Universitetskanslersämbetets
utbildningsutvärderingar

Självvärdering forskarutbildning

Lärosäte	Uppsala Universitet
Forskarutbildningsämne	Analytisk kemi
Licentiatexamen	Ja
Doktorsexamen	Ja

Skriv en självvärdering per utbildning som leder fram till den examen som ska utvärderas. Självvärderingen baseras på bedömningsgrunder inom områdena:

- Förutsättningar
- Utformning, genomförande och resultat
- Doktorandperspektivet
- Arbetsliv och samverkan

För en mer preciserad vägledning till lärosäten vad gäller bedömningsgrunder, se *Vägledning för utvärdering av utbildning på forskarnivå*.

- Självvärderingen indelas i enlighet med rubrikerna som anges nedan. Eventuella underrubriker kan lärosätet fritt besluta om.
- Lärosätet ombeds göra en så reflekterande självvärdering som möjligt, identifiera styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Tyngdpunkten på självvärderingen ska ligga mer på värdering än på beskrivning. Lärosätet ombeds belysa med exempel.
- Självvärderingen ska utgå från aktuella förhållanden för utbildningen.
- Självvärderingen ska inte överstiga 30 sidor exklusive efterfrågade bilagor.
- Självvärderingen ska kunna stå för sig själv, det vill säga det ska inte inkluderas länkar. Om lärosätet anser att kursplaner krävs för att styrka det som står kan dessa laddas upp i UKÄ Direkt.
- Som bilaga till självvärderingen ifylls angivna tabeller och publikationslistor, se Bilaga 1 i vägledningen, *Instruktion för bilagor till självvärderingen.*
- Samtliga tabeller laddas upp i Excelformat i UKÄ Direkt. Publikationslistor laddas upp i Word- eller PDF-format i UKÄ Direkt.

Bakgrundsinformation

Självvärderingen inleds med en beskrivning av forskarutbildningsämnet och utbildningen. Redogör övergripande för utbildningens organisation, upplägg och inriktning. Redogör även för hur länge utbildningen har getts vid lärosätet.

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.

Background description

Introduction

This self-evaluation was produced by the program professor responsible for Third cycle studies (FUAP, Bergquist) in Analytical Chemistry in collaboration with all the other nine internal supervisors and with important input from the ten PhD students. We chose to write the document in English to be able to include all supervisors and PhD students in the process. To ensure and allow for input from all presently active PhD students, we conducted a survey during spring 2020 and asked one representative PhD student to summarise the results of the survey. The result from this survey is included unaltered in the PhD student perspective section in the report.

The UU central unit for Evaluations read the resulting version, and after their feedback we revised and completed the self-evaluation.

The surveys we used as a base for our self-evaluation were **a)** our own PhD student survey (Spring 2020), **b)** the department work environment survey 2020 (summary for the Analytical Chemistry program), **c)** the program alumni survey 2015 (“Hundragubbe jubileum”), **d)** the survey of postgraduate education at Uppsala University from three perspectives. Doctoral students, supervisors and alumni at the Faculty of Science and Technology. The unit for Quality and Evaluation. 2016, **e)** the National Analytical Chemistry Program survey in 2019-2020 (“the Future of Analytical Chemistry” conducted by the FUAPs in Analytical Chemistry at UU and LU), **f)** the European Survey of Analytical Chemistry, Education and careers of European analytical chemists by Reiner Salzer in ABC 2014, **g)** UU Quality and Evaluation unit survey with report for our Faculty 2017, **h)** UU-wide evaluations “Quality and Renewal” (”KoF”) 2011 and 2017.

Subject orientation

Analytical chemistry is based on current analysis problems and deals with theories and experiments needed to solve them. The subject includes the development of new and improved principles, methods and techniques for the weakest link in analytical issues. The subject also includes developing new methods and techniques for quantification, increased

sensitivity and increased specificity of selected molecules and sample matrices. The subject thus has a strong role in fundamental basic research but is also an important auxiliary subject to a large number of other subjects both within and outside chemistry.

Based on the basic education within the subject area, the doctoral education must provide additional insights within the more important parts of the subject as well as in-depth knowledge within at least one sub-area. Through supervision, research methodology and dissertation work, the doctoral student must be made well prepared for critical and independent research activities or for other qualified professional activities where high demands are placed on subject insight and research knowledge. Quality and accuracy are two important cornerstones of the subject.

The doctoral student must also be able to present his / her goals and results in oral and written form to different target groups in English and, in the case of Swedish-speaking doctoral students, in Swedish.

The research program in analytical chemistry has its original origins already in the second half of the 18th century when Torbern Bergman at Uppsala University became the world's first analytical chemist with his basic analysis of, among other things, the minerals' elements and the discovery of the art of carbonating water. The subject has since then had an important place at the Department of Analytical Chemistry as part of the Department of Chemistry (Kemiska Institutionen) in the English Park to move to the Biomedical Center in 2004 as part of the Department of Physical and Analytical Chemistry, and since 2008 in the Department of Chemistry - BMC (together with research programs in organic chemistry and biochemistry).

At the department, we have introduced an institutional joint revision period for individual study plans during the period October 1 - December 1 for all doctoral students except those who have been admitted after September 1 or will defend their dissertations soon. To secure the doctoral students' perspective, the doctoral students are represented in all formal working groups at the department. The doctoral education committee has three doctoral students, the department board has two regular students + two deputy places, and one doctoral student is included in the work environment group and the equal conditions group, respectively. The doctoral student council consists of all doctoral students and elect representatives to the various working groups. All types of issues concerning doctoral students are discussed here and these can, if necessary, also be raised to various decision-making or preparatory bodies at the department or the doctoral student council at the faculty (Teknat doktorandråd).

We have a process for the introduction of new doctoral students with director of research education (FUS) and administrator were an introduction to the formal aspects and how the education is organized at the department is presented.

The department's guidelines for the PhD education course component (adopted by the board 20190221), states that doctoral students who are to teach must plan to attend a higher education pedagogical course (a total of five weeks is required for teaching undergraduate students) as early as possible and are expected to complete their pedagogical education before half time. The doctoral students must apply for an ethics course immediately. Before the licentiate seminar / part-time seminar, the doctoral student is expected to have taken the ethics

course. Supervisors are expected to support doctoral students to apply for and complete courses on time. Supervisors are expected to contribute to the subject / specialization's course offerings at postgraduate education level. The ISP half-time revision is critical for final course planning. If there are not enough registered courses at this time, the course component must be given full priority. In the case of an ISP revision 1 year before the planned dissertation, all courses must normally be completed. If this is not the case, but it is reasonable that all courses can be completed before the dissertation, a schedule incl. follow-up is established at this time. All courses according to the ISP must be completed and registered in Ladok before the opponent is booked for the dissertation (3-6 months before the dissertation).

At the Department of Chemistry – BMC we have a number of general institutional processes and routines for the postgraduate education. We have a department's Postgraduate Education Committee where the FUS gathers FUAPs, 1 doctoral student/program, and sometimes an administrator. Recurring agendas are recruitment and courses, RISP discussions, revision of subject study plans, seminars etc. We also have a general recruitment process where common routines adopted by the department board are used. The process briefly follows the order: **a)** the board recommends that recruitment can begin (finance + supervision should be in place), **b)** the supervisor sends the ad text to the postgraduate education committee, FUS compiles the comments and notifies the supervisor + HR who is advertising**, c)** the supervisor sends a plan for the interviews to the FUS / R&D committee. Then the supervisor selects 3-5 top candidates for interview, where also with HR and external senior researchers participate, **d)** the supervisor sends the application documents for the top candidate to the committee + comments from HR and senior researchers. The committee provides feedback to the supervisor, **e)** FUS sends feedback to the head of department before a decision on admission.

At the department we also conduct a continuous quality work, including regular discussions (2 times/year) of the doctoral education. Participation has mainly been supervisors, doctoral students, FUAPs, FUS and doctoral education administrator.

We have also recently conducted an internal survey of the research education where three researchers from different programs, with experience of doctoral education from universities outside Sweden, were commissioned to unconditionally investigate and produce proposals for quality-enhancing measures. Based on the results of this survey we are now changing the procedures for the halftime evaluation and also will introduce a predissertation strategy to secure quality of examinations.

The organization and structure of the education in Analytical Chemistry

All doctoral students in analytical chemistry are recruited on an international basis in open calls and the research projects in which they are involved usually have a global focus. Between 50-120 applications are received for each call, and the selection takes place through an established open procedure with clear selection criteria, interviews and suitability tests. Both supervisors and external seniors participate in the selection together with a representative from HR department. Doctoral students in research programs and research groups are also asked for their views and input. A postgraduate education committee at the

department ensures that matters are prepared and handled correctly both during the announcement but also before the department board's decision on appointment.

The number of doctoral students in analytical chemistry is currently (September 1, 2020) 10, of which 8 originate from countries other than Sweden. Two of the current doctoral students are connected to industrial projects (at Stora Enzo and Fresenius Kabi, respectively) and therefore carry out most or part of their research projects within these organizations. These, partly external PhD students still follow the same requirements and study plans as the internal students and are invited to all activities within the program. Main supervisor for those two students is prof Bergquist.

In connection with new recruitment, an individual study plan is written, which is revised annually. In addition, there are reviews of the doctoral students' status at special supervisor meetings to see if extra measures need to be put in place (these meetings have been paused for a while due to the pandemic but will continue to be held via Zoom until the situation has returned to normal). Regular supervisor-doctoral student meetings are expected to be held and any problems are brought forward to the professor responsible for postgraduate education (FUAP), the director of postgraduate studies (FUS) (and head of department if required). There are always at least 2, but sometimes 3 or more, supervisors around each doctoral student. FUAP is also responsible for research seminars where each doctoral student presents his or her research and receives feedback once per semester. The doctoral students also write a 5-page annual summary of their projects which is discussed with the supervisor.

Doctoral students are also encouraged to apply for scholarships to participate in at least one international conference per year. With the digitalisation that is taking place now, this is much easier and the doctoral students participate in most conferences across digital platforms.

To date, just over 150 doctoral students have been educated in the program and then found their place and further careers in academia, industry or the public sector. Since analytical chemistry is a sought-after profile in virtually all areas of society, doctoral students have no problem finding the next step in their careers.

Förutsättningar

Personal

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel. Relatera till ifylld och bilagd tabell över handledare och lärare.

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.

Conditions

Academic Staff

The staff in the program currently consist of one professor, four senior lecturers, four researchers and two research engineers. Together their combined competence covers the broad subject area of analytical chemistry. Since the research education within the analytical chemistry program covers both organic and inorganic analytical chemistry with an emphasis on mass spectrometric analysis, this is crucial. The main research areas that PhD students are active in include several “omics” disciplines such as; proteomics, lipidomics, metabolomics and metallomics. Other areas are environmental analysis, instrumental development, surface analysis and large data handling. Currently ten PhD students are active in the research education programme, and they all have (with one exception) their main supervision from the staff within the program, but often also have co-supervisors outside the program (eg from other programs or from industry). All the main supervisors and a majority of the co-supervisors have taken the mandatory courses in supervision of PhD students (either a 3 week university course or the shorter course at the Teknat faculty). A continuous competence development for supervisors is offered, both via courses that are offered from the university centrally (the unit for university pedagogy) and in Teknat faculty (MINT, TUR – with focus on under graduate education). Additional co-supervision resources from outside the analytical chemistry program are listed in the attached Table, including two professors and three supervisors from industry. All external co-supervisors are included in the supervision meetings with the PhD students, but are also invited to be a part of the discussions with colleagues in the program. The scientific competence of the supervisors and teachers of the program is very high, with both width and depth in Analytical Chemistry as well as in related areas. All supervisors are frequently involved in teaching at the bachelor level, as well as on master level, in particular in the master program for Analytical Chemistry and the Joint Erasmus Mundus master program Excellence in Analytical Chemistry. A continuous development of supervisor competence in scientific and pedagogic terms is done through supervisor meetings, workshops, teacher meetings (currently every week due to the special situation during the pandemic). At all these events we often also discuss aspects of doctoral training. The TekNat faculty pedagogics council (TUR) organizes regular seminars and workshops, where several supervisors participate.

The currently active main supervisors are prof. Jonas Bergquist, assoc. prof. Ingela Lanekoff, assoc. prof. Sara Lind and dr Jeffrey Hawkes. As active internal co-supervisors we have dr Per Sjöberg, dr Kumari Ubhayasekera, dr Ganna Shevchenko, dr Kyle Duncan, dr Jean Pettersson and dr Marit Andersson (the latter two will retire in 2021).

Besides his professorship at Uppsala University, Jonas Bergquist, holds a position as Adjunct Professor in Pathology at the Department of Pathology, School of Medicine, University of Utah, USA, and Distinguished Professor in Precision Medicine, Binzhou Medical University, Yantai, China. Bergquist is more over receiver of the High-End Foreign Expert Award, States Administration of Foreign Experts Affairs, China and the Taishan Scholar Foreign Expert Award, Shandong Province, China. He is also elected as a member of the scientific advisory board of Open Medicine Foundation at Stanford University, a research fellow member of

SciLifeLab, chairman of the Swedish Chemistry Society sections for Mass Spectrometry and of the section for Analytical Chemistry, Chairman of the Chemical Society of Uppsala.

Associate professor Ingela Lanekoff joined the program 6 years ago and has since then received the Ingvar Carlsson Award from SSF and the Berzelius silver Medal from the Swedish Mass Spectrometry Society. In addition, she has secured over 19 MSEK from funding agencies and serves on the board for the European mass spectrometry imaging society.

Associate professor Sara Lind (until lately the FUS at the department) was recently (this summer) recruited to a new position at the central administration of the faculty, but will stay active as an external supervisor with us and be connected to the research program through the Bergquist group. Sara has together with professor Ylva Ivarsson (in the biochemistry program, and the new FUS) secured a major grant from SSF that support one of the PhD student's projects in the program. Prof. Ivarsson has now taken over the role as main supervisor for the PhD student although still in the analytical chemistry program. This is a very good example of how the best supervision of the PhD students is in our main focus and not the formal subject definition.

Researcher Dr Jeffrey Hawkes has recently secured his own personal VR grant and been ranked A for the ERC starting grant. Dr Hawkes is very much involved in the PhD education as supervisor internally and externally (at the department of Limnology), but also strongly supporting the quality work and strategic development of research education within the department and program.

The program is currently in a generation shift, where two lecturers working half time are retiring and one new full-time lecturer Dr Daniel Globisch is joining the program. Dr Globisch will bring in three-four new PhD students to the program which is very positive for the environment.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

There is a current general trend of reducing the numbers and increasing the sizes of departments at faculty level. In the research programs (former departments) the focus is more and more on the individual research groups. This could be potentially positive for the independency of each group leader but may also lead to a lost identity and collaborative engagement in the subject. This will also inevitably impact the research education and the PhD students. Based on the National Analytical Chemistry Program survey in 2019-2020 "the Future of Analytical Chemistry" conducted by the FUAPs in analytical chemistry at UU and LU (Bergquist and Turner), this is an issue that analytical chemists among others must act on by better identifying the strengths and identity of the subject and declaring its important role in society.

As in all generation shifts there is an obvious risk of losing competence in certain areas. In the ongoing strategic discussion we try to direct the development of the program and thus also the focus of the research education into areas where we can maintain strong expertise

and progression. We lose competence in inorganic analytical chemistry but gain knowledge in organic analytical chemistry and metabolomics.

Förutsättningar

Forskarutbildningsmiljö

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel. Relatera till ifyllda och bilagda tabeller.

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.

Conditions

Third-cycle program environment

Research at the faculty of Science and Engineering (“TekNat”) at UU is organized in about 60 programs; there are nine programs in the Chemistry section divided between two departments (Ångström and BMC). Most of the faculty financing for research and research education (ca. 70%) is directed to the programs. Each program has a responsible professor. The research education/doctoral training is organized in subjects (e.g. Chemistry) often with specializations (e.g. Analytical Chemistry), where each specialization has a responsible professor (“FUAP”). PhD students within the research program in Analytical Chemistry are financed with 75% external grants and 25% with faculty funding (“studiestöd”). One current PhD student is fully funded and employed at the industry (Stora Enzo).

Analytical chemistry as part of Chemistry – BMC is located in a very rich life science environment where chemistry, biology, pharmacy, medicine and social sciences are sharing infrastructure and localities. The Biomedical Centre is an infrastructure for life sciences in its widest sense. Research encompasses the smallest molecule up to complete organism. This includes for example, how molecular structures can explain biological processes, the life cycle of microorganisms and their interaction with their hosts and how intracellular processes and intercellular communications control normal tissue development, cancer and degenerative diseases. In addition, several aspects on drug design, delivery, metabolism and function are addressed at the pharmaceutical departments at BMC. Although basic research is the principal point, it is a balance on the border between basic research and technical application. Especially analytical chemistry with the nature of the subject and our PhD students gets ample possibilities to be involved in true translational research projects cross disciplines,

The research education within the analytical chemistry program is strongly influenced by the research profile of the supervisors but also highly dependent on the availability of state-of-the-art instruments and techniques. Furthermore, with the exception for newly recruited lecturers who get their first PhD student fully financed by the program, the PhD students within the analytical chemistry program are funded through external grants, which leads to fluctuations in student numbers and occasionally gives rise to periods with too few students. With the occurring generation shift the number of PhD students will increase to 12-15, which is also a good number for a vivid research environment within the program.

Today, the research infrastructure/instrumentation includes a large array of mass spectrometers and separation systems. There is a regular demand to renew the instrumentation to keep the department on the cutting edge of analytical chemistry, especially to be able to provide sufficient instrument time for research education. The program is continuously setting aside money to enable PhD students' access to state-of-the-art equipment for mass spectrometry. Still there are time periods when the demand of instrument time is higher than the availability and this can be stress full for the PhD students. We have an instrumentation group that actively plan the use and try to make it as fair as possible.

The research education within the program responds and connects to several important societal challenges and urgent needs in prioritized areas of life science, health care and environment. To identify the needs and succeed in these efforts, the program has wide-ranging collaborations with partners from industry, healthcare, governmental authorities, private-non-profit organizations, civil society including both Swedish and international journals, television and radio, patient organizations, libraries and schools. This gives our PhD students a good and relevant exposure to the society and a possibility to also present their research studies to a broader audience. This also often results in that their post-graduate career is facilitated and they very early get in personal contact with potential future employers. In our alumni surveys we see that approximately 50% of the former PhD students are employed by biotech (such as Cytiva) and pharma industry (such as Astra Zeneca), while the rest stay in academia or in the public sector.

The main supervisor is responsible for planning and following up on progression and goal fulfillment in all parts of the doctoral student's education, including the dissertation work. For planning and follow-up, the ISP is an important document in the collaboration between supervisor and doctoral student. In order for the collaboration during the education to work as well as possible, the supervisor and doctoral student should make it clear at an early stage what requirements and expectations they have of each other. Some research groups within the program use student-advisor expectation scales to discuss responsibilities of both parties.

Currently the program holds two main research groups that contain PhD students, the group of Prof. Jonas Bergquist with four internal (and 6 external) PhD students, and the group of Assoc. Prof. Ingela Lanekoff with four PhD students. In addition, the program has recently recruited Assoc. Prof. Daniel Globisch who will join the program in December 2020 with three to four PhD students. All group leaders and the independent researchers Associate professor Sara Lind (Sara just left the program this summer for an appointment at the central faculty but is associated with prof Bergquist's research group) and Dr. Jeff Hawkes are involved in supervision of PhD students as co-supervisors. The research environment for the PhD students is further positively influenced by the currently 4-5 post docs/researchers that

are part of the research groups. They often contribute to an important aspect of practical supervision with their hands-on skills, but also enrich the scientific atmosphere by taking active part in seminars, education courses etc.

All supervisors at the program frequently give keynote/invited talks, participate in evaluation of national and international research grant applications, sit on boards of different societies, and act as faculty opponents, or the equivalent, at PhD dissertations both in Sweden and abroad. In addition, supervisors within the program hold prestigious fellowships from, e.g., the Royal Society of Chemistry, FRSC, UK, Regia Societas Scientiarum Upsaliensis, KVS, and Academiæ Regiæ Scientiarum Upsaliensis, KVSU, SSF, VR etc. Moreover, all of the program's supervisors have contributed with invited review articles, book chapters, and served as chairs and expert reviewers for scientific conferences and journals. This gives a good visibility for the research program nationally as well as internationally. This also support the PhD students in their possibilities to gain a supportive scientific network of their own and can also facilitate for the post-graduate career by giving post-doc opportunities and future employment offers.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

The research areas for the research education are to a large extent directed by the external funding and resources. In the Analytical Chemistry field there is an evident global shift towards more and more applied research while the more fundamental research topics are harder to finance. This could potentially influence the width and depth of the subject. We strive to always include both the theoretical and fundamental aspects of the analytical chain in all research education projects – to stress the importance of deep understanding of technologies and methodologies even in the most critical applicable field. The wide network of the supervisors substantially helps here to expose the PhD students to societal questions and research tasks. We should always remember that the results from any front-of-the-line technology never gets better than the weakest point of the pre-analytical or post-analytical steps.

Utformning, genomförande, resultat

Måluppfyllelse – kunskap och förståelse

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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.

Design, implementation and outcomes

Completion of Goals - Knowledge and Understanding

The third-cycle studies in chemistry with specialization in Analytical Chemistry comprises 240 credits, of which at least 40 credits are the student's own course work. At least 30 credits of the course work have to be from scientific subject courses. This is also defined in the subject study plans. A licentiate degree exists, and approximately 50% of the PhD students take a licentiate on the way to the PhD, while the rest present a half-time seminar and a half-time report.

All PhD students teach, mainly as lab teachers on bachelor and master level courses. No PhD student is teaching more than 20% of full time over a year. A pedagogic course for university teachers (7.5 credits) is obligatory for PhD students who teach.

The formal coupling between learning activities, outcomes and examination goals is controlled in the ISPs, where the examination goals are written into the ISP template. The ISP must state what progress has been made towards each goal, and give concrete examples what was done to make that progress, and what is planned to fully reach each goal. Thus, the examination goals are broken down in partial goals, and learning activities and outcomes to reach these goals are identified (see also below).

As decided by the Higher Education Ordinance there is only a general study plan complemented with an individual study plan. At Teknat, we have a faculty-wide general study plan and subject-specific study plans (e.g. for Analytical Chemistry). These two together correspond to the general study plan in HF. These are attached to the self-evaluation as appendixes.

The individual study plans are very important tools to help the PhD students (and supervisors) towards their goal of a high-quality research education. The ISP functions as an agreement between the doctoral student and the supervisor. The doctoral student, together with the supervisor, continuously updates the ISP during the doctoral program, to reflect progression and any changes in the planning. Activities for degree objectives are planned, implemented and documented in the ISP. The ISPs are revised until 1st of December each year. The revision is carried out with a meeting between the doctoral student, the supervisors and often an additional external person. It is mandatory to involve an external person in the revision. E.g. the FUAP can be this "third part", if he is not also one of the supervisors. After the meeting, the revision of the ISP is completed, which must be approved and signed by the doctoral student, supervisors, and FUAP. Originals of the revised ISP are archived on paper. The department reports at the individual level to the Faculty Board that the ISPs have been revised accordingly.

The most important elements for giving the doctoral students a broad knowledge and understanding both in the postgraduate subject and of scientific methodology in the postgraduate subject, are the individual research work, the postgraduate courses and the exposure to the research environment and its network. The research work is typically carried out in research groups, typically in the form of projects. Uppsala University has a broad and high-quality research and postgraduate education environment in chemistry in general and

specifically in analytical chemistry. Through their research work, doctoral students acquire knowledge and scientific methodology in the specific postgraduate subject. The subject contains different methodologies, e.g. theoretical and fundamental understanding of analytical techniques, sampling and pre-analytical sample handling, analytical experiments, evaluation of the methodologies in applications, data managements and multivariate analysis. Part of the education is that the doctoral student learns to choose and use appropriate methodology for their research work. Often the initial project is planned to be of a more basal level while the subsequent projects are more challenging – to secure the learning progression. Most research projects take place in collaboration with other research groups within the framework of local, national and international collaborations. The doctoral education environment in analytical chemistry with its critical mass and open collaborative climate provides opportunities for doctoral students to interact and collaborate with other doctoral students and researchers even outside each doctoral student's specific doctoral education and focus. Just to give one current example, we have a PhD student with training in analytical chemistry in the program who collaborate with a clinical PhD student in Gynecology and Obstetrics at Linköping University Hospital to develop and apply a new methodology for the challenging analysis of oxytocin in women during labour. A very exciting cross-disciplinary collaboration with important relevance in both analytical chemistry and health care. This culture of collaboration is in itself important in order to give the doctoral student a broader understanding of the subject and its applications. The environment has a very great value for achieving the degree goal "broad knowledge" in the postgraduate education.

Postgraduate courses must provide both broader and deeper insights into the subject as a complement to the specialist competence needed in the research work, to lay a foundation for the research conducted within the doctoral student's research project and to fulfil the goal "broad knowledge". We have the ambition that each major area should have (at least) a “basic course” in postgraduate education, which should be taken by each doctoral student for whom this area is relevant, and which can also be taken by others to broaden their knowledge. Within the analytical chemistry program we (FUAP, supervisors and PhD students in collaboration) have as part of the continuous development of the research education in 2019 initiated a mandatory 15 hp research education course in ”Advanced Analytical Chemistry” where 10 hp is a reading course (oral examination in two parts) and 5 hp is a practical part where the students will develop an analytical tool or device and present this to the research program. This course introduces students to a wide spectrum of theory, tools and techniques in the field. In addition, there are courses that cover the research front within the area or a complementary area, and which are offered with varying regularity, often according to need and interest (see attached Table for the current research education courses offered). In addition, doctoral students may attend master courses at the advanced level if there is an obvious need and usefulness for the research education and project. In the revision processes of the individual study plans, the aspect of a broad education is stressed.

Analytical Chemistry PhD Courses 2020 (credits and term)
Separation and Mass Spectrometry (15hp, VT1, fulltime) Advanced Mass Spectrometry (15hp, HT2, fulltime) Advanced Molecular Technology and Instrumentation for Proteome Analyses (3 hp Aug-Sep 2020, before HT1, fulltime) Buffer Solutions (5hp, self-studies) Analytical Data Processing with MatLab (3hp, self-studies) Advanced Analytical Chemistry PhD course (10+5hp, start VT1 or HT1, partly self-studies)

Reflections, Identified Critical Issues and Suggestions for Future Improvements

Since a majority of our PhD students do not come from our own educational undergraduate program, we see a large variety of background profiles and knowledge areas. In order to better unify the program research education and also set the standards for the "Analytical Thinking Process" we have initiated the mandatory Advanced Analytical Chemistry course and think this will have a major impact on the quality we strive for.

It is the joint responsibility of student and supervisor that the PhD training proceeds towards completion within the stipulated time. Some aspects are mainly in the supervisors' control (e.g. lab and instrument access, scientific guidance), other mainly in the control of the student (focus, planning of work hours, etc.). The progress is monitored continuously by the supervisors, who will take action if the situation is not satisfactory. Progress is also monitored via the yearly revisions of the ISP, discussed by the supervisory group, and the formal presentations (yearly seminar and licentiate or half-time seminars). If progress is slow, and if the formal presentations are not given within reasonable time, the situation is discussed with the FUAP and the supervisory group, and appropriate actions are taken. We have at occasions had PhD students being delayed in their progress due to problems with instrumentation, with publications or postponed dissertation due to lack of time for writing up the thesis summary "kappa". As there are limited possibilities for prolongation of time on top of the guaranteed 48 month, solutions have been based on the situation and alternative options. So far all doctoral students have reached their PhD except for one who decided to end with a licentiate. Another issue that we have identified is the delay for some students to actually request their formal PhD degree from the UU Exam Unit ("examensenheten") which also causes a delay in the refund to the department. We have suggested a number of measures to secure the mandatory courses to avoid this situation and will evaluate if this is the right way to go.

Utformning, genomförande, resultat

Måluppfyllelse – färdighet och förmåga

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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.

Design, implementation and outcomes

Completion of Goals - Skills and Abilities

In the Analytical Chemistry program we follow the learning objectives as stated by the Higher Education Ordinance (SFS 1993:100), also included in the ISP as a very important part.

As described above the individual study plans are a very important tool to help the PhD students (and supervisors) towards their goal of a high-quality research education and the new revised version of the ISP has really improved the clarity and possibility to monitor the progress.

We follow and update yearly the progression by carefully filling the progress chart in the ISP with the additional reports and reflections by the student year by year. We stress the need for the students to actually refer to the specific goal in their reflection (by including #1, #2 etc in their text). This makes it easy for both students and supervisors to closely follow the progression.

During the whole research education process but certainly when the students are getting closer to the thesis defence it is also important to discuss their own view of their contribution and that can be facilitated by asking a number of appropriate questions as listed below. These questions can also very much support the students in their writing process, as they can use these ideas in their summary for the thesis (kappa).

For all doctoral students their progress towards the goals of the education is reported in the yearly revision of their ISPs, which couples learning activities and outcomes to examination and examination goals. The ISPs include a list of goals where the student and supervisor report and evaluate to what extent the student has accomplished them and document the specific achievements that have led to the indicated progression, and what is needed to achieve particular goals in the future. Learning progress is achieved by students taking a gradually increasing responsibility for planning and evaluating their research, and for

communicating the results in scientific papers. The later papers build on the outcome of the previous ones, which provides progression in subject learning. It gives a possibility to go deeper into the scientific questions, and critically discuss their previous publications. Each doctoral student presents their research and receives feedback once per semester. The doctoral students also write a 5-page annual summary of their projects which is discussed with the supervisors.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

It has over the years been difficult to clearly follow and document the progression of the doctoral student's skills and abilities in the learning process. This has also affected the students themselves who sometimes has difficulties feeling that they are doing "the right thing". Although we have had a type of ISP with revisions since the 90th for our PhD students this has been a matter of concern. With the introduction of the new ISP format this has dramatically improved since it is so much more obvious to both the students and the supervisors (and FUAP) what progression has been made. We also feel that this has given the students a much better self-esteem and less stress.

Utformning, genomförande, resultat

Måluppfyllelse – värderingsförmåga och förhållningssätt

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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.

Design, implementation and outcomes

Completion of Goals - Values and Attitude

In the very begin of their PhD program the students are directly involved in the discussion of their individual study plan where values and attitude towards the scientific question is central. . The ISP contains examination goals that evaluate the student's ability to independently carry out research science with specific attention paid to: i) intellectual autonomy, ii) scientific integrity, iii) research ethics, iv) perceiving the possibilities and limitations of research, v) awareness of the role of research in society, and vi) the responsibility of the individual for how research is used. Progression in judgment and approach is fostered by many activities that are inherent to the PhD program.

Training in reading and writing makes progression and from the first careful attempts to the final ability to write a complete draft of a manuscript to discuss with co-authors it is easy to see this. When composing the final thesis summary ("kappa"), the student should be able to present his/her own results, discuss how they are interpreted and put in relation to the work of others. Research ethics is also stressed, not only in the mandatory ethics course (2.5 cr) but also throughout the whole education. Students will prepare and give many research presentations while in the program. The formal presentations each semester, halftime and shortly before the defence are some of them. Group meetings are also a good platform for training and to get feedback on presentations by other group members and strengthens the student's abilities also in intellectual autonomy and scientific integrity. Outside the program the doctoral student has ample possibilities to take part in seminars, lecture series, and courses. The Biomedical Centre as a scientific research environment offers lectures from world-leading visiting scientists almost every day. This broadens the PhD student perspective beyond what is regularly encountered in the department. In the daily experimental activities, students need to consider the ethics and environmental impact of their own (and others) research. Risk assessments are used to ensure responsible handling of chemicals and equipment, and these skills are further implemented in the doctoral students teaching when supervising undergraduate students. PhD students must communicate their scientific achievements to the broader scientific community by preparing manuscripts for publication in peer reviewed journals and writing a thesis. These activities further build their intellectual independence, research ethics and integrity, while the peer review process tests their scientific reasoning, possibilities and limitations of their research by those outside the department. Taking charge of the peer review process by, for example, responding to referee comments further develops their intellectual autonomy. Finally, by publishing their research, students need to consider the implications of how their research may be used by others. Towards the later part of the research education, students are also encouraged to take on the role as corresponding author. The described training in ethics and autonomy is naturally complemented with informal and formal discussions with FUAP, supervisors and other senior members of the program.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

It may be difficult for especially a new PhD student to reach independent critical thinking and manage the full analysis of their own research. Self-confidence and self-esteem have to be built carefully in combination with personal insights and the ability to be humble. It can often also be difficult for the less experienced PhD student to feel confident to share their research with a larger group of peers outside the own group. Here it is important to stress the fundamental value of each piece of scientific data, positive as well as negative. It is important that the doctoral students feel that they are in a "safe" and open environment where all questions can be asked, where constructive criticism is something positive and that it is totally fine to fail with an experiment – as long as you take note of it and learn from it. Actually, many Noble Prizes are based on results from a mistake. All seniors must and do help out to create this atmosphere.

Utformning, genomförande, resultat

Jämställdhet

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

Bedömningsgrund:

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

Design, implementation and outcomes

Equal Opportunity

Gender and diversity balance in the analytical chemistry program is achieved on all levels as can be seen in the attached Table describing our PhD students and their supervisors. We have an active Equal Opportunity representative and a board for equal opportunities at the department level, and we pay close attention to the phrasing or recruitment ads in order to make sure that they are phrased in such a way to ensure a diverse pool of candidates apply. Also when a candidate is recruited diversity aspects have to be justified in the requirement (what was the pool of applicants like, how was the gender distribution etc). We have in the Equal Opportunity board included a PhD student representative to ensure that the board activities of the department focus also on PhD students and postdocs, and not mainly on senior (faculty). The PhD student representative can bring in a younger researcher perspective and activities, whereas as a professor would be more biased towards faculty issues. We have a very good support at TekNat faculty level in that if you have taken parental leave for more than 4 months continuously, you can get a 3-month paid extension on your research education. For PhD students: https://teknat.uu.se/education/postgraduate/postgraduate-student/ . At the department level we have also set aside some funding for extra support to PhD students during and after parental leave. This is part of a broader strategy at both department and faculty level to ensure a workplace that is compatible with parental obligations. No equal opportunity issues have been identified in any of the surveys.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

We currently do not observe any issues here but it is important to always keep in mind that equality can quickly be lost when the staff is small. The equal opportunities group together with the HR administration monitors questions concerning gender equity. This is a long-term work aiming at equal opportunities regarding gender, social background, ethnicity, disabilities and age. At the faculty level we have taken measures to improve our meeting cultures, by performing meeting observation with equity as focus. This is a strategy we would like to maintain also at our program, since it has shown to be efficient.

Utformning, genomförande, resultat

Uppföljning, åtgärder och återkoppling

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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.

Design, implementation and outcomes

Follow-up, measures and feedback

Preparation and follow-up of the progression of PhD students – learning objectives and appropriate questions to ask to support the students

Many of the societal challenges facing the world are linked to health and environmental issues. Analytical chemistry, with the strengths and capabilities described, plays an important part in this context. Progress requires, however, dissemination and interpretation of obtained data and results to the public, and clarification of the societal impact. Therefore, to verify the research-based knowledge and promote its further implementation in society, the scientific achievements within the analytical chemistry program are often linked with research in the areas of social sciences/humanities, e.g., in psychology, archaeology and art. To further strengthen the program, several collaborations with partners within strategic innovation areas have been established during recent years, including projects carried out in cooperation with Research Institutes of Sweden (RISE), National Institute of Health (NIH, USA), Center for Disease Control (CDC, USA) and National Institute of Standardization (NIST, USA). These collaborations and networks significantly help the PhD students to identify not only important research tasks and areas of interest, but also help in the decision about their future career by offering a wide scientific network of collaboration, joint publications and grants, and also even more important the possibilities to visit the external partners to experience new environments. This in combination with the importance of applying for grants and presenting at national and international conferences are also stressed through-out the PhD education.

The PhD students are able to give feedback regarding their studies through their representatives in the Faculty PhD Council (“Doktorandråd”), in the Faculty Board for third-cycle studies (FUN) and the Chemistry – BMC Department Board. The individual PhD student are requested to give feedback during the ISP revisions, and in the yearly meeting

with the FUAP. They are also welcome to give feedback at any time, and can chose to do so via their supervisors, FUAP, Director of third-cycle studies or Head of Department.

The department and the research programs are evaluated regularly with respect to the quality of our research and the research environment, which are important also for the PhD education. UU has conducted three large evaluations of all research, the Quality and Renewal evaluation (KoF 2007, KoF 2011 and KoF 2017), including site visits by international panels, one for each discipline (e.g. Chemistry). The analytical chemistry program has received good results in all three evaluations. The KoF 2017 panel specifically commented on the multidisciplinary nature of the PhD training and that students are given necessary training and are given hands-on access to the advanced equipment of the department, with plenty of opportunities for collaborations with other disciplines and the society. This provides an excellent and unique research training that will give an important competitive advantage to the graduated PhD students for their future career.

On a UU level, the unit for Quality and Evaluations is regularly evaluating third-cycle education via e.g. survey studies (https://mp.uu.se/web/info/undervisa/kvalitet-och-utvardering/rapporter/doktor). The most recent one for the TekNat faculty was conducted in 2015, and the responders were PhD students (658 individuals), alumni (560 individuals) and supervisors (568 individuals). In all three groups, 55-58% responded. The report was presented in January 2017 together with written reflections on the results from each Department, with the aim to identify areas for development and demonstrate good examples. Reports from previous studies have been presented in 2003 and 2009, and the latter survey was followed up on the TekNat Faculty level with a report (2010). In our own PhD student survey (see under doctoral student perspective) the responses were overall very positive.

Positive aspects from the students in the 2017 report were the possibilities for independent work and development, and the availability of good supervisors. On the negative side was that many were uncertain of the demands and what was expected from them, and many were unaware of the examination goals. A large fraction among both supervisors and students did not find the ISP helpful in planning and following up progress. In response to this, the TekNat faculty and the departments has improved the ISP template, and developed a structure where plans, activities, examination and progress towards the examination goals are clear.

In combination with the new much more useful ISP we also use the following set of targeted questions linked to the goals and help the PhD students reflect on the examination goal (see table below).

The Research Education Learning Goals and their Applications **Knowledge and understanding**	
Demonstrate broad knowledge and systematic understanding of the research field as well	**Theory and Conceptual framework** What are your specific research questions? How did you create your research questions; where did they really come from?

as advanced and up-to-date specialized knowledge in a limited area of this field.	Why did you decide on those questions rather than something else to investigate? How did you use your research questions? What are your variables in your studies?
Demonstrate familiarity with research methodology in general and the methods of the specific field of research in particular.	**Appropriate methodology** How did the reading of theory influence your choice of methodology? How would you justify your choice of methodology?
Competence and skills	
Demonstrate the capacity for scholarly analysis and synthesis as well as the ability to review and assess new and complex phenomena, issues and situations autonomously and critically.	**Engagement with theory, Coherent argument and Conceptual conclusions** Based on what theories and previous knowledge did you design your experiments? What are your variables (independent variables/parameters that you control/the x-axis; and dependent variables/what is measured/the y-axis)? How did you limit your study? Any assumptions on the research design? Any practical considerations that influenced your choices?
Demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work.	**Research question, Research design, Appropriate methodology and Correct lab work** How do you expect the chosen method/technique to affect the quality of your data? Which step in your method limits the quality of the data and why?
Demonstrate through a thesis the ability to make a significant contribution to the formation of knowledge through his or her own research.	**Conceptual conclusions and the ability to Demonstrate doctorateness*** How did the bridging theory and practice help you to design your research? What assumptions did you make in your research? Were you surprised by the conclusions that could be drawn from your data? Are you convinced that you have answered your research questions? How do your conclusions connect to your research questions and is the applied methodology valid for drawing such conclusions?

	How are your conclusions aligned with current theory? What new knowledge to you claim to have contributed with? Why do you feel that your findings justify those claims? Demonstrate doctorateness (establishing conceptual links between findings, synthesising evidence into conceptual conclusions, critiquing the research process, advancing contributions to knowledge, and defending doctorateness of thesis)
Demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and society in general.	**Clear and concise presentation (eg in the thesis production)** Design of the thesis (structure, presentation, content, figures, administrative aspects). Oral presentations at national and international meetings. Why did you decide to have so many / so few chapters of text / the order of the chapters? What is your main message you want to bring forward? To whom are you presenting? Theoretical perspectives (awareness of literature, theoretical perspectives, implication of findings).
Demonstrate the ability to identify the need for further knowledge.	**State the gap in knowledge!** What is the gap of knowledge that your research is focused on? How did you identify the gap in knowledge which your research investigated? Why do you believe that the gap existed? Why did others not investigate this gap in knowledge? Is the foundation from the literature sound? How did you make sure to cite all the expected sources on the topic? Why (if so) are there only references for the background of your research, and not on the actual topic of your research? Which is the most well-known other research group working on similar research, and what have they accomplished in that group in relation to your own accomplishments?
Demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some	**Teaching skills and Third task** Practice of teaching skills as laboratory assistant, pedagogic education courses, seminars to colleagues and popular science events. Supervision of bachelor/master students?

other qualified professional capacity.	Popular science activities?
Judgment and approach	
Demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics.	**Coherent argument Ethics** How did your theoretical perspectives help you to frame the research questions, to develop conceptual frameworks and design your research?
Demonstrate specialized insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used.	**Third task and Ethics** Practice of research (emergence and use of research questions, choice of topics, collection of data, explanations about the gap in knowledge, understanding the practice of research).

**Vernon Trafford and Shosh Leshem, Stepping stones to achieving your doctorate, Open University Press, 2008. ISBN-13: 978 0 335 22542 2.*

The UU unit for Quality and Evaluations has conducted two larger surveys among alumni on a third cycle level (2006 and 2015). The TekNat alumni were asked in what way that different component of their PhD education have been useful, and in what way. 85% of the respondents said that they were very or rather satisfied with their PhD education at UU, and 88% were employed within three months after finishing their PhD studies. For PhDs in analytical chemistry, we estimate that about 50% get a job in biotech industry and research institutes. About 25% go to the public sector, agencies and healthcare. About 25% do postdoctoral research, mostly with their own grants. A few studied pedagogics and become high-school teachers. From our own alumni survey and the surveys made both nationally and internationally, we know that the employability of our PhDs in analytical chemistry is very high. The average study time for our PhD students is slightly above the stipulated 48 month but this often relates to parental leave (which we strongly encourage, and we have a very supportive system of 3-6 month prolongation as support). Only one PhD student has during the last 20 years decided to quit after the licentiate examination to become a high-school teacher.

The Master program in Chemistry was evaluated by UKÄ in 2013, and the outcome was very positive (“high quality”). The evaluation committee concluded that the strong research and its international reputation permeates the whole master programme in chemistry and is also an important reason for recruitment. The Joint Erasmus Mundus Master program Excellence in Analytical Chemistry has been annually evaluated by the European Higher Education board with excellent quality and has recently been granted a third prolongation of a 3-year grant support (we were granted as one among very few international programs). Our PhD students are very much involved in the success of our master programs and the master programs are also an important base for our recruitment of new PhD students.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

Since the research projects as a base for the research education are to a large extent directed by the individual supervisor's abilities, interests and funding, there is a risk of isolation between the research groups and as a direct consequence between the PhD students. We try to counteract this by running the PhD student's seminars, have an open atmosphere in the scientific discussions (in the coffee room and elsewhere) and try to be inclusive in the projects. We have had regular supervisor meetings where the progress of projects and students have been discussed, and where the focus has been to try to identify if any extra ordinary efforts are called for, or if there could be options for new collaboration around a specific student. Due to the pandemic etc we have not been able to maintain that tradition in regular form, but meanwhile the Zoom version will have to do. This also offers an important possibility for guidance of younger and less experienced supervisors.

Doktorandperspektivet

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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 student perspective

Evaluation of Research Education - the PhD Student Perspective

Doctoral students in Analytical Chemistry participate during the training in various committees, commissions, boards and working groups (the Department Board, the postgraduate education committee, the work environment group and the equal conditions group). In matters that specifically concern the doctoral program (eg design of doctoral courses), FUAP convenes working groups where doctoral student representatives have had a great deal of influence. All doctoral students at the department meet in a joint doctoral student council. Matters from the doctoral student council can be handled at all levels depending on what it is about and the doctoral students have a standing item on the department board's agenda.

The yearly revisions of the ISPs include explicitly the view and reflections of the Ph.D. student concerning the role of the supervisor, the quality of the supervision, and whether the goals of the research education are being fulfilled satisfactorily. The students thus participate actively in the evaluation and future planning of their education.

In order to be able to further catch the PhD student perspective of the research education within the program, we have asked them to fill in a questionnaire (anonymous) and the summary (made by a student representative) is presented below.

1. PhD student courses in Analytical Chemistry and in subjects relevant to the field
   - Extent and availability
   The students in the program generally think that the courses offered are sufficient and have a good scope. Students who have completed the program's own master's program have difficulty taking courses in analytical chemistry. This situation has been helped when a course in advanced analytical chemistry of 15 credits was established, which the students appreciate.

   - Information of and application for courses
   Most people have no problem finding courses offered both internally and by other departments or universities. We also receive emails from many course coordinators as advertising for their courses, then a lot of information goes 'informally' between students.

2. Teaching – how does this influence the research education in Analytical Chemistry
   - The possibility to get pedagogic merits.
   For the interested party, it has not escaped any student that there are very good opportunities to develop pedagogically (TUR, MINT etc.). (Comment: These are education programs developed and offered by the Teknat faculty for undergraduate and graduate teaching).
   - The possibility to broaden the knowledge in Analytical Chemistry (teaching in other areas than the research subject)
   Most students also teach techniques that they do not use themselves, and all find it edifying to do so.
   - The time set for teaching vs how long time it actually take to perform the teaching
   It is a bit different from student to student. Some people think that it takes too long to prepare for teaching while others think it is perfectly okay. But the biggest problem is that there is usually no time to give constructive criticism to a lab report and really help the student (s) to develop their writing.
   -The fact that research and teaching should be combined
   This is quite project specific. If you have a project that requires weeks where you prepare for experiments every day, it will be more difficult than if you teach one to two days a week.

3. Supervision and research discussion
   -Supervision by main supervisor (availability, group wise, separate etc)
   All students have a good relationship and good communication with their main supervisor. Everyone also has some form of regular meeting.

-Supervision/interaction with co-supervisor
Same answer as above.
-Interaction with FUAP
Rare with any issues, but good interactions when needed.
-Interaction with FUS
None of the students know who / what FUS is. (Comment: The director of research studies (FUS) at the department was recently changes and the structure for this task has changed over time)

-Interaction with other seniors
The students have a good relationship with senior researchers.

-Discussions on theory / methods and constructive criticism

Most students have a good dialogue with their supervisor about theory and / or presentations within the group. Then seminars sometimes work well for this type of discussion.

-Do you have someone to contact if you have problems with your supervisor?
Most mention assistant supervisors, FUAP or HR.

4. PhD progression
-How do you as PhD students experience that the progression of studies is checked and supported?
Most students are happy that their supervisor enables them to submit reports with a certain frequency so that he can help them in the best possible way. In addition to this, most students have good experiences of ISP auditing which they see as a tool also for themselves to develop.
-Licentiate?
The students think that a lic is unnecessary and steals time and focus from the goal. Some people think of licentiate as a possible way out if for some reason you want to quit, so that you get away with something.
-ISP revision is one way of checking progression – comment on this process, +/-
All the students think that ISP is a good yardstick for measuring progression and - even if it is a bit difficult - think it is worth the effort.
-Examination goals – how aware are you of these goals and how do you plan and work to reach them?
Most students are aware of the goals thanks to the annual ISP audit. How to specify how to reach them is discussed with the supervisor(s), especially when revising the ISP.

5. Research environment
   - Infrastructure and instrument time
   The students think that we have good infrastructure within the program, sometimes it can be difficult to get instrument time.
   - Negative stress has been identified in previous evaluation as a problem for PhD students – what would be the general opinion now?
   It is very personal how you react to stress, and those who start doctoral studies are often used to not having any problems at all with their studies, so there is definitely a certain bias. The students experience a certain pressure to publish and teach at the highest level, but most have a good relationship with their supervisors and at the moment it looks quite good.
   -Psychosocial working environment
   The students experience a good relationship with senior researchers and with each other. There is a good atmosphere in the coffee room which makes it easier to support and encourage each other.
   -Can you influence as a PhD student?
   The students experience themselves as being heard in both program-specific contexts (e.g. APT (arbetsplatsträffar) meetings) as well as in the doctoral student council and the department board.

6. Support in thesis production
   Nobody has experience with this yet since all current students are fairly early in their education. (Comment: Earlier students has experienced some stress when dealing with the printers office, but all have been solved in a good way at the end of the day).

7. Seminars
   -What seminars do you join?
   The students participate as much as possible in the program's seminar series and the SciLifeLab seminars. We also occasionally attend other programs' seminars and defense.
   -Do the seminars stimulate to scientific discussions?
   The consensus is that in most cases it does.
   -Open-minded
   Yes
   -Priority to participate?
   Yes
   -Miniconference in chemisty +/-
   Much appreciated, good relaxed environment to develop in.

8. Future working life
   In previous investigations and surveys, it has been stated that a large part of graduated students find a job in the near future after ending their education. They feel prepared

for working life.
- Support/discussion with supervisor about future working life
The students at the program have not yet started to think about what comes after doctoral life, since they are early in their education.

Reflections, Identified Critical Issues and Suggestions for Future Improvements

Overall the doctoral students seem content with their situation. Most of them are rather newly recruited why they may not have experienced the problems and stress that inevitably will occur along the research education time. One point that is raised though is the stress that teaching duties generates. The doctoral students are asked to engage in up to 20% teaching during their studies. Teaching is a very good way to solidifying your own knowledge and also will help the students in their future career. However, the workload can be very high during certain periods and the correction of reports are often a big burden. We have during 2020 initiated the development of a new tool for supporting the doctoral students in this process and we will evaluate if this helps in the right direction. The pandemic situation has of course also put stress on the PhD students as well on all other staff and we have initiated an appendix to the ISP to evaluate the effect of the pandemic on the student's situation.

Arbetsliv och samverkan

Beskriv, analysera och värdera. Redogör för styrkor och svagheter samt hur dessa hanteras för att säkra att en hög kvalitet nås i utbildningen. Belys med hjälp av exempel.

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 akademin.

beredskap att möta förändringar i arbetslivet, både inom och utanför akademin.

Working life and collaboration

Examples of the Analytical Chemistry program co-operations with academia, industry and society

All PIs within the program have on-going research collaborations on both a national and an international level. There are numerous collaborations within UU, specifically within medicine (both human and veterinary), chemistry and biology, but recently a revival of a closer collaboration with pharmacy has been initiated. On national level collaborations exist with most of the universities, almost all major hospitals, major governmental authorities, and several Biotech and Pharma companies. International collaborations include numerous hospitals and universities, such as Stanford University, Harvard University, University of

Leiden, University of Utah, Binzhou Medical University, University of Melbourne, Max Plank Institute, Charité Hospital Berlin, King's College, London. Exchanges take place continuously for a short or long period and doctoral students are encouraged to use the supervisors' national and international network to continue to develop their own. Supervisors also spend longer or shorter exchanges abroad, depending on the nature of the projects. As an example, exchanges are currently taking place with the United States (Stanford and Harvard), China (Shandong Province), South Africa (Cape Town, Stellenbosch and Pretoria) and Sri Lanka (Peradynia, Colombo, Galle). In all these projects, the focus is on all parts of the sustainability work. All doctoral projects, even those with a smaller international connection, have an ecological and / or social (health) connection in some form. Doctoral students are also encouraged to apply for scholarships to participate in at least one international conference per year. With the digitalisation that is taking place now, this is much easier and the doctoral students participate in most conferences across digital platforms.

Research and education within the program respond and connect to several important societal challenges and urgent needs in prioritized areas of life science, health care and environment. For instance, the programme profile includes research aiming to isolate disease-related biomarkers, analyse traces of dissolved organic matter in aquatic environment, detect titanium release from dental implants, as well as to supress antibiotic- and chemoresistance by employing novel drug delivery systems. To identify the needs and succeed in the efforts, the programme has wide-ranging collaboration with partners from industry (GE Healthcare/Cytiva, AstraZeneca, Fresenius Kabi, Recipharm, Oncopeptides etc), healthcare (all major university hospitals, etc), governmental authorities (Swedish Medical Products Agency, National Food Agency, National Veterinary Institute, Swedish Radiation Safety Authority, The National Board of Health and Welfare, Ministry of Justice, Ministry of Education and Research, Ministry of Health and Social Affairs etc), private-non-profit organisations (BalticSea2020, Swedish Nuclear Fuel and Waste Management Company, etc), civil society including both Swedish and international journals, television and radio, patient organisations, libraries and schools. Successful examples of the utilization of re-search and translation to society are the spin-off companies Bodymarkers and Autism Biotech.

In this evaluation of the PhD student research education, we want to specifically stress the importance of all the possibilities that can be gained by all types of co-operations in Analytical Chemistry. Since PhD students after graduation can end up in academia, governmental organisations or industry it is also important for them to be able to take part in co-operations with different fields already during their research education. The co-operations from within the analytical program at the Department of Chemistry-BMC, UU with the surrounding world are quite substantial. Only a few (maximum 5 per supervisor) are listed below as recent examples where projects have rendered in an article within the last five years and also when a PhD student have been centrally involved in both the scientific work and the writing of the article, are included.

Examples from PI:s with whom the cooperation have been done (place, title of article, publication data)

Professor Jonas Bergquist, Department of Chemistry-BMC, Analytical Chemistry

1. Prof Lars Tranvik, Department of Limnology UU, Investigating the ionization of dissolved organic matter by electrospray ionization. Analytical chemistry 2020, DOI:10.1021/acs.analchem.0c03438
2. Drs Lucia Kovac and Fredrik Lehmann, Recipharm and Oncopeptides companies, Investigating the Impact of Sample Preparation on Mass Spectrometry-Based Drug-To-Antibody Ratio Determination for Cysteine- and Lysine-Linked Antibody-Drug Conjugates, Antibodies 2020, Volume:9 Issue:3 DOI:10.3390/antib9030046
3. Dr Elham Rostami, Uppsala Academic Hospital, Nyköping Hospital, Sahlgrenska Hospital, Acute necrotizing encephalopathy with SARS-CoV-2 RNA confirmed in cerebrospinal fluid. Neurology 2020, Volume:95, Issue:10, Pages:445-449, DOI:10.1212/WNL.0000000000010250
4. Prof Lars Larsson, Karolinska Institute, Chaperone co-inducer BGP-15 mitigates early contractile dysfunction of the soleus muscle in a rat ICU model, ACTA PHYSIOLOGICA 2020, Volume: 229 Issue: 1 Article Number: e13425 DOI: 10.1111/apha.13425
5. Prof Göran Laurell, Department of Neuroscience, UU, The proteome of perilymph in patients with vestibular schwannoma. A possibility to identify biomarkers for tumor associated hearing loss?, PLOS ONE 2020, Volume: 13, Issue: 6, Article Number: e0198442, DOI: 10.1371/journal.pone.0198442

Associate Professor Sara Bergström Lind, former member of Department of Chemistry-BMC, Analytical Chemistry now associated to Bergquist group

1. Dr Matthijs Pijnappel, and others, Recipharm OT Chemistry AB and more places, Application of triple quadrupole mass spectrometry for the characterization of antibody–drug conjugates, Analytical and Bioanalytical Chemistry (2019) 411:2569–2576

Researcher Dr Jeff Hawkes, Department of Chemistry-BMC, Analytical Chemistry

1. Prof. Thorsten Dittmar (University of Oldenburg, Germany), ICBM-OCEAN: Processing ultrahigh-resolution mass spectrometry data of complex molecular mixtures, Analytical Chemistry 2020, 92 (10), 6832-6838.
2. Dr. Urban Wunsch (Chalmers), Mathematical chromatography deciphers the molecular fingerprints of dissolved organic matter, Analyst 2020, 145 (5), 1789-1800
3. Dr. Maria Jose Farré (ICRA, Girona, Spain): Orbitrap molecular fingerprint of dissolved organic matter in natural waters and its relationship with NDMA formation potential, Science of the Total Environment 2019, 670, 1019-1027
4. Dr Stefan Lofgren, SLU and including Masters student from our program, Regional diversity of complex dissolved organic matter across forested hemiboreal headwater streams. Scientific reports 8 2018, (1), 1-11

Associate Professor Ingela Lanekoff, Department of Chemistry-BMC, Analytical Chemistry

1. Dr Malin Andersson (Uppsala University) Quantitative Mass Spectrometry Imaging of Small-Molecule Neurotransmitters in Rat Brain Tissue Sections using Nanospray Desorption Electrospray Ionization, *Analyst*, 2016, 141, 3686-3695
2. Profs Fredrik Palm and Jan Kihlberg (Uppsala University) Metabolite aberrations in early diabetes detected in rat kidney using mass spectrometry imaging., *Analytical and Bioanalytical Chemistry* 2019, 411 (13), 2809-2816
3. Prof Julia Laskin (Purdue University, USA), Susan Stevens and Mary Stenzel-Poore (Oregon Health and Science University, USA) CpG preconditioning reduces accumulation of lysophosphatidylcholine in ischemic brain tissue after middle cerebral artery occlusion**.** Analytical and Bioanalytical Chemistry – revisions with minor comments resubmitted

Lecturer Dr Jean Pettersson, Department of Chemistry-BMC, Analytical Chemistry

1. Dr Mattias Pettersson, Umeå University, Effect of cobalt ions on the interaction between macrophages and titanium, Journal of Biomedical Materials, 30 April 2018, Part 1
2. Prof Leif Nyholm, department of chemistry Ångström UU, On the Capacity Losses Seen for Optimized Nano-Si Composite Electrodes in Li-Metal Half-Cells, Adv. Energy Mater. 2019, 9, 1901608

Lecturer Dr Per Sjöberg, Department of Chemistry-BMC, Analytical Chemistry

1. Dr Constantin Recknagel, Leibniz Institute for Baltic Sea Research Warnemuende, Department of Marine Chemistry, Talanta.2018.05.072
2. Prof Charlotta Turner, Lund University, Jörgen Samuelsson, Karlstad University, Evaluation and analysis of environmentally sustainable methodologies for extraction of betulin from birch bark with a focus on industrial feasibility, Green Chem., 2016, 18, 516–523
3. Dr Kasper Reitzel, Department of Biology, University of Southern Denmark, Speciation of Inositol Phosphates in Lake Sediments by Ion-Exchange Chromatography Coupled with Mass Spectrometry Inductively Coupled Plasma Atomic Emission Spectroscopy, and ^{31}P NMR Spectroscopy, Anal. Chem. 2015, 87, 2672−2677
4. Prof Joseph S. M. Samec, Stockholm University, A General Route to β-Substituted Pyrroles by Transition-Metal Catalysis, J. Org. Chem. 2016, 81, 1450−1460
5. Prof Joseph S. M. Samec, Stockholm University, Brønsted Acid-Catalyzed Intramolecular Nucleophilic Substitution of the Hydroxyl Group in Stereogenic Alcohols with Chirality Transfer, J. Am. Chem. Soc. 2015, 137, 4646−4649

Reflections, Identified Critical Issues and Suggestions for Future Improvements

We feel that the PhD students are maybe not thinking so much about their future career until the last year of research education. This could of cause reflect that they feel certain about there future career but could also be a sign of neglect. Currently, neither the program nor the department organizes any institutionalized career days. We think that the exposure of the PhD students to extensive possibilities for collaborations is one way to go but also by connecting them to our alumni from the program. One recent successful activity is to include company representatives in the chemistry mini-conference, which is held annually and organized by PhD students in the Chemistry programs. Another important activity is to invite alumni to research education courses and informal get-togethers at the program. We have also as another example, recently applied for and received a joint SSF grant for a two-year translational research exchange between the Swedish Food Administration (SLV) and the program, where dr Aida Zuberovic (a former PhD student in the program) will spend 50% of her time participating in Bergquist's research group, contributing to research, research supervision and basic education.