This is a bright example of how a PhD student can be "a driving force" for a completely new research area in Col and how collaborative networking facilitates success in graduate education.

Weaknesses and Challenges (Collaboration with University of Oulu, Finland) Another example is the collaboration with Prof. J. Vaara, Prof. V.-V. Telkki and Dr. P. Lantto at the Department of Physics, University of Oulu (UO). The UO group is world-leading in the theory development for quantum mechanical calculations of NMR parameters in paramagnetic systems, such as REE-complexes. Oleg N. Antzutkin and Anna-Carin Larsson established a collaboration with the UO group in 2011. The magnetic resonance laboratory at UO has access to 300, 400 and 600 NMR spectrometers and built equipment for hyperpolarisation NMR techniques (optically pumped Xe and para-hydrogen). Members of the Col group are currently engaged in a joint project with the UO group, funded by the Horizon 2020 "Imaging-4-Future" programme (2017-2020). We planned to enrol two PhD students for a double PhD degree between the physics group at UO and Col at LTU within the Imaging-4-Future program. However, difficulty in eliminating the obligation for LTU to fund 30 k€ per project and solving all formal agreements for joint education, led to severe delays with enrolment and ultimately a decision to cancel the plan for the double PhD degree. Resolving all formalities and different national requirements for PhD education in the limited space of time available between approval of funding and project start is a great challenge in EU programs focused on training of PhD fellows "across borders". Funding of the extra 4th year of PhD education in Sweden can be especially challenging in this context. Still, Col now has a fine-tuned plan for future co-education of PhD students with our collaborators at UO. We are confident that co-education with UO is possible, since we have had a positive experience in the past. Dr. Vasantha Gowda who completed his PhD in 2017 (see **Table 1b** in Appendix) was enrolled at both institutions and successfully fulfilled the requirements for a double degree. This is an approach that we have used to widen the research education environment for PhD students in Col and at LTU, in general.

Collaboration with National Universities Within Sweden, the Col group mainly collaborates with researchers at Stockholm University (SU) and KTH. Within the research area of amyloids, we currently collaborate with the group of Prof. Astrid Gräslund at SU and Assoc. Prof. Christofer Lendel at KTH. The collaboration with Lendel's group is particularly tight. One of our former PhD students, Dr. Vasantha Gowda, is a PDRA in Lendel's group and we have regular meetings and discussions with

him. Furthermore, we have recently received funding for a new computation project at the supercomputer Swedish centre (SNIC), in which Antzutkin is the PI and Gowda is a “proxy”, i.e., having access to the data and performing calculations on the supercomputers.

The Col group also collaborates with researchers at SU and at KTH within the field of tribology and tribochemistry, in particular with Prof. Anja-Verena Mudring at SU and professors Glavatskih and Rutland at KTH. In the currently running REFIT (Reduced Friction by Ionic Technology) project, funded by The Swedish Foundation for Strategic Research (SSF), 35 MSEK during 2019-2023, we are extending our knowledge to heteroleptic orthoborate-based IMs to further tune their properties and are synthesising other classes of anions for non-halogenated IMs. There are six PhD students at SU and KTH, who are involved in these projects and actively involved in all workshops and regular project meetings. We will adjoin Col's future PhD students into the named activities, which will facilitate quality in the PhD training at LTU.

The Col group is also working in collaboration with Prof. Patrik Johansson, Chalmers, with projects related to non-halogenated IMs as future non-toxic and non-flammable electrolytes for lithium ion batteries and supercapacitors and IMs for CO₂ absorption and conversion to organic substances. These projects are funded by the Swedish Energy Agency, the Swedish Research Council and the Kempe Foundations. One of Col's newly admitted PhD students, Mukhtiar Ahmed, is working in the former project (non-halogenated electrolytes for LIBs) funded by the Swedish Energy Agency and co-funded by LTU. This is a great opportunity for him to receive training and tutorial support from supervisors at both LTU (Faiz Ullah Shah serves as the Principal supervisor) and at Chalmers (Patrik Johansson serves as the Assistant supervisor) and to actively communicate with the PhD group at Chalmers. Col will recruit one more PhD student in 2021, who will join the LTU-Chalmers group.

Our PhD students are engaged in our external collaborations with SU and KTH through regular workshops (see Måluppfyllelse – färdighet och förmåga). In addition to shorter (e.g., workshops) and longer (e.g., research periods abroad) visits to other institutions, study visits to big facilities are considered depending on the nature of the PhD students' projects. These visits are generally financed through different scholarships that the students are encouraged to apply for. As an example, Mylène Trublet's visit to the synchrotron facility in Thailand in 2017 was supported by the Knut and Alice Wallenberg Foundation (It was Trublet's own initiative to write an application to KAW for a scholarship-research-trip to this big facility). During the research trip, she was assisted by Prof. Ingmar Persson from SLU, Uppsala, who is the recognised expert in EXAFS methodological applications in inorganic and coordination chemistry. Recent (December 2019) educational visits to the MAX-IV facilities in Lund were supported by internal strategic funds at LTU.

Collaboration with Industry Col has, since the late 1990s, established long-term collaborations with industrial partners including LKAB, New Boliden, Nynas and Axel Christiernsson AB, to mention a few. Previous PhD students were actively involved in regular project meetings and workshops with our industrial partners, who co-funded projects or were stakeholders of the results obtained. The PhD students who were involved in these collaborative projects with industrial partners/funders learned to adapt and tailor the presentation of their results to a different kind of audience compared to that at scientific conferences. Visits of industrial partners (LKAB, New Boliden) were always followed by excursions to the industrial plants (flotation, leaching plants or the mining site), during which PhD students obtained knowledge about the processes and obtained useful ideas on how to perform a model “on-bench” experiment in the Col laboratories, so that the results obtained could be more useful or even directly implemented in the real industrial processes.

Laboratory and Equipment

Col has well-equipped laboratory facilities with state-of-the-art equipment for research within our area of expertise, accessible to our PhD students (see **Fig. 3**). Using funds from the Kempe Foundations and the LTU laboratory fund, the group has purchased a 7 MSEK Bruker AVANCE-III/Aeon 400 MHz triple-channel NMR spectrometer (in operation since December 2015) with two liquid probes (5 and 10 mm), a wide range of dedicated magic-angle-spinning probes for solids: (7.5 mm, 5 mm, 4 mm and 2.5 mm) and a few NMR diffusion probes with a range of probe-head coils (¹H, ¹³C{¹H}, ³¹P, ¹¹B, ²H, ⁷Li, ²³Na). A new, state-of-the-art bench-top 80 MHz ¹H-¹³C NMR spectrometer (on permanent

magnets), which will be used for *in-situ* control of the reactions during syntheses of IMs, will be installed during fall 2020. Other equipment purchased and operated by the Col research group are: Densimeter and microviscometer, TG/DSC, two potentiostats, Karl-Fisher calorimeter, FT-IR, FT-IR-ATR, two FT-Raman spectrometers (one with an advanced optical microscope for mapping of surfaces), UV/viz, a new glove-box, three rotor evaporators, two vacuum ovens, eight fully equipped fume-hoods and a wide range of specific glass-wear for the synthesis of IMs. We also share the following instruments at DCE: High-resolution SEM, PXRD, BET/N₂, DLS. At UoW, UK, Antzutkin has access to a wide variety of NMR spectrometers with double, triple and specific (DOR, DAS, DNP/MAS) probes for solids: 90 MHz (DNP/NMR), two 300 MHz (one with magnetic field sweep), 400 MHz, 500 MHz, 600 MHz, 620 MHz (DNP/NMR with a 4-mm MAS/DNP “Doty” probe) and 850 MHz (UK National NMR facility) and two novel XPS instruments. The UK’s first 1 GHz solid-state NMR spectrometer (£8 million ≈ 91 MSEK grant from the Engineering and Physical Sciences Research Council [EPSRC]) will be installed shortly at UoW. This instrument will serve the UK national research community in the physical and life sciences.

The long list of the scientific instruments above is the solid basis for the systematic and high-quality training of Col’s PhD students during the whole period of their graduate education. Chemistry of Interfaces, as a natural part of Physical Chemistry, is using advanced spectroscopic methods to study properties of matter at interfaces between liquids and solids, as well as structure of complexes and supramolecular aggregates, such as amyloid fibrils. It is a tedious task and duty of all faculty members, researchers and PDRAs at Col to properly run, update and perform timely services of all scientific instruments, so that Col’s (and DCE’s) PhD students will have regular access to the instruments. PhD students’ projects have the highest priority at Col and they must run smoothly without unforeseen delays. Therefore, we always consider “back-ups”, in urgent cases, when some instruments at Col are broken or under service: If such instruments are not available at other departments at LTU, Col’s wide collaboration networks are frequently used in such cases. Either urgent samples are sent to our collaborators, or supervisors with PhD student(s) are travelling themselves to the laboratories of collaborators to run urgent experiments. The results obtained during such research trips to other laboratories then form the basis for research papers written in co-authorship with our collaborators. Col’s PhD students, thus, additionally learn a good practice of both synergy and ethics in the scientific collaboration.

Utformning, genomförande, resultat

Måluppfyllelse – kunskap och förståelse

Bedömningsgrund:

Utbildningen möjliggör genom utformning och genomförande samt säkerställer genom examination att doktoranden, när examen utfärdas, kan visa bred kunskap och förståelse både inom forskarutbildningsämnet och för vetenskaplig metodik/konstnärliga forskningsmetoder inom forskarutbildningsämnet.

Competence and a deep understanding of principles in chemistry of interfaces by graduate students at Col is achieved via systematic long-term work using the following scientific, pedagogical and practical tools and principles:

- I. Attending and examination graduate courses in specific subjects;
- II. Systematic training and tutorials for the use of the scientific equipment at Col and DCE (and “big” facilities if/when applicable);
- III. Scientific discussions with supervisors during regular (monthly) project meetings;
- IV. Oral presentations at Col seminars;
- V. Preparations of posters for international scientific conferences (in discussions with supervisors);

- VI. Preparation of oral presentations for meetings with industrial partners, for workshops, conferences, for the Licentiate seminar and for the PhD defence;
- VII. Systematic work on research papers together with supervisors and co-authors/collaborators in the research projects;
- VIII. Systematic work with the scientific literature and regular discussions with supervisors on the “state-of-the-art” methodology and novel findings in chemistry, physical chemistry and chemistry of interfaces in particular;
- IX. Open discussions with supervisors on personal new ideas and hypotheses in the research subject and on methodology and experiments for validation of these scientific hypotheses.

Literature Review and Development of Scientific Publications

For addressing the following criteria: “*Demonstrate knowledge and understanding within the research area, including current specialist knowledge within a defined part of this area as well as an in-depth knowledge of academic methodology in general and of the specific research area's methods in particular*”, supervisors within Col have a joint strategy for training PhD students in literature search, experimental design and the art of writing scientific papers. This strategy is based on the collective experiences from our own PhD training at Linköping University, Chemical Physics; Stockholm University, Physical Chemistry; Umeå University, Inorganic Chemistry; and LTU, Col. We have adapted a common strategy for working on scientific publications with our PhD students based on our own experiences as third-cycle students. Just after admission, new PhD students are given the task of doing a literature search and writing a short mini-review report on previously published results related to the student’s research project. Using this “kick-off” strategy, PhD students learn the good practice of searching and reading the literature and creating bibliographies on a regular basis. They also create their own database of previous results, which will be needed for further development of new ideas and new experimental directions within the project. The PhD student is then asked to present a summary of the report (as a PowerPoint presentation) to all supervisors during a regular project meeting, which will then stimulate discussions, planning and design of the synthetic work and experiments to be performed in the near future. Equipped with knowledge from the literature search and a good understanding of previously reported results, the PhD students will be more “free” to discuss and design new ideas and methods and suggest their own systems and hypotheses. The main approach of supervisors at this stage is not to drive the project into a “do that” and “be ready by” structure, but to carefully direct the thoughts and ideas of the PhD student towards a more plausible hypothesis and approach. Using this approach, the ideas born during the supervisory meetings will be formed around ideas and suggestions from the PhD student him/herself. We, humans, will readily do a task if it is based on our own ideas and initiatives! This general approach has led to excellent scientific results of our graduate students over the last 15 years. Indeed, two doctoral theses from our group have received “the best PhD thesis at LTU” award (issued by Bergfors). The PhD thesis of Faiz Ullah Shah (2011) included one patent application and five peer-reviewed articles. Furthermore, one of the articles reported results included in an additional patent application that we submitted to the Swedish patent office and the international patent office (PCT-application). The latter led to approved patents in Sweden (in 2012), Russia (2015), Japan and China (2016), USA (2017), EPO (2018) and Canada (2019). Therefore, this single PhD thesis in our research subject resulted in eight (8) approved national and international patents. The novelty in research is the bases for our on-going (and new) projects supported by the Swedish Research Councils, agencies for strategic research and foundations.

Special attention is paid to supervision of PhD students in writing research papers. The two-day “Scientific writing and reviewing” course of the CENE TCS Introduction School (Antzutkin is one of the teachers) provides a well-structured basis for the development of our graduate students’ writing skills. During lectures and discussions, the classical “four moves”¹ for composing the introduction of

¹ The “four moves” in Introduction of a research paper are: 1) Establishing the field (asserting centrality, stating current knowledge, introducing the topic by showing that the field is significant, and/or the research is relevant by stating what is known, or by summarizing what is known; 2) Summarizing previous research (from the perspective of this research and showing the relationship between this research and the whole field); 3) Preparing for present research (indicating a gap, raising a question, justifying the need for this research by showing there has not been enough research in this field yet or there have been problems

a research article is outlined, typically illustrated using a recently prepared manuscript ready for submission from Col. Within Col, we always request that our PhD students write the first draft of their articles by themselves. When received, both supervisors critically read the draft and make comments and suggestions for reworking the draft, remaking figures and tables and the Electronic Supporting Information for the article. Special meetings are devoted to discussions on the draft, its drawbacks and ways to improve it. Sometimes, we circulate the manuscript more than four-five times, until the article reaches the required level of quality and is ready to be submitted to a good (high-impact) chemical journal. As it is a process of learning by doing, the first article takes the most time and effort, for both supervisors and PhD students. In addition to learning the skill of writing articles, the graduate students are engaged in the subsequent process of getting an article published, gradually being given more and more responsibility for submission, writing a proper rebuttal in response to reviewers' criticism, proofreading an accepted article and, finally, taking part in our traditional celebration of a just-published article. A copy of the published paper is printed out, all authors (including the PhD student) sign the front page and this copy is displayed ("spikat") on a whiteboard in the CoL corridor.

The main documented results of the PhD training are the Licentiate and PhD theses, which are comprehensive works reporting high-quality scientific results and applications. We believe that it is reasonable to expect three full articles (or manuscripts) to be completed at a high level of quality during the ca. 2.5 years of PhD training towards the Licentiate degree and five-six full articles towards the Doctoral degree, i.e., a publication pace of approximately one article per year. This ambition level is stated in the General Syllabus for Col and communicated to the PhD students.

Methodology and Practical Training in Chemistry of Interfaces

For addressing the following criteria of the competence and skills: *"To demonstrate the skills to critically, independently and creatively, and with academic rigour, identify and formulate problems, to plan and use appropriate methods to conduct a limited research work and other advanced tasks within given time frames and thereby contribute to the development of knowledge as well as evaluating this work"*, Col's supervisors appreciate that the first year is usually the most challenging one for graduate students, as there is a steep learning curve to grasp both the planning, execution and analysis of experimental work and the fundamentals of writing a good scientific publication. Being aware of this, Col supervisors usually allocate more supervisory time for the very first paper. We set more time aside to ensure very thorough planning of the first syntheses and experiments, usually together with the PhD student in the wet-chemistry laboratory, showing how to use the equipment and actually doing most of the synthetic procedures ourselves, while the PhD student is observing, asking questions and taking notes in a personal chemical notebook. The regular engagement of Col's supervisors in practical laboratory work is an important motivator and a driving force for our PhD students and postdoctoral researchers to excel in the laboratory work. In addition, the researchers have more time for discussions within the laboratory than in the office environment. Since Col at LTU is a research subject predominantly based on experimental approaches, sufficient time is also allocated for tutorials to perform NMR, FT-IR, Raman and other experiments to characterise the obtained crude product. Postdoctoral research associates actively help the PhD students, acting as mentors and tutors in the laboratories. When the results are obtained and analysed, the sketching and writing of the first paper is started.

Training of Oral and Communication Skills

For addressing the following criteria of the competence and skills: *"To demonstrate the skills to, in both national and international contexts, orally and in writing, present and discuss research and research results in dialogue with the academic community and society in general and demonstrate the competence required to independently participate in research and development work and to work independently in other qualified contexts"*, Col's PhD students are informed at the very early stage of their graduate training that most of our research projects are interdisciplinary and carried out in collaboration with "non-chemist" researchers belonging to physics, materials science, surface science, and engineering sciences within Sweden and around the world. Therefore, our PhD students

or errors in previous research; 4) Introducing present research or this research paper or application (clarifying the research project itself, or just the research paper or application by stating its purpose and/or stating its outline).

and postdoctoral researchers are frequently exposed to multidisciplinary discussions during our project meetings and workshops, enabling them to think critically, and “out of the box”, and to improve their learning abilities. This multidisciplinary nature of Col research projects has produced highly innovative and successful researchers who are currently working in both industry, research institutes and academia. Some of the researchers (for example, Anna-Carin Larsson and Faiz Ullah Shah) have decided to stay within the Col research group after graduation and have proven to be excellent independent researchers.

Our researchers are encouraged to join international conferences within the field, at least one conference every year for a postdoctoral researcher and every second year for a PhD student, and to present their recent results to a broader scientific community. After visiting an international conference, every researcher has a duty to share with other group members, within the regular Col meetings, what he/she has learned and any new ideas generated. Some of these ideas have led to successfully granted new research projects. One such example was the short meeting of Faiz Ullah Shah with Prof. John B. Goodenough from the University of Texas at Austin, who won a Nobel Prize in Chemistry (2019) for his work on “Lithium-Ion Batteries”. After the very fruitful meeting in 2018, Faiz Ullah Shah has further developed the ideas and wrote an application to the Swedish Research Council (VR), which was granted as a four-year project (2019-2022).

Course Work

PhD courses (60 hp in total) are carefully selected for every PhD student during the first meetings between supervisors and PhD students. Certain PhD courses (ca. 20 hp) are the same for all graduate students at the Department. Another 20 hp of courses are shared by the PhD students at the Division of Chemical Engineering. The division runs a range of PhD courses given in different blocks of the “Instrumental Analysis” platform. Two of these courses, “Instrumental Analysis – Scanning Electron Microscopy (SEM) 5.0 ECTS” and “Instrumental Analysis – X-ray diffraction (XRD) 5.0 ECTS” are also offered to PhD students at other research subjects within and outside of the Department of Civil, Environmental and Natural Resources Engineering (CENE). The final 20 hp of courses are selected in connection to specific research projects, in which PhD students are involved. Appended ISPs of three alumni PhD students at Col during 2016-2018 and one currently active PhD student illustrate this approach (see the list of selected PhD courses coordinated with the needs and timelines of an increase in their complexity). During the first to second year, courses on instrumental analysis are prioritised, because these will create the foundation for the PhD students’ future work with scientific equipment. Then, during the next two-three years of the PhD training, more theoretical and advanced courses are selected and planned in the ISPs. The latter courses are needed for deeper capabilities for analysing, modelling and validating the scientific hypotheses suggested in the course of the work, with specific research questions based on their research projects.

Summer PhD courses given at different Swedish universities are also be considered and planned, in case the subjects and knowledge to be acquired during these courses are particularly suitable for the specific directions of a project, taking into consideration whether equivalent courses are given at LTU or not, before the planned defence of the Licentiate (or PhD) degrees. In some exceptional cases, we also consider the option of a “reading course” given by the supervisors for the PhD students. In such a case, the course is focused on a specific scientific book important for the project (or education). Examination in such course(s) follows the general rules at LTU, i.e., in the form of a written examination on a selection of new (created by the examiner) problems on the related topics described and analysed in the book. The number of credits in such courses is calculated from the number of full weeks needed for a thorough reading and a deep understanding of all the materials in the suggested book.

Weaknesses and Challenges Backgrounds and learning skills vary for different PhD students at Col. It is a challenge for supervisors to learn personal talents and habits of graduate students they supervise. Coaching is gradually transforming with years to give more freedom and independence to PhD students to design and test their own ideas and set-ups for new experiments. A weakness of this approach is that some subprojects initiated by PhD students may come to the “dead” end without any significant success. There is a risk that a PhD student will lose his/her interest to research in such critical situations. Supervisors may overlook such “crisis” situations, because of their other

occupations (overload in teaching, writing grant proposals, travelling, etc.). Another serious issue, which actually happened at Col ca. 10 years ago, that some PhD students worked too hard and did not notice that their health could be in danger. It is a duty of supervisors at Col to recognise such cases in time and to talk/explain to PhD students that they have to take regular breaks and physical exercises. A good practice is to have such activities in the whole group of PhD students, supervisors and researchers. Col has such traditional weekly outdoors events at the end of the working day. One can discuss science and to come to new ingenious ideas in research even outdoors, not always in the university offices.

Utformning, genomförande, resultat

Måluppfyllelse – färdighet och förmåga

Bedömningsgrund:

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

One important aspect of high-quality training of PhD students (and postdoctoral research associates) is to practice presenting research and science to different types of audiences. As part of their departmental duties the PhD students must be able to explain the proper use of the analytical instruments for which they are responsible so that they can help other users. Since the PhD students are also involved in teaching, they learn to give feedback to the students, and experience how difficult it can be to explain things to others. Some PhD students have also been involved in recruiting activities aiming at attracting students to the Chemical Engineering programme. Then they have had to practise presenting their research in a popular scientific way.

There are many occasions where the students present their results, ranging from internal meetings, meetings with industrial partners, workshops, and national and international conferences. Before the oral presentations, the PhD students always have at least one rehearsal in front of the Col group. The entire Col group is invited to the rehearsal and contributes with questions and specific advice on the content of the presentation, the sequence of the slides, the format of figures and tables, conclusions and future perspectives and plans for short- and long-term research. Hence, these rehearsals provide good training for PhD students to exercise and improve their presentation skills interactively. Here, the PhD student is actually learning about the logic and appropriate language for the oral presentation, such that research results are clearly and effectively communicated to the audience. For poster presentations, an equivalent type of feedback is given.

Despite some Swedish universities already having discarded the Licentiate of Technology examination and usually go straight to the PhD thesis and defence, we have kept the “old Swedish tradition” of the Licentiate thesis examination and the Licentiate seminar. We at Col believe that a Licentiate seminar 2-2.5 years after admission is a “licence for continuing research” and a very useful tool for advancing PhD student skills in presenting and discussing research before the PhD defence. The Licentiate of Technology degree is also a step in the personal development of a young scientist.

The Licentiate degree offers great training for the graduate student in writing the introduction of the thesis and combining the logic of the already written manuscripts, which are appended to the thesis. It has the advantage that the student already halfway through the process of finalising the PhD is forced to summarise and think intensely about the results obtained so far, which can better help the

student understand where he/she is going. The regular supervisory meetings most often only follow up on and discuss the plans made at the previous meeting. Hence, writing the Licentiate thesis ensures that time is put aside to “connect the dots” between individual papers and aggregate the results obtained to a higher, more advanced level of understanding.

On the day of the Licentiate seminar, disputes with the opponent, in public, is a critical learning tool. From the questioning session, the PhD student gains experience in the art of scientific debate and learns to argue for his/her hypotheses and models presented and summarised during the oral presentation. Often, the opponent gives very constructive criticism and suggestions for future experiments and measurements. The opponent is in many cases a great asset for the PhD student during the second half of the PhD journey. The PhD students in Col quite frequently develop collaborations with their opponents and benefit from their expertise to learn more and/or get access to research facilities and equipment that is lacking at LTU. In this way, the Licentiate examination provides a good opportunity for the PhD students to widen their professional network.

Unfortunately, currently, because the PhD students in the group are so few, there are not many opportunities for them to practice giving and receiving feedback from each other. This was (and is) a good opportunity for the students to contribute their specific knowledge and skills to other students' projects, and also to get to know each other. Here the CENE PhD school is beneficial, as a provider of a larger group of PhD students. As was mentioned above, the CENE PhD School offers PhD courses in, e.g., Scientific writing and review, where the students can practice these important skills.

The research projects are usually planned together with collaborating partners in industry and/or funded by research agencies with a societal perspective on the research conducted. This means that from the beginning of their project the students are contributing to the development of society by providing solutions to important problems, e.g., environmentally friendly products and processes.

Utformning, genomförande, resultat

Måluppfyllelse – värderingsförmåga och förhållningsätt

Bedömningsgrund:

Utbildningen möjliggör genom utformning och genomförande samt säkerställer genom examination att doktoranden, när examen utfärdas, kan visa intellektuell självständighet, (konstnärlig integritet) och vetenskaplig redlighet/forskningsmässig redlighet samt förmåga att göra forskningsetiska bedömningar. Doktoranden ska också ha insikt om vetenskapens/konstens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används.

Fostering of Intellectual Independence through Gradual Transfer of Responsibilities and Engagement in Scientific Dialogues.

It is our practice to direct PhD students to focus on the development of a single research article at a time, as a singular focus in our experience is beneficial to both the learning process and the quality of the article. When the first article is submitted, we all (the PhD student and supervisors) switch our focus to the second article, and so on. This consecutive process helps both supervisors and PhD students avoid unnecessary stress and facilitates a gradual transfer of responsibilities from supervisor to students, so that the PhD student with each article becomes more and more independent and gradually matures to be able to design the experiments and report the scientific results by him/herself. The development of Mylène Trublet's PhD thesis is a useful example (see her ISP in attachments). Her PhD thesis is based on four published articles and one manuscript submitted for publication just before her PhD defence in 2018. The first three articles were published in co-authorship with supervisors, while the fourth article, and the submitted manuscript, were written by herself in close collaboration with researchers from another research subject at the Department of CENE. Moreover, Ms. Trublet was the corresponding author on the last two articles, communicating on her own with the editorial board of prestigious and high-ranked journals, *ACS Sustainable Chemistry and Engineering*

and *Journal of Hazardous Materials*, and responding to the reviewers' comments until these two articles were successfully accepted for publication.

The fostering of intellectual independence is further supported through regular discussion of research progress at departmental and supervisory meetings and during the Licentiate examination, as outlined in the previous sections *Måluppfyllelse – kunskap och förståelse* and *Måluppfyllelse – färdighet och förmåga*.

In addition to the processes involved in drafting research papers, the internal and Licentiate seminars, we train and examine PhD students in intellectual independence and scientific dialogue with external partners by facilitating engaged participation at scientific conferences. An illustrative example of how this can be done was an approach that we first tested at an internal "two-day" conference on "NMR spectroscopy, Chemistry of Interfaces and Bioprocessing Technologies" in 2015. This conference was adjoined to the inauguration event of a Bruker NMR spectrometer newly installed in our NMR laboratory, with a helium-zero-boil-off "Aeon" magnet, the first of its kind in Scandinavia. The conference programme consisted of selected oral presentations given by invited world-leading scientists from Swedish universities and from abroad (Oulu University, Finland, Odense University, Denmark, the University of Warwick, UK, to mention a few). Each speaker was asked to prepare two written questions related to the topic presented during their lecture. One hp in this "conference course" was given for simple attendance of PhD students registered at all lectures given during two full days of the conference. Another 1 hp was given to PhD students who correctly solved/answered >80% of the questions distributed after every given lecture. This examination form is a more active training of the PhD students' ability to grasp and analyse pioneering achievements of science as opposed to attendance at "ordinary" scientific conferences, where students usually have a more passive role as listeners and observers without much responsibility to grasp the essence of the oral presentations.

Ability to Make Assessments of Research Ethics

The PhD students obtain practical insight into research ethics and scientific rigour/honesty on numerous occasions throughout their third cycle studies. To start with, research ethics is part of the CENE TCS Introduction School, which introduces the students to different kinds of ethical considerations. In one of the assignments, they are asked to interview their supervisor about good research practice; in another, they have to formulate ethical issues connected to their project and present to their classmates. Research ethics is also an integral part of several of LTU's postgraduate courses such as Academic Publishing (FOR029F, 4.5 credits) and Philosophy of Science (FOR042F, 7.5 credits), which all PhD students in Col undertake, and is comprehensively dealt with in the Research ethics course (FOR023F, 4.5 credits). The questions of ethics and accurate (honest) presentation of results also come up in the various seminars arranged for PhD students (e.g., dissertation seminars) where they present and discuss their research to (and with) senior researchers, junior researchers and other PhD students. Furthermore, in addition to discussing the PhD student's research, the external reviewer at the licentiate examination also probes various aspects of intellectual independence, scientific honesty and issues of research ethics (if applicable). Col pays great attention to the issue of plagiarism in scientific writing, which in our experience can be a temptation, especially for those students with more limited English skills. Ethics in scientific writing is thoroughly discussed during the project meetings between the PhD students and supervisors. After learning a difficult lesson with a PhD student regarding plagiarism, which was treated according to ethical and legal procedures at LTU, all supervisors of PhD students at Col take issues of plagiarism seriously in discussions with PhD students they supervise and use the named case as an example. They thoroughly cross-check Licentiate and PhD theses for possible plagiarism. In addition to these prior cross-checks in manuscripts, all theses are proofread for plagiarism by professional services at the LTU library. Requirements for good knowledge and skills in both spoken and written English are included in the announcements for recruitment of new PhD students. Certificates of TOEFL and ESTL tests are inspected for every candidate for a PhD post and then spoken English and skill in formulating and answering questions (communication skills) is also tested for short-listed candidates during interviews with the evaluation board at Col. When admitted, PhD students are also recommended to take specific English language courses to improve their skills. It is noteworthy that some students take the initiative in learning Swedish, which they use for communication with undergraduate students during teaching

duties and supervision of project and BSc and MSc diploma students at Col. Skills in both English and Swedish are considered by PhD students and supervisors as a “must” for future career development, whether in academia or in industry, particularly, if PhD students decide to stay and work in Sweden after the defence of their Doctorate degrees in Col. We also involve our PhD students in reviewing scientific papers for journals, which helps them develop skills to critically evaluate their own research results and further improve their scientific language and logic. Advice and guidance on research ethics and good research practice is available to all PhD students (and staff) at LTU from the University Ethics Council, established in 2020. Information and contact details are available on the internal webpage: www.ltu.se/internt/forskarwebb/forska/forskningsetik. PhD students in Col are informed about this resource and encouraged to familiarise themselves with the information gathered there.

Supporting Development of an Appreciation of the Possibilities and Limitations of Science, its Role in Society and People's Responsibility for How It Is Used

Col's PhD students are actively involved in writing grant proposals for different funding agencies. This is not a duty, but a strong recommendation from supervisors and the initiative of PhD students themselves. As a bonus, 1-2 hp course credits are given for such training. For example, application templates of the Swedish research council Formas includes:

1. Popular scientific description of the proposed project and its importance for a sustainable society, minimum climate and environmental impact;
2. A critical examination of the current state-of-the-art in science and “the research gap” in the methodology;
3. Description of the potential societal value of the research question and planned communication with stakeholders, end users and the general public;
4. Reporting of ethical considerations. In line with global sustainability and ethical considerations, we follow the main trend of “green” instrumental methodology applied on “green” chemistry in all new projects run at Col and in new grant proposals. These topics are thoroughly discussed with our PhD students at Col during their entire period of graduate studies.

Utformning, genomförande, resultat

Jämställdhet

Bedömningsgrund:

Ett jämställdhetsperspektiv beaktas, kommuniceras och förankras i utbildningens innehåll, utformning och genomförande.

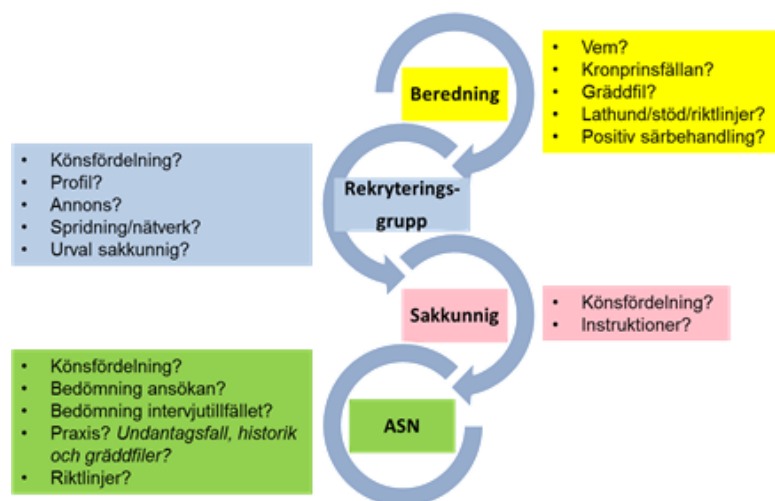
Safeguarding Gender Equality in Recruitment

Col pays special attention to the question of equality between the sexes (jämställdhet) in recruitment processes. To reduce the risk of unconscious biases, both genders are always included in recruitment groups and all members in a recruitment group do an individual assessment of all candidates before candidates are discussed jointly. Attraction of applicants of both genders and selection on merits is supported by activities to increase awareness of gender equality, for example through LTU's project on gender equality and sustainable recruitment during 2012-2013, which resulted in LTU's recruitment process described in the picture figure and which is also the basis of Col's practice.

However, during recent years we have had a gender imbalance in the Col group. Therefore, in the case of two candidates having rather similar research profiles, competences and track-records, the preference is given to the candidate of the underrepresented gender in the Col group. Over the course of the subject's history, five Licentiate and Doctorates were defended by women and 16 Licentiate and Doctorates by men. The Col group currently consists of three female and eight male group members. Therefore, for the next few PhD and PDRA positions the preference will be given to female

candidates. However, the gender balance can vary from project to project, e.g., Antzutkin as the Principal supervisor of Ms. Myléne Trublet (PhD student) was the only man in “Mylene’s team” working in the project supported by the Research Council Formas and New Boliden from 2013 to 2018.

Col has throughout its 15 years since the subject’s establishment in 2006 been a highly international group with PhD students, PDRAs and staff members from all over the world, including Sweden, Europe (France, Russia, UK) and Asia (Iran, India, Pakistan, China). The group is proud of this tradition and welcomes other nationalities to join the group. We have a map of the world on the wall, where we flag birthplaces of all Col’s members and our short-term international visitors and collaborators. The group’s international composition reflects that the focus during recruitments is firmly aligned with ambitions to select the best candidates based on scientific merits



Competence-enhancing Measures

The Research Supervisor Course There is a formal requirement at LTU that there be at least one supervisor for each PhD student whom has undergone formal supervisory training and within Col we strive for all senior staff to undergo this training. LTU's course for research supervisors is given by the university's higher education pedagogical centre and contains a half-day workshop, plus preparation and follow-up work on gender equality. The purpose is to develop a concrete work plan for gender mainstreaming within one's own research subject. An example from Col is that all new employment in the research subject should take place via an inclusive recruitment process in accordance with recommendations described in the figure above.

Gender Equality is an Integral Part of the General Courses Offered to PhD Students

The faculty boards at LTU have decided that all university-wide postgraduate courses must include integrated aspects of gender equality. This is implemented and monitored through the Joint Committee Group of the Faculty Boards - Education at Third-Cycle Level, led by Dean Lena Abrahamsson. Two courses have already integrated gender aspects into the curricula, Research Ethics FOR023F and Theory of Science FOR022F, and all of LTU's comprehensive and university-wide PhD courses are being reviewed to better include gender aspects. PhD students at Col tend to complete at least one of these general PhD courses. However, we see that the issue of gender equality is an area that needs strengthening within the PhD education in Col. A welcome addition to the University's offering of general PhD courses is a new 2-hp course on “Genus och jämställdhet”, which will be held for the first time in 2021 and which we intend to take advantage of. We will recommend that Col's PhD student(s) and supervisors include this course in their ISP(s). The subject's General Syllabus is in the process of being updated to a new template. In the revised version, the issue of equality will be highlighted, alongside advanced chemistry and research ethics, as one of the core subjects to be included in compulsory courses (and hence securely examined).

Continuous Professional Development

In addition to the above, LTU annually conducts several university-wide seminars, including seminars on gender mainstreaming, which are aimed at both PhD students and their supervisors as well as teachers in postgraduate courses. An example is the seminar "Gender equality in our program educations and general research educations at LTU", which was given by Professor Lena Abrahamsson in 2019 and which is now available online.

Equal Representation in the Examining Committee and Other Committees

LTU applies a policy that both genders must be represented in the examining committee for a PhD defense. This is a means to ensure that scientists of both genders are visible as experts and role models. It also forces supervisors (and PhD students) to widen their network of contacts, if the network of contacts only includes one gender, and helps to ensure that relevant expertise is not overlooked due to unconscious bias. The policy of equal representation is applied throughout LTU's existing processes, including representation on the Faculty Boards and Employment Boards.

Departmental Culture for a Balanced Life

The Department of CENE supports PhD students who want to combine doctoral studies with parenting, as parenting is seen as a normal and encouraged part of life during doctoral studies. A high proportion of the research students at the Department, both male and female, are or will become parents during their studies. They are encouraged to take part in the support that is provided, for example through parental leave for childcare. This is reviewed with the PhD students at Col within the framework of the introductory course and at the introduction for new employees.

Follow-up and Evaluation

LTU conducts regular surveys of PhD students that cover all aspects of their studies, including issues related to gender equality. The Joint Committee Group of the Faculty Boards - Education at Third-Cycle Level, is responsible for these, which are carried out every three years. The Col research group is critically analysing the results of these surveys at LTU and CENE and openly discusses the criticism and possible ways to resolve the issues in focus. One of these issues was a lack of scientific discussions and exchange of experiences between PhD students at DCE. As a result, a PhD initiative group was created and organised regular meetings and seminars, as discussed in further details in section "Doktorandperspektivet".

To summarise, gender equality is clearly a part of the formal process and a general part of the research education at Col and the university; whether it is part of the core of the research is dependent on the individual research questions. The PhD students are made aware of the topic of gender equality in different parts of their education, and are encouraged to be active on the topic.

Utformning, genomförande, resultat

Uppföljning, åtgärder och återkoppling

Bedömningsgrunder:

Utbildningens innehåll, utformning, genomförande och examination följs systematiskt upp.

Resultaten av uppföljningen omsätts vid behov i åtgärder för kvalitetsutveckling och återkoppling sker till relevanta intressenter.

Lärosätet verkar för att doktoranden genomför utbildningen inom planerad studietid.

The Individual Study Plan" (ISP, see appended files) is the principal document to monitor progress during the PhD education, including achievements and challenges, and to control the timeline of the whole process up to the Licentiate of Technology degree and then to the PhD degree. All PhD students at Col have an ISP, which is approved and signed by all supervisors, the PhD student him/herself and the Head of Department. The ISP is a "living document" that is updated once, or even twice, a year and again just before the Licentiate or PhD defence. The old template, approved by the Faculty Board and Vice Chancellor of LTU for all research subjects in 2012, was recently updated to

a new version valid from the 1st of July 2020. Three ISPs of PhD students at Col, who defended their PhD theses in 2016-2018, are in the old format, while Mukhtiar Ahmed's ISP follows the new ISP template.

The ISP is used for planning, follow-up and evaluation of the students' PhD education, including courses, publications, participation in conferences or other meetings, career development, milestones, department duty and supervision. All activities in the ISP are linked to the goals and learning outcomes given in the High Education Ordinance (see Sections 2.2 and 2.3 in appended four ISPs). As the ISP is updated regularly (for most students twice a year), deviations from the time plan, or other problems, are discovered early and countermeasures can be taken. Both the PhD student and the supervisor have to state (section 7.2/10 in the old/new template, respectively) whether they consider that the education is progressing according to plan and comment if it is not the case. Reasons for delays for our PhD students can be (i) problems with analytical equipment, (ii) delayed delivery of spare parts or restrictions of using laboratories during reconstructions or/and pandemic. Countermeasures can be to rearrange the time plan and proposing tasks that are not depending on the results from the analyses, i.e., writing methodical parts of a publication, or taking a course, if available. The progress of the ongoing activities are also discussed during other meetings between PhD student and supervisor.

Section 3 of the ISP (5.4 in the new template) is devoted to PhD courses. As stated in the General Syllabus for Col, 30 and 60 credits (hp) of completed courses are required for the Licentiate and PhD degrees, respectively. The number of credits may be different from requirements of foreign universities, with which double PhD degree agreements are signed. Therefore, it is important to adjust both the selection and timelines for courses to be taken by the PhD student at LTU and at the other university, during his/her visits and training abroad at the alliance university (for example, see Vasantha Gowda's ISPs). The timing of the courses is also important for the planning of other activities such as research visits to other institutions, conferences and so on.

Section 4 of the ISP provides details on the academic thesis. As specified in the General Syllabus for Col, the thesis equates to 90 or 180 credits (hp) for the Degree of Licentiate or PhD, respectively. The timeline for the Licentiate degree is usually set at 2-2.5 years, taking into account some (5-10% time) teaching duties at the undergraduate level (usually as laboratory assistants or/and tutorials and assignments for first- or second-year undergraduate students reading chemistry courses) and also some department duty (another 5-10% time), such as curation of specific scientific instruments or laboratory safety mentorship and instructions for the external users of our equipment. These extracurricular activities are well appreciated by PhD students, as they acquire useful experience in teaching and administrative tasks with associated transferrable skills. In subsection 4.3, planned and completed academic work is tabulated and regularly updated. In this section, a list of conference contributions, research reports and other publications are also listed and regularly updated to monitor progress.

A detailed plan of supervisory activities and regular updates are described in Section 5 of the ISP. The planning of activities is divided into semesters, and includes information about distribution of responsibilities between the Principal and Assistant supervisors and a brief description of the planned activities for the coming semester. In addition, detailed follow-up of the previous semester and planning of the coming semester is provided. Section 6 in the ISP is devoted to the detailed planning and follow-up of the PhD student's performance. Here, all planned activities of the PhD student are split into (i) courses and academic thesis; (ii) planned departmental duties, external duties and their scope and (iii) planned external collaboration. The follow-up of the previous semester and planning of the coming semester is detailed in a separate subsection (7.2), where the reflections of achievements and the progress in PhD training are documented from both the PhD student's and supervisor's viewpoints.

Table 2 presents the statistics of the PhD student completion rate at Col since 2006. Gross period of study (median) for the licentiate degree is 2.5 years, while the same for the PhD degree is 5.5 years. Actual periods of study, when teaching and other duties are excluded, are (median) 2.15 and 4.125 years, respectively. These numbers are very close to the planned rate of the PhD education. Some

deviations were because of personal reasons of graduate students. For example, the case 8 in table 2 illustrates a graduate student at Col, who had severe problems with expressing and writing in English. The case 10 illustrates an interruption in PhD studies between the licentiate and PhD these for a period of four years. Note that themes of the named two theses were very different. Licentiate thesis was defended in the topic of structure of amyloid fibrils, while the PhD theses was based on NMR studies of ionic liquids. To summarise, Col has shown a reasonably good completion rate for PhD students from 2006 to 2020.

Table 2. PhD student completion rate. (Source: Ladok. Student listed in order of enrolment. Students 1-4 were enrolled prior to 2006 and obtained their Licentiate degrees in Inorganic Chemistry and Physical Chemistry, respectively.)

Graduate Student	Degree of Licentiate		Degree of Doctor	
	Actual period of study (years) (nettostudietid)	Gross period of study (years) (bruttostudietid)	Actual period of study (years) (nettostudietid)	Gross period of study (years) (bruttostudietid)
1			4.3	6
2			3.925	5.5
3			3.95	5
4			3.825	5
5	3.25	4	4.75	6
6	2.15	2.5	3.285	5
7	2.65	3.5	4.465	6
8	3.06	6		
9	2.25	2.5	3.71	4
10	2.08	2.5	4.43	8.5
11	1.505	2	3.91	4.5
12	2.025	2.5	4.57	5.5
13	2.07	2.5	4.56	5.5
Median:	2.15	2.5	4.125	5.5

LTU uses a set of indicators for regular evaluations of all research subjects in two-year cycles. Among other parameters, there are four indicators, which are directly related to the performance and quality of the PhD training, namely: (1) supervisory capacity; (2) number of registered and active PhD students; (3) mean number of PhD defenses per year during the last two years and (4) number of peer-reviewed publications at levels 1 and 2. Based on the performance of the research subject, specific recommendations are given that are followed up on 12 months later. An example of such an evaluation of Chemistry of Interfaces in 2016 is given below:

Nämndens bedömning (Gränsytorskemi) 2016

Ett ämne med mycket god utveckling på externfinansieringen och utökad handledarkapacitet sedan föregående utvärdering. Glädjande. Ämnet uppmuntras att, om möjligt, utöka doktorandgruppen ytterligare och bevaka de något nedgående publikationssiffrorna.

Statusrapportering 2017

Inga nya doktorander antogs under 2016, däremot ökade (dubblerades) antalet publikationer till en klar grön nivå. Ämnet har initierat en ansökan om dubbel examen för utbildning på forskarnivå med University of Oulu.

Doktorandperspektivet

Bedömningsgrunder:

Doktoranden ges möjlighet att ta en aktiv roll i arbetet med att utveckla utbildningens innehåll och genomförande.

Utbildningen säkerställer en god fysisk och psykosocial arbetsmiljö för doktoranden.

Doctoral students are co-designers of their education

The PhD students in Col are very much co-designers of their education in an open and supportive dialogue with their supervisors, as also described in previous sections. The students have the opportunity to choose doctoral courses in dialogue with supervisors, request seminars be arranged, formulate research questions in papers and for the thesis, and choose to engage in teaching at the undergraduate and advanced level or other departmental assignments of their own interest. The doctoral students also have the freedom to initiate quality-enhancing activities themselves. For example, after one of the regular questionnaires at the department, many PhD students pointed out that: (i) more regular meetings are needed with supervisors to discuss the progress in graduate education and research projects and (ii) there is a lack of communication between PhD students working at the same division. These questionnaires were critically analysed by the staff members at the Division of Chemical Engineering (DCE) and scheduling of regular meetings on the weekly basis were strongly recommended to all supervisors with the PhD students they supervise.

Some years ago, PhD students organised a “PhD seminar group”, consisting of PhD students from the DCE. During these internal seminars PhD students shared their experiences in graduate education and courses, exchanged ideas on methodology, scientific equipment and data analysis, and discussed contacts with Alumni and industrial partners. The student group also invited researchers from different research subjects (including Col) to give seminars on specific research topics (preselected by the PhD seminar group). These initiatives of PhD students were strongly supported by the senior researchers and supervisors at Col that actively participated in the named seminars and considered them as an important departmental duty. Since the number of PhD students has been low during the last few years, this activity has ceased. Nevertheless, now that the numbers of PhD students are increasing, the activity will restart.

It is worth noting that there is a formal and general influence of PhD students in the proceedings of the University Board, faculty boards, faculty boards' committees, employment boards and university-wide working groups, as well as in the department management via the PhD Student Association within the Student Association of Engineering. Some of Col's PhD students have been actively involved in the named activities in previous years.

Working Environment

The PhD students who have a doctoral position at Col have the same rights and support as other co-workers within the university. When employment starts, in addition to start-up meetings with the supervisors, the doctoral students also have meetings with the department's project administrators to get practical information. They are offered the same introductory training as all new employees. The doctoral students have their own workspaces and receive computers, telephones and other equipment needed for the research projects and writing research papers and theses. When it comes to the physical office environment at their own workplace, doctoral students receive corresponding ergonomic chairs and tables, like the other staff at Col, and also introduction to and safety courses for working in the laboratory. Here we try to meet individual needs as much as possible. The doctoral students also have access to the same benefits as other employees in terms of wellness activities and occupational health care (e.g., the STIL physical exercise facilities) and are covered by the same regulations and routines regarding the work environment, such as LTU work and travel insurance and all facilities to meet safety regulations in the chemical and analytical laboratories.

All PhD students must attend a “Safety in the laboratory and risk assessment” course, pass the examination and sign the official agreement that they have received the needed skills and are aware of possible risks at each workplace and piece of equipment, particularly at the start of a new research project, synthetic work on a new chemical compound, etc. Safety in the laboratory is one of the central responsibilities of the Chair Professor and supervisors in regard to the health and safety of Col's PhD students. It is strictly forbidden for any person of the Col group to work by himself/herself in laboratories. There must be minimum of two persons working in the same laboratory. All supervisors and the Chair Professor strictly enforce these safety requirements and continuously remind PhD students to check and coordinate with each other to work in pairs if the work is urgent (for example, changing a sample or checking the progress of the synthesis, etc.).

What we assess from a work environment perspective as a serious risk is the psychosocial work environment including the PhD students' experiences of workload, performance requirements, responsibility and stress. Our strategy in the PhD education is to primarily handle this through the ISPs and the supervisory sessions and, as discussed in previous sections, by focusing on one research paper at the time. Another risk assessment tool regarding the psychosocial work environment is the yearly employee dialogues, where potential issues, performance and future plans are discussed with a party outside of the other supervisory team, i.e., the Chair Professor or the Head of Division. If needed, help via the occupational health care company Previa is offered, to support mental or physical health.

We also have plans to develop a series of regular conversations about the workload and stress for PhD students. We will talk about expectations and attitudes about performance requirements and how we can help each other maintain an even workload even during periods with deadlines. So far, this is a direct responsibility of supervisors and the Chair Professor. During the time of COVID-19, Antzutkin is requesting regular "Monday updates" via e-mail from all members of the Col group including PhD student(s) on their health status, their work progress during the past week and plans for the coming week. During the pandemic situation, the whole research group is organised into two subgroups and further into pairs, so that Col can operate safely in laboratories even when some staff members are working some days remotely outside the university campus.

Safeguarding a good working environment generally and also for PhD students in their education does, of course, also include ensuring a good workplace culture, which we strive to develop through a coaching tone in all dialogues, joint social activities and by jointly celebrating achievements, for example the previously mentioned signing and "spikning" of new publications and "after-the-defence" parties.

We try to be clear that we take work environment issues seriously and if a PhD student or other staff has questions, he/she can turn to the Chair Professor (Oleg N. Antzutkin) and the Head of the Division (Josefine Enman), as well as the Department management or the health and safety officer.

Central support and advice is also provided to PhD students who are facing issues in their education or work environment through the PhD ombudsmen. The university has two senior staff members that act as PhD student "ombudsman", one male and one female, that issues can be discussed with in confidence. In addition to this, the faculty-wide research education group undertakes questionnaires to both current and previous PhD students that include questions about the PhD students' work environment and take actions based on the information gathered. The student union's PhD student associations at LTU also closely monitors the development of the PhD students' work environment. This is done through elected representatives at LTU's internal bodies and through the PhD student section's own formal and informal work.

Reflections of Previous Students

Since the Chemistry of Interfaces' establishment at LTU in 2006, two current staff members of the Col group, Assoc. Prof. Anna-Carin Larsson and Assoc. Prof. Faiz Ullah Shah have developed their careers at LTU the entire path from PhD studies to associate professorship. Both of them have become experienced teachers at the undergraduate level and skillful supervisors of PhD students. Therefore, it is interesting to analyse "both sides of the coin", i.e., the personal experience of a fellow being first a PhD student at Col and then to serving as a teacher and supervisor of graduate students in the same research subject. Below, the detailed analysis of the PhD training quality at Col, both strengths and weaknesses of the education and the physical and psychosocial climate in the research group is provided by Assoc. Prof. Shah, who received his PhD training at Col from September 2007 to June 2011. Currently, Shah supervises one PhD student as the principal supervisor (Mr. Mukhtiar Ahmed) and one postdoctoral research associate (Dr. Inayat Ali Khan). One more postdoctoral research associate (Dr. Sourav Bhowmick) will join his research team in November 2020.

Faiz Ullah Shah (as a PhD student):

Strengths:

- During my PhD studies, I was supervised by Prof. Oleg N. Antzutkin (Principle supervisor) and Prof. Sergei Glavatskih (Assistant supervisor) and Prof. Erik Höglund (co-supervisor). I was given

complete freedom to think about new ideas and to design experiments and implement experimental work independently, which is one of the reasons behind the innovative research I performed during my PhD studies. We have obtained a few approved patents from the PhD thesis in less than four years.

- I received great support in terms of time from all my supervisors and we used to discuss openly new research ideas in our group discussions, which enabled me to obtain cross-disciplinary knowledge during my PhD studies.
- Group discussions with researchers working on other topics within the Col helped me learn about related topics and made me think more critically about my project.
- I saw my supervisors working in the lab, which encouraged me to work to achieve my goals.
- The friendly working environment within Col was helpful in completing my thesis work.

Weaknesses:

- Grant proposals for required instruments were not funded in time during my graduate studies.
- There was lack of sufficient collaboration with other researchers within the field, which resulted in less exposure to the scientific community.

Faiz Ullah Shah (as a supervisor):**Strengths:**

Being a supervisor, I am using all the lessons I learned during my PhD studies. For example:

- I give intellectual freedom to my PhD students and postdoctoral researchers and have found it to be a very fruitful way of conducting teamwork.
- I have frequent meetings with my students and researchers to help them solve problems within their projects.
- We have group discussions to help them learn from each other, both good and bad experiences.
- Now we have installed all the necessary instrumentation needed to perform our research without any unnecessary delays.
- Now we have more external collaborations and will be collaborating with new researchers within Sweden and outside in the near future, which will help our PhD students and researchers learn from other researchers.

Weaknesses:

- The application process for research funding is time consuming, which is used predominantly for salaries of staff members of the research group. Faculty co-funding is not sufficient to cover salaries for PhD students. There is a risk that the funding process takes focus from time spent on the research education.

To summarise, different aspects of the work environment are central in the PhD education within Col, and there is ongoing communication on the topic at the research subject, division, department and university levels.

Arbetsliv och samverkan

Bedömningsgrund:

Utbildningen är utformad och genomförs på sådant sätt att den är användbar och utvecklar doktorandens beredskap att möta förändringar i arbetslivet, både inom och utanför akademien.

Planning for a Career after third-cycle education (Section 2.4 of the Individual Study Plan, ISP) is thoroughly discussed during the first meeting (devoted to ISP) and then just before the Licentiate of Technology and PhD thesis defences. Depending on the original plans of the PhD student (and possible changes in his/her plans with time during the PhD training), supervisors make appropriate suggestions for activities that are most suitable for either an engineering career (in industry), or research/teaching career in academia. Another aspect of planning for a future career is early contacts with industrial partners and alumni in industry and/or an early search for future postdoctoral positions through national or/and international collaborators or contacts obtained during conferences and

oral/poster presentations. The PhD students are encouraged to attend at least one international conference during their PhD studies.

Activities and Courses included in the PhD education develop general knowledge and skills useful everywhere so that the PhD graduate from Col can move between industry, academia, or the public sector. These activities include, e.g., planning and performing tasks, designing experiments, analysing and summarising results, reading and writing, communication with different audiences (students, staff, project team, at conferences), discussing and criticising one's own and others' results. Depending on the plans of the student, there is room in the ISP for selecting courses that are more directed towards industry and engineering, or more directed towards academia, e.g., some PhD students take the course in University Pedagogics, which is a requirement for future employment in academia.

Departmental Duties of the PhD students usually take ca. 10% of their occupation. The duties are discussed during the regular meetings when the ISP is updated. Normally, the departmental duties involve taking care of the analytical instruments, which they frequently use. They make sure that the equipment works properly, contact the supplier for discussions, and help other staff with analysis of samples, which gives them experiences in analysing different types of samples, and not only their own samples. The students also participate in teaching as part of the departmental duties. They usually start as a lab supervisor in undergraduate courses where they prepare and set up the lab, supervise the students during the lab, and correct the lab reports afterwards. Depending on their interest, in the final years of the PhD education, they can also participate in tutorials and supervision of student projects up to the MSc level. Teaching is an excellent way of practising good planning, because the teaching session cannot be postponed and the feedback from students on an unprepared session is immediate.

Weaknesses are that the supervisors at Col have no personal experience working outside academia, which can make it difficult for them to support the students who prefer a career in industry rather than in academia. However, the supervisors have an established wide network in both academia and industry. Therefore, upon request from PhD students or colleagues, they openly discuss future job opportunities, taking into account the specific skills, achievements and results obtained in the projects, in which PhD students were actively involved during the whole period of the PhD training at LTU. LTU as a university also arranges career days where students and PhD students can meet potential employers. In addition, many of the PhD projects involve collaboration with the surrounding industry with the research project being planned in close collaboration with the supporting companies to make sure that the project targets a problem of interest for the company. The companies are involved during the entire project through regular meetings, twice per year, where company representatives can give input on the results from their point of view. In this way, both students and supervisors learn from the different perspectives on research in academia compared to in industry, and the student builds his/her own network with industry.

Alumni: Not a single PhD student in Col (**Table 1**) has had difficulty finding a job after their PhD defence. Some of them work in academia, in Sweden or in their home countries, and others work in industry or at research institutes. A few of them have changed jobs over the years, going from academia to industry, or from industry to leading positions in non-industrial activities, or starting their own companies (Dr. Mamoun Taher, Graphmatec). The successes of former PhD students are presented as good examples for the PhD students regarding possibilities after the PhD defense. In a few cases, the alumni have been directly involved in the supervision of later PhD students (e.g., Dr. Daniela Rusanova-Naidenova was supervising Dr. Mylène Trublet).

Although the Col group keeps contact with most of their previous PhD students, their experiences in work-life after the PhD could be better used to improve the PhD education in this regard.



Third Cycle Studies at CENE – Introduction school

(5 credits)

Study Guide 2020

Department of Civil, Environmental and Natural Resources Engineering
Luleå University of Technology



1 Introduction

Welcome to the Third Cycle Studies Introduction School at CENE!

Doctoral studies, or third cycle studies (TCS), usually take four to five years to render a Doctoral thesis and a PhD degree. The studies are individually conducted by the student in close collaboration with a principal supervisor and at least one assistant supervisor and the success depends largely on the student.

During the studies, the student has to attain knowledge and skills by (among others) the active participation in and successful completion of courses and by conducting own research, both individually and in collaboration with other researchers. For both courses and research, each research education subject at LTU has formulated a syllabus, which determines the TCS framework based on the Swedish Higher Educational Ordinance (HEO). Learning goals explicitly mentioned in the HEO are interpreted and implemented in the individual study plan (ISP) of the student.

The dependency on the involved individuals on each other, the balance between course and research work, and the uncertainties of the success of a research project result in a number of risks. However, the risk of failure is minimized if the student is well prepared and equipped with appropriate knowledge as well as relevant tools to conduct the studies. To work focussed and with correct tools and methods right from the start is essential to achieve the goals of the studies on time. The introduction school aims at providing admitted PhD students with important knowledge, methods and tools to succeed in third cycle study.

Apart from the dialogue with the supervisor(s), exchanging experience with other PhD students is an important means to understand how things work, to discuss all types of questions and to avoid pitfalls. The introduction school will help to become connected with other PhD students at CENE department that are on the same level.

2 Learning Objectives

The learning objectives of the TCS Introduction School are aligned with the learning goals of the HEO. After successful completion of the introduction school and the first year of TCS studies, the student shall be able to

- Define relevant research questions.
- Create a credible research plan to address a research question.
- Discuss ethical issues of the own research work and know about IPR.
- Understand publication strategies and how to build a publication portfolio.
- Review scientific publications and know how to conduct review assignments.
- Structure a scientific publication.
- Understand how research results can be made available to the public.



- Distinguish between research methods, understand their limitations, and know when they are applicable.
- Plan and conduct a good oral presentation of popular science character and in teaching situations.
- Know about the learning goal for TCS of the HEO and have a good idea on how to achieve them during the own studies.

In order to achieve the learning objectives, different activities (“mini courses”) will have to be passed. These activities are independent of each other and will be timely distributed over about twelve months.

3 Examination

The school has a runtime of one year. PhD students will be enrolled on a regular basis and after completion of the first year, the student will hold a final seminar.

The seminar not only concludes the participation in the school, but also assesses the abilities of the student to create a credible research plan and in what way the subsequent years of study will be conducted.

The seminar should contain or discuss the following:

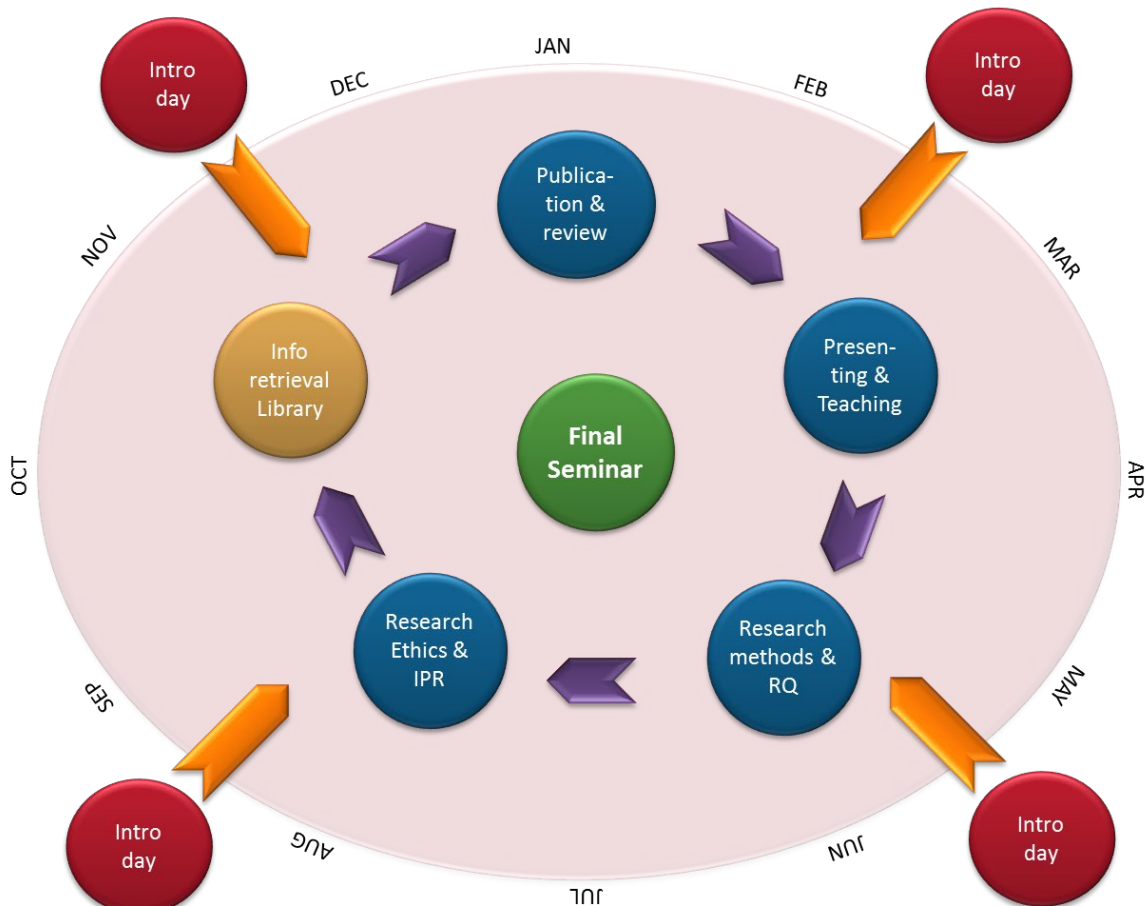
- Presentation of your research questions.
- A plan ahead for your research studies.
- Reflections on literature, risks, methods, and publication strategy.
- Review of the progress during the first year.

The seminar will be given at department level and a group of senior researchers will act as panel to assess the student.

4 Course layout

- Examiner: Lale Andreas, room T2330,
tel. 492262, e-mail: laan@ltu.se
- Language: Lectures are given in English. All material is available in English.
- Course page: Canvas classroom SBN/CENE PhD Intro School is used for information, course material, assignments etc. <https://ltu.instructure.com/courses/2318>
- Activities: see chapter 6
- Credits: 5 course credits (1 for each part and 1 for the final seminar) which all will be credited after successfully passing the final seminar
- Literature: There is no general textbook for the school. Necessary literature will be made available by the individual course teachers.

The following illustration shows the principle idea and setup of the introduction school.



5 Compulsory elements and responsibilities

Participation in all study activities is compulsory. In case that the student is not able to participate in an activity, it is up to the student to contact the responsible for the activity to find alternative dates or tasks.

The examiner shall be informed prior to any rearrangements. The examiner is responsible to provide the participants with an appropriate planning in good time ahead of the activities.



6 Study activities

Upcoming dates can be found in the weekly info of the department as well as on <https://www.ltu.se/internt/Enheter/SBN/Forskarutbildning?l=en>

Examples for the schedules for each activity are given in the appendix.

6.1 Introduction day

Date: 3-4 occasions per year, 9:00 - 15:30

Teacher: Lale Andreas, Hans Mattsson

Brief description: The introduction day aims at introducing the participants to each other, welcome them to the department and give an overview on third cycle studies at the department. The framework for third cycle studies, the individual study plan and the governing rules according to the Higher Educational Ordinance will be discussed.

It is recommended but not necessary (and not always possible) to attend the Intro day as first activity within the Intro School. After contacting the research education leader of the department (Lale.Andreas@ltu.se), who adds you to the Canvas course room, you are free to register for any of the activities within the Intro school.

6.2 Research Ethics, IPR and career planning (1 credit)

Date: October/November

Teacher: Alireza Ahmadi, Thomas Olofsson and invited guests

Aims and topics:

- To be aware of and able to discuss ethical considerations in your field of research
- Introduction to IPR, Ownership of result and implementation of research results
- Career planning

Format: Two sessions (half + full day) where the first day introduces the topics and hands out assignments which are presented and discussed by the PhD students at the full day seminar two weeks later.

6.3 Publication & Review - scientific and popular science writing and publishing (1 credit)

Date: September

Teacher: Lale Andreas, Oleg Antzutkin

Aims and

- To become aware of and able to apply important tools for scientific pub-



- topics: Publishing - What is a good scientific paper and how to write it?
- Publication planning, publishing strategies, academic portfolio
 - The impact of publishing: evaluation of researchers, groups, universities
 - Introduction to the reviewing process of scientific publications
- Format: Two sessions with lectures, discussions and exercises, presentation of your homework and feedback

6.4 The Power of Methodology (1 credit)

- Dates: February
- Teachers: Susanne Engström, Savka Dineva
- Aim and topics:
- What different methods are available to solve diverse research questions?
 - What is good research?
 - Scientific argumentation
 - How to evaluate a good thesis?
- Format: Four sessions with very limited work between sessions. Instead, the sessions will vary between lectures, workshop format, discussion, presentation and collection of data. The students' area of research will be respected when choosing papers and material to read and work with.

6.5 Teaching and Popular science presentation (1 credit)

- Date: April/May
- Teacher: Annelie Hedström and invited guests
- Aim and topics: The overall aim of this part of the course is to prepare you for oral presentations and make you feel more comfortable in presentation situations. Focus will be on teaching situations and popular science presentations. Topics that will be dealt with is how to adapt the presentation to the audience, how to keep the audience interested and active, presentation techniques, body language and how to use the voice etc. A short session will also deal with other teaching related aspects that will contribute to increased confidence in the classroom.
- Format: Four sessions with lectures and presentation exercises, auscultation and home work



6.6 Final seminar (1 credit)

- Date:** 2-3 times per year
- Brief description:** Each participant will hold a final seminar presenting a thesis proposal. You will plan its content individually, supported by your supervisor and the examiner of the course. It is important that your supervisors are present during your presentation to assess your scientific skills within your research subject. See also chapter 3.
- The seminar shall address the following aspects:
- Research question:** Here you should present the research questions that you will address during your PhD studies. Do not just copy the questions that your supervisor may have defined at the beginning of your studies. It is important that you show your own interpretation and perspective.
- Research plan:** Present a credible research plan for the remainder of the studies, including the methods you use and some milestones that you need to achieve on your way to your thesis defense. Also, discuss ethical aspects in your field of research and your work.
- Publication plan:** Present a publication plan indicating why, when and where to publish your results. This plan probably aligns with your research plan yet should be discussed in a separate section.
- Format:** Oral presentation of each participant (about 20 minutes) using Power point (or similar) slides, followed by a questioning by a senior panel and an open discussion of about 15+15 minutes.
- Poster presentation. Use the poster to present your research so that others at SBN will know what you are doing. See it as “internal marketing” for you, your project and your subject. The posters will be framed and exhibited outside the coffee room until the next group of new PhD students will have their final seminar. During the Final seminar, time is reserved for a special posters session where you present your poster. The Best Poster will be awarded based on the evaluation of an expert jury during a get-together in the poster exhibition area in the evening.



Appendix

Examples of schedules for the intro day and the courses



1. PROGRAM Introduction day

Time	Activity
9:00 -9:30	Welcome, presentation and expectations of all participants
9:30-9:50	The Introductory School – Third cycle studies at LTU / CENE (Lale Andreas)
9:50-10:00	10 min break
10:00-10:20	Experiences from my PhD studies (Faez Sayahi)
10:20-10:30	PhD student Association at LTU (Yang Zuo)
10:30-10:35	Short break/stretch your legs
10:30-11:30	The Life of a PhD student (Lale Andreas) <ul style="list-style-type: none">• Supervision & supervisors• PhD student representatives• Problem solving
11:30-12:30	Lunch break
12:30-13:00	Presentation of LTU and the department of CENE (Charlotta Johansson)
13:00-13:05	Short break/stretch your legs
13:05-14:00	The Life of a PhD student: Me and my elephant – Motivation factors (Lennart Elfgren)
13:00-13:05	Short break/stretch your legs
14:00-14:45	Individual study plan ISP (Hans Mattsson) <ul style="list-style-type: none">• Governing framework and goals for higher education in Sweden• General syllabus (Allmän studieplan ASP)• Activities in order to fulfil the goals• PhD Courses
14:45-15:00	15 min break
15:00-15:20	Administrative systems (Anneli Engström, Katrin Sannerborg) Time registration, Travel booking and billing, Personal system, Checking your study credits, Vacation, ...
15:20-15:30	Questions and Feedback



2. Research Ethics, IPR and career planning

Schedule 2020

- Tuesday, **24th Nov** ([13-16](#)) [Good research practice and ethics](#),
 - Instructor: Thomas Olofsson, SBN Research School Ethics & IPR_2018.pdf
- Tuesday, **December 1** (13-16) Career planning and elevator pitch,
 - Instructor: Heather Jacksic -LTU Career center
 - In this 3-hour lecture in career planning, you will learn about career styles, the labour market, employability, transferable skills and personal branding. You will also have the chance to prepare and practice a pitch to present your research.
- Friday, **December 4** (13-16) , How to develop a roadmap to successful commercialization of your research results
 - Roger Tuomas and Kent Mrozak, LTU Business, Aurorum 1A Luleå Science park
- Friday, **December 11** (13-16), Presentation of assignment in Good research practice and ethics



3. The Power of Methodology - Scientific research methods

Schedule 2020

Friday 7/2/2020 9:00-16:00 Room: F236

What is a good research (discussions) - Movie Clips to Watch during seminar

"Notes from your discussions during seminar will be published here"

pic 1, pic 2, pic 3, pic 4

What is good research (lectures)?

Additional material

Assignment 1:

Organize a discussion with your supervisor(s) pinpointing "what is good research" to them. To facilitate for a rewarding discussion, prepare for the meeting by reflecting on what you think is good research and how this, in turn, is reflected in thoughts concerning your own research project(s). During the discussion, take notes and add your own reflections. Bring your notes to the third Friday meeting, and prepare to give a short presentation.

Friday 21/2/2020 9:00-16:00 Room: F236

What is a good research question (lectures)?

Additional material

Assignment 2

Friday 28/2/2020 9:00-16:00 Room: F236

What is a good research? (lecture and further discussions)

Formalities and considerations around presenting a thesis (lecture)

Judgment of thesis manuscript (lecture)

The defense (lecture)

Round table discussion

If you miss one Friday - additional assignments

The module is organized based on the premise of active participation. That basically means that you need to attend to complete the module. However, if you miss one of the three seminars there is the opportunity to do an additional assignment.

Additional assignments



4. Teaching and Popular science presentation

Schedule autumn 2020:

13 October 8.15-11.45	Room F531
15 October 8.15-11.45	Room F436
22 October 8.15-14.45	Room F232 OBS New day and new room
27 October 8.15-13.00	Room F531

Lecture 1 Introduction

Course introduction

Workshop 1 Comfortable in the class room?

Workshop 2 Practical arrangements, planning, rules etc related to teaching at university

Bring your laptops to lecture 1

Presentation given at lecture 1

Lecture 2 How to do a good presentation

Bring your mobile phones or tablets to lecture 2

Presentation given at lecture 2

Lecture 3 Teaching, Pitches & Popular science presentations

Bring your laptops to lecture 3

Presentation given at lecture 3 Education & Organisation

Presentation given at lecture 3 Popular science presentations

Lecture 4 Popular science and stakeholder presentations



5. Publication & Review – scientific and popular science writing & publishing and reviewing scientific work (Lale Andreas & Oleg Antzutkin)

Task to do PRIOR to the course: Read one scientific article within your subject area; bring a paper copy of the article to the class

Program Day 1

Time	Activity
9.00 -9.15	Welcome and presentation
9.15-9.45	Intro – Why do we read and write scientific articles? Why do we want to read and produce <i>good</i> articles? What is a <i>good</i> article? – Brief discussion and feedback
9.45-9.50	Mini break – stretch your legs
9.50-10.20	Introduction to the reviewing process of scientific publications
10.20-10.25	Mini break – stretch your legs
10.25-11.30	How to write a good article: Title, abstract, introduction Small tasks
11.30-12.30	Lunch break
12.30-14.00	Individual work and discussion with your neighbour (3 students per breakout room): Is the article you brought a good one? Why - or why not? Feedback in the whole class. Each group shows one example on screen
14.00	Coffee/tea break – stretch your legs
14.15-15.45	How to write a good article: methods, results, discussion, conclusions, acknowledgements, references and electronic supplements Language – using proper English Small tasks
15.45-16.00	Introduction to homework – Write an introduction to your next article Questions, Wrap up

Program Day 2

Time	Activity
9.00 -9.45	H-index and journal ranking, choice of journal, authorship Monetary compensation for scientific publishing at LTU



9.45-10.00	Break – stretch your legs
10.00-10.15	Electronic supplements, graphical abstract
10.15-11.40	Review of homework: group work (3 people): read and review the introduction of your group mates (15 min per introduction). Formulate a title for each intro. Explain your comments to the author of the intro (5 min per person) and compare your title with the original title. 5 min break Report interesting outcomes of your work to the whole class.
11.40-12.40	Lunch break
12.40-13.00	Language – using proper English Small tasks
13.00-13.40	Publication planning, publishing strategies Group work: discuss your publication strategy using your ISP. Feedback to whole class
13.40-13.55	Short break
13.55-14.40	Other types of publications Differences between scientific and popular science publications Small task
14.40-14.45	Questions, Wrap up

Vetenskapsteori 7,5 hp FOR042F

Publicerad: 9 januari 2017

KURSPLAN

Kursnamn: Vetenskapsteori (Philosophy of Science)

Högskolepoäng: 7.5

Kurskod: FOR042F

Utbildningsnivå: Forskarnivå

Kursplanen fastställd av: Stefan Lundström

Examinator: Ingemar Friberg

Förkunskapskrav: Antagen till forskarutbildning

Lärandemål: Att den studerande efter avslutad kurs skall:

- äga förmåga att systematiskt reflektera över den egna forskningsverksamheten i ett större filosofiskt och vetenskapsteoretiskt perspektiv,
- ha kännedom om vissa allmänna metodologiska frågor, samt kunna se hur dessa relaterar till det egna forskningsområdet,
- kunna problematisera sin forskning eller sitt forskningsområde ur ett vetenskapsteoretiskt perspektiv,
- ha kännedom om grundläggande vetenskapsteoretiska frågor, begrepp och problem, och kunna relatera dessa till den egna forskningen,
- ha kännedom om allmänna frågeställningar inom feministisk kunskaps- och vetenskapsteori, samt kunna applicera ett genusperspektiv på vetenskap och forskning.

Kursinnehåll: Övergripande frågeställningar rörande begreppet vetenskap, vetenskaplig metod, hypotesprövning, förklaringsbegreppet, etc. behandlas i föreläsnings- och seminarieform.

- Vad vetenskap är och bör vara. Vetenskaplig metod. Feministisk kunskaps- och vetenskapsteori. Definitionslära.
- Vetenskapliga hypoteser. Induktion och induktionsproblemet. Hypotetisk-deduktiv metod. Naturvetenskap kontra teknik-, samhälls- och humanvetenskap.
- Vetenskapliga förklaringar.

- Mening, tolkning och förståelse.
- Objektivitet. Tolkning och hermeneutik.

Genomförande: Föreläsningar och seminarier. Kursen examineras genom aktivt deltagande i seminarier, en muntlig presentation av en originaltext vid ett av seminarietillfällena, samt författandet av en uppsats.

Examinationsform: Deltagande vid seminarier, muntlig presentation samt uppsats. De studenter som inte har möjlighet till deltagande på plats ges möjligheten att delta på distans, t.ex. genom Zoom.

Betygskala: U G

Litteratur:

Backman, Y., Gardelli, T., Gardelli, V. & Persson, A. (2012). *Vetenskapliga tankeverktyg*. Lund: Studentlitteratur.

Chalmers, A. F. (2013). *What is this thing called Science?*. 4th edition. Maidenhead: Open University Press/McGraw-Hill Education.

Kompendier med stencilerat material tillkommer (distribueras elektroniskt).

Kurstid: Lp4 V2021

Ansökan till: edukkl@ltu.se Ange namn, personnummer, mailadress och institution i ansökan

Sista anmälningsdag: 8 mars 2021

Kontaktperson: Anders Odenstedt, anders.odenstedt@ltu.se

PUBLICERAD: 9 januari 2017

UPPDATERAD: 11 november 2020

AV: [Linnea Lindberg](#)

Vetenskaplig publicering 4,5 hp FOR029F

Publicerad: 9 januari 2017

Kursen är öppen för registrerade doktorander, och ges i läsperiod 1, årligen. Anmälan skickas till instregets@ltu.se, inkludera kursnamn, ditt namn, din institutionstillhörighet och kontaktuppgifter senast den 15 augusti.

Kursen ges på Campus i Luleå, via sex tillfällen (föreläsningar/WS). Du behöver vara där, och aktivt bidra, vid fem av de sex tillfällena. Följande datum gäller för ht 2020:

8/9 13-16

9/9 9-12

24/9 13-16

25/9 9-12

20/10 13-16

21/10 9-12

KURSPLAN

Kursnamn: Vetenskaplig publicering/Academic Publishing

Högskolepoäng: 4.5 hp

Kurskod: FOR029F

Utbildningsnivå: Forskarnivå

Kursplanen fastställd: Sara Thorgren

Examinator: Professor Karolina Parding

Behörighet

Deltagare ska vara antagna till utbildning på forskarnivå vid Luleå tekniska universitet.

Lärandemål

Doktoranden ska efter avslutad kurs kunna:

- förklara publiceringsprocessens faser och funktioner
- förklara review-processen, och visa praktiskt prov på hur den kan omsättas i praktiken
- jämföra olika traditioner och modeller kring vetenskaplig publicering
- sammanfatta vilken betydelse vetenskaplig publicering har för spridning och erkännande av ny kunskap inom det egna forskningsområdet
- diskutera och värdera bibliometri som ett mått på produktivitet och kvalitet i forskningen
- förklara hur kön utgör en möjlighet eller ett hinder i publiceringsprocessen

i syfte att

- självständigt kunna presentera och diskutera forskning och forskningsresultat i skriftlig dialog med vetenskapssamhället, och
- genom egen forskning väsentligt bidra till kunskapsutvecklingen.

Kursinnehåll

Kursens lärare föreläser om publiceringsprocessens olika faser och funktioner utifrån sina olika angreppssätt, forskningsperspektiv och publiceringstraditioner. Syftet är att skapa förutsättningar för förståelse för och diskussioner om hur kunskap produceras, sprids och utvärderas inom och utanför vetenskapssamhället. I anslutning till föreläsningarna hålls workshops, vilket förutsätter aktivt deltagande av kursdeltagarna. Dessa inkluderar praktiska övningar som syftar till att ge verktyg för att hantera samt strategiskt planera, komma igång och genomföra publiceringsprocessen.

Genomförande

Kursen genomförs via föreläsningar, seminarier och diskussioner företrädesvis fördelat över sex halvdagar, vid tre tillfällen.

Examinationsform

Kursen examineras genom muntliga och skriftliga inlämningsuppgifter. Kurstillfällena kräver närvaro och aktivt deltagande då dessa utgör en del av examinationen.

Betygsskala: G/U

Litteratur: En litteraturlista meddelas vid kursstart.

Kurstid: Lp 1 2019, 2020

Ansökan till: instregets@ltu.se Inkludera personnummer, LTU-institution och all kontaktinformation i meddelandet. Sista dag för anmälan är 15 augusti.

Kontaktperson: Karolina Parding

PUBLICERAD: 9 januari 2017

UPPDATERAD: 15 juni 2020

AV: [Linnea Lindberg](#)

Research ethics 4,5 credits FOR023F

Published: 21 December 2016

Spring 2021

COURSE SYLLABUS

Course name: Research Ethics

ECTS/HP: 4,5

Course code: FOR023F

Education cycle: Third-cycle (doctoral level)

Syllabus established: Gunilla Isaksson

Examiner: Åsa Engström

Course Leader: Silje Gustafsson

Entry requirements: Admitted as doctoral student at Luleå University of Technology. Doctoral students from other universities can apply and will be admitted depending on availability.

Course aims: On completion of the course, the PhD candidate should be able to:

- Show independence and scientific honesty in one's own research work, as well as reflect on one's own values and how these affect the approach to research
- Show the ability to make relevant research ethical assessments in relation to one's own and others' research work, based on ethical principles for research, guidelines and relevant laws and regulations
- Demonstrate the ability to systematically reflect on one's own and others' research activities with respect to research ethics, equality, gender and sustainability
- Demonstrate the ability to assess questions about the role of science in society and on the researcher's responsibility towards society based on research ethical and scientific norms

Course content:

- The philosophical foundations of research ethics

- Principles of research ethics, guidelines, codes and declarations
- Ethics and legislation
- Research ethical reasoning on the impact of research on people, societies and the resources of the earth
- Gender, intersectionality and equality in research and academia
- Scientific conduct

Realization: Literature studies, lectures, seminars and the writing of reflective reports after the seminars have been completed.

Examination format: The course is examined through active participation in seminars, writing of reports after seminars and the writing of a report.

Grading scale: Pass/Fail

Literature:

ALLEA (2011). The European Code of Conduct for Research Integrity. Retrieved from: http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf

Lag (2003:460) om etikprovning som avser människor.

http://www.riksdagen.se/sv/dokument-lagar/dokument/svenskforfattningssamling/lag-2003460-om-etikprovning-av-forskning-som_sfs-2003-460

Mustajoki, H. & Mustajoki, A. (2017). A New Approach to Research Ethics. Using Guided Dialogue to Strengthen Research Communities. London: Routledge

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1978). The Belmont report: Ethical principles and guidelines for the protection of human subjects of research. [Bethesda, Md.]: The Commission.

Shamoo, A.E. & Resnik, D.B. (2015). Responsible conduct of research. (3.ed.) New York, NY: Oxford university press.

Vetenskapsrådet (2017). Good Research Practice. [Elektronik]

Stockholm: Vetenskapsrådet. Retrieved from:

https://www.vr.se/download/18.2412c5311624176023d25b05/1529480532631/God-forskningssed_VR_2017.pdf

World Medical Association. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA*. 2013;310(20):2191–2194. doi:10.1001/jama.2013.281053

Additional teaching material of about 100 pages in accordance with the teacher's instructions.

Deadline for registration for the course: 11/01, 16:00 PM

Course period: Study period 3, 2021.

Contact person: Silje Gustafsson

[Application](#)

PUBLISHED: 21 December 2016

UPDATED: 16 September 2020

BY: [Linnea Lindberg](#)