

Assessment Report

Life Sciences

PhD studies

Estonian University of Life Sciences

Tallinn University

Tallinn University of Technology

University of Tartu

2018

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Introduction

Quality assessment of a study program group involves the assessment of the conformity of study programs and the studies and development activities that take place on their basis to legislation, national and international standards and developmental directions with the purpose of providing recommendations to improve the quality of studies.

The goal of quality assessment of a study program group is supporting the internal evaluation and self-development of the institution of higher education. Quality assessment of study program groups is not followed by sanctions: expert assessments should be considered recommendations.

Quality assessment of a study program group takes place at least once every 7 years based on the regulation approved by EKKKA Quality Assessment Council for Higher Education *Quality Assessment of Study Program Groups at the Level of Doctoral Studies*.

The aim of the assessment team was the evaluation of the Study Program Groups (SPG) of Life Sciences at the level of doctoral studies in four universities: University of Tartu, Tallinn University, Tallinn University of Technology and Estonian University of Life Sciences.

The team was asked to assess the conformity of the study programs belonging to the study program group and the instruction provided on the basis thereof to legislation and to national and international standards and/or recommendations, including the assessment of the level of the corresponding theoretical and practical instruction, the research and pedagogical qualification of the teaching staff and research staff, and the sufficiency of resources for the provision of instruction.

The assessment process was coordinated by, the Estonian Quality assurance organization for higher and vocational education (EKKKA). The following persons formed the assessment team:

Rik Leemans (Chair)	Professor, Wageningen University (The Netherlands)
Laurent Counillon	Professor, University of Nice-Sophia Antipolis (France)
Markus Dettenhofer	Executive Director, Central European Institute of Technology (Czech Republic)
Kari Keinänen	Professor, University of Helsinki (Finland)
Owen Lewis	Professor, University of Oxford (UK)
Hynek Roubik	PhD student, Czech University of Life Sciences Prague (Czech Republic)
Andrus Tasa	CEO, Tartu Biotechnology Park (Estonia)

After the preparation phase, the work of the assessment team in Estonia started on April 9th, with an introduction to the Higher Education System and the assessment procedure by EKKKA. The members of the team agreed the overall questions and areas to discuss with each group at the four institutes, who were part of the assessment process. The distribution of tasks between the members of the assessment team was organized and the detailed schedule of the site visits agreed.

During the following days, meetings were held with the representatives of the four universities. In all cases, the schedule for discussion on site for each of the various study

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programs only allowed for short time slots to be available for team members to exchange information, discuss conclusions and implications for further questions.

On April 14th, the team held an all-day meeting, during which both the structure of the final report was agreed and findings of team meetings were compiled in a first draft of the assessment report. This work was executed in a cooperative way and the members of the team intensively discussed their individual views on the relevant topics.

In the following sections, the assessment team summarize their general findings, conclusions and recommendations which are relevant across the whole SPG. In so doing, the team provides an external and objective perspective on the programs and the contexts within which they are delivered. Ultimately, the intention is to provide constructive comment and critique which may form the basis upon which improvements in the quality of the programs may be achieved. In formulating its recommendations, however, the assessment team has not evaluated the financial feasibility associated with their implementation.

General findings and recommendations

The Evaluation Committee assessed the Life Sciences PhD programs within four universities in Estonia: University of Tartu (Chapter 1), Tallinn University (Chapter 2), Tallinn University of Technology (Chapter 3) and Estonian University of Life Sciences (Chapter 4). The Committee's findings are based on the self-evaluation reports and other detailed documentation provided by the different programs of the four universities, together with verbal and written evidence gathered during the site visits, when the Committee met with senior leadership representatives of the universities and faculties, faculty involve in program management, academic staff (including supervisors), students and alumni.

The Evaluation Committee evaluated all aspects of PhD education, including the experiences of students and supervisors, the recruitment and selection of PhD students, PhD courses in the doctoral schools, the evaluation of PhD progress, and the research impact and employment prospects of PhD graduates. This report represents the findings of these visits. This chapter focusses on the common findings that emerged from the information from all universities. The next chapters provide specific findings for each university separately. However, often the common and specific findings overlap, although their perspective and details could differ. This has unfortunately led to overlaps between chapters. The Evaluation Committee apologizes for these possible redundancies in the different discussions of the PhD programs.

Resources for operating a successful doctoral studies program include financing, human capital, access to information, and necessary research infrastructure and facilities. In assessing the programs, the Committee considered the key objectives of each doctoral program, the improvements needed to address any weaknesses, future plans, and also the anticipation of barriers and risks to meeting these objectives. The appropriate allocation of resources, both financial and in terms of personnel, will be critical to continuing success, as will regular review of progress towards meeting specific objectives.

The programs displayed many good steps towards efficient resource use. The different universities each have their own culture, with inherent strengths and weaknesses when it comes to educating Life Science PhD graduates. Consequently, they all have developed different strategies to cope with the overall sub-critical expenditure of national finances on science and education of PhD students. These are discussed in the sections devoted to individual universities.

Overall, PhD students are very satisfied and content with their research and studies, and particularly appreciate the flexibility freedom to make their own choices (in terms of research and study curriculum). In addition, the interactions between supervisors and their PhD students are appropriate, stimulating and generally inspiring in all the PhD programs evaluated.

The Evaluation Committee was generally impressed with the high quality of the universities' research infrastructure with respect to their capacity to support and supervise PhD students. The effective use of European Union development and structural funds in the inter-institutional doctoral schools and the use of competitive funding schemes at national and institutional level also encouraged PhD students' participation in international conferences and visits to laboratories abroad. However, the Evaluation Committee also found several challenges and barriers to Estonian PhD studies in the Life Sciences. These affect their value to the student, supervisor, institution, university and society. These challenges are dealt with differently in the individual programs (and are discussed in detail in individual sections where appropriate), but have a similar origin. They are:

- Responding to national and European funding trends;
- Inadequate state stipends causing a high drop-out rate for students;
- The scientific quality of the PhD-thesis and the criterion of a minimum of three published peer-reviewed scientific papers;
- The annual PhD progress evaluations;
- The future of the Doctoral Schools; and
- The link between the programs, PhD graduates and society.

These aspects will be discussed below and whenever appropriate detailed in the programs' individual evaluations.

Responding to national and European funding trends

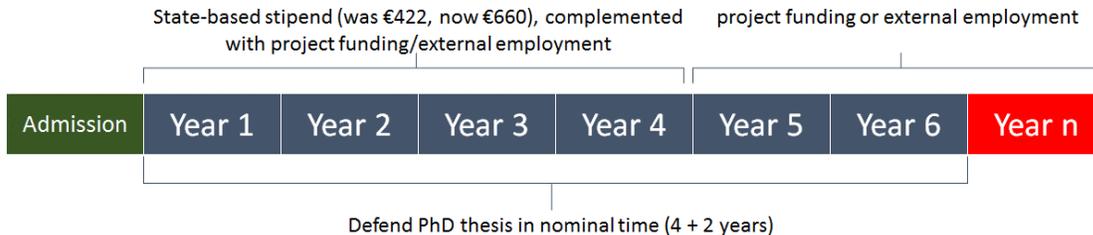
The current ongoing strategic plan of the Estonian government is to increase funding for research and development. The current level is approximately 0.6% of GDP and this will soon increase to 0.8% and likely to 1.0% in 2020. This could increase the universities' baseline funds, which are managed by the Ministry of Education and Research, and enhance the competitive project funding of different funding calls controlled by the Estonian Research Council. However, the EU development and structural funds, which effectively helped to create the excellent research infrastructure and effective doctoral schools in Estonia is very likely to decline in the near future. The net outcome of these trends remain uncertain and will influence the vitality and future of the Estonian PhD programs.

The Evaluation Committee considers that universities urgently need a more stable and sustainable income stream. Universities should **lobby the Estonian Government to increase the research and development funds to at least 1% of GDP**, correcting for a possible decrease in EU development and structural funds. At the same time, all universities and PhD programs should **enhance their capabilities to improve the critical mass of externally-funded projects and thus the success rate of their national and International (e.g. H2020, InterREG and ERC) competitive grants**. This can be achieved by pro-active university grant offices that link researchers with relevant funding calls, help to identify possible partners, review draft proposals and better train and coach applicants. If possible, more students from outside the EU could be invited to participate in Estonian higher education programs. Their competitive tuition fees could also create a steadier (but probably small) source of income.

The inadequate state stipends causing discontinuation of individual PhD studies

The eligible length/time of a PhD study is four years plus two years (Figure 1). An Estonian PhD study does not require tuition fees and each accepted PhD student receives a stipend from the national government during their first four years of their PhD studies (i.e., the main nominal study period). The monthly stipend was raised from €422 to €660 in December 2017. However, this stipend is still inadequate to support a modern one-person household or to establish a family. The interviews with supervisors and PhD students revealed that students routinely need to top their stipend with additional income. Some take on junior research positions supported by project funding. Others hold employment, sometimes full time, outside the university and unrelated to their studies; these students inevitably struggle to submit and defend their PhD theses within the eligible length/time period allocated. Based on our discussions with faculty, students and alumni, the inadequate stipend is clearly a major reason for the high drop-out rate of PhD students.

Ideally, the final two years of a PhD student’s study should be covered by employment as a (junior) researcher, funded on a research project. However, this funding is frequently not available. Most of the PhD programs we evaluated attempted to ensure that students received sufficient financial support during their studies by making the availability of project funds one of the selection criteria for allocating PhD projects; however, this was rarely guaranteed for years five and six. When a thesis is not submitted in the eligible length/time (i.e. after six years) the official university responsibility for the PhD study terminates but the student often continues and eventually graduates. These PhD students seem generally on their own with little official support (e.g. no progress evaluation, no regular supervision or library support). This contributes to the currently low PhD success



rates.

Figure 1 The timeline and funding sources of an Estonian PhD trajectory.

To summarize, as the availability of financial resources (i.e. government stipends, scholarships and project employment) is limited, PhD students can rarely focus full-time on their PhD studies. This leads to unnecessary delays, reduced motivation, increased work stress and sometimes constraints on participation on courses or seminars, because of the need to prioritize external work or family duties.

These challenges are compounded by the fact that PhD students, by virtue of their MSc degrees, can often secure relatively well-paid and secure jobs outside academia. This makes an academic PhD position unattractive from both a financial and a peers’ perspective, and leads to excessively long PhD trajectories (i.e. more than six years) and very high drop-out rates.

Unfortunately, although drop-out rates are clearly high by European standards, a thorough analysis of their causes is lacking. Anecdotally, the university representatives, faculty, alumni and PhD students all indicated that the poor financial circumstances are the main issue. Based on the course data provided (Table 1), this is likely true, but the Committee would have liked a more detailed breakdown of data and analysis focusing on, for example, gender issues and year of drop out. We assume that in the later phases of PhD study, financial security rapidly declines and this simultaneously increases drop-out rates because students have to find alternative employment to support themselves. Furthermore, these students often enter the cohort wishing to start families, increasing the need for secure and reliable incomes. Finally, the often extended period required for submitted manuscripts to navigate the peer review process inevitably reduces PhD students’ motivation to revise and resubmit. Although in some universities already use improved monitoring systems, the Evaluation Committee therefore recommends **to develop a better monitoring system to follow success and failure of PhD students**. Every student dropping out should be interviewed or survey at exit to document motivation, financial situation and the date of exit, and drop-out rates should be monitored as a function of gender. Such data are essential to better understand drop-out rates, to develop effective strategies to reduce them and to better argue for higher PhD

funding with national authorities (see below). Elements of such system are recently implemented by Tallinn University of Technology. This could be an model for other programs.

To reduce drop-out rates the Evaluation Committee recommends that **universities lobby to increase national stipends to a level similar to the average net salary of an MSc graduate** (c. €1200). If this is not possible, or during a transition time, universities should more actively guarantee that during the nominal PhD period the PhD-student's income remains adequate to focus full-time on their studies. To lower drop-out rates **measures should also be taken to stimulate PhD students to submit their thesis within the eligible length/time**. Supervisors have a specific responsibility here to help in realistic and effective research and publication planning so that this does not add to the delay and drop outs.

The scientific quality of the PhD-thesis and the minimum criterion of three published peer-reviewed scientific papers

While the precise rules and norms varied a little across the programs evaluated, the main criterion for a defensible thesis is the publication of three peer-reviewed papers in recognized international journals (i.e. those listed in either the ISI Web-of-Science or SCOPUS databases). This was confirmed by all the interviewed representatives (staff, students, alumni etc.). One of these papers should be first authored by the PhD-student. This rule has certainly helped to increase the international esteem and impact of Estonian research over the last few decades. However, the Committee believes strongly that it now acts as a straightjacket, leading to delays in graduations and probably unnecessary drop outs.

The Evaluation Committee was puzzled because this criterion is currently not listed in the most recent "Estonian universities' Agreement on good practice regarding quality"¹, but all programs still adhere strongly to it. Most interviewees thought that the criterion guarantees a certain proof of quality, while some supervisors thought it actually reduced the quality because the three papers were generally published in less impactful journals. In our discussions with staff representatives, a few mentioned that one paper of exceptional impact in, for example, *Science* or *Nature* should be acceptable, while some others were strongly advocating against it. Nevertheless, applying for such exemptions rarely occurs. In some universities, however, the rule is indeed used more flexibly, where the Dean or Program Council can grant exemptions. (This is discussed in the individual program sections.) The PhD representatives often indicated that the rule increased work stress towards the end of their PhD trajectory.

The Evaluation Committee appreciated that all the PhD-theses we scrutinized listed all the published papers and a statement of the role and contribution of the PhD student in each papers². However, when the Evaluation-Committee members reviewed individual statements, they learned that often not the highest impact journals (i.e. ISI-Web-of-

¹ Annex 1, Mandatory Component 1.2: "... The mandatory components of doctoral studies are the following: pre-reviewed international publication or other publication of the results of research and creative activities; participation in international conferences (presentations) and other specialization-related teaching, research and creative activities or education abroad;..."

² However, this authorship-contribution statement is not always satisfactorily. Some statement only indicated major and minor contributions and not the specific or detailed contributions.

Science Q1 and Q2 journals) were selected but only relatively low impact journals (i.e. ISI-Web-of-Science Q3 and Q4 journals). Focusing on a major high-impact publication could thus indeed increase the overall scientific impact, the ability to attract external funds and probably also relevance for society.

The time from manuscript submission to acceptance can extend to a year or more, particularly when the initial outcome is rejection or a major revision. Unfortunately this process is outside the control of the PhD student or his/her supervisor. These delays could lead to frustration, discouragement and violating to the eligible length/time for the PhD study (and eventually an additional drop out). Furthermore, since rejection is more likely to occur at high-impact journals, this can lead to an understandable but counterproductive reluctance to submit their work to leading international journals. The rules have the unfortunate and unintended consequence of incentivizing quantity of publications over their quality.

The Evaluation Committee recommends that **the three-paper-publication rule is reassessed and that more flexible rules are introduced**. For example, a rule that allowed for a single published paper in an excellent (i.e. ISI-Web-of-Science Q2 or Q1) journal could serve to enhance the quality of published output, increase motivation and reduce the nominal study time. Figure 2 shows the likely qualitative trade-offs and synergies of the current rule and two alternative scenarios. Shifting to a model that de-emphasizes the quantity of published work will inevitably put more responsibility on the PhD supervisors, the opponents and the defense committee (Figure 2). However, this is often the case in other countries, and should not pose major problems. Since there would be additional scrutiny by the opponents and committee of the student's ability to justify and defend their work as well as their contribution to publications, which form part of the thesis, the level of quality control should be maintained or enhanced. Furthermore, applying this three papers requirement as the unique rule for 'PhD quality' detracts from using a broader set of indicators. This responsibility shift could well be complemented by developing and applying other, more comprehensive indicators of a successful PhD thesis.



Figure 2. Indicative consequences of publishing none, one, two or three papers in a PhD thesis (Red indicates negative effects, green positive effects and black indifferent effects).

The annual PhD progress evaluations

All programs indicate that they have implemented a thorough annual progress evaluation. Most PhD students must file an annual progress report, which is discussed with the annual evaluation committee, usually comprising scholars who are not involved directly in the student's project. This helps to not only discuss the student's progress but also the quality of the supervisor's advice or possible conflicts between the student and the supervisor. Potentially, this setup allows for an effective and objective annual assessment.

The PhD student representatives were generally satisfied with the procedure. They also indicated that between annual meetings immediate problems will be solved by discussing the issues with the supervisor or, if necessary, other students or staff members. However, the focus seems mainly on the planned progress (as specified in the study plan) in courses, conferences and credits and less on the research itself. This is effective in the first few years but not later when the interpretation of research (observational or experimental) data and other results must be synthesized into manuscripts. At this stage, delays easily develop and their consequences are more difficult to assess. An effective assessment now requires a focus on the research with a short presentation of results and an interpretation and reflection on their significance, together with the feasibility of forthcoming research activities and publication plans. These elements should be discussed by the student, the evaluation committee and supervisor. A more content-focused assessment of this type would help identify any problems with progress of a student's research at an early stage, helping the student and his/her supervisors take appropriate steps to.

The paperwork relating to these evaluation meetings generally comprises the student's progress report and several general progress indicators. Once approved, the relevant boxes are ticked and the form is signed. The Evaluation Committee considers that this represents a missed opportunity to provide a formal record of the evaluation process and the action points arising from it. Instead, **the discussion, comments and suggestions should be summarized and documented, and included in an updated research strategy.** The success of this strategy then can then inform the next annual evaluation meeting.

The Evaluation Committee understands that annual evaluations at most universities end once a PhD-student's nominal study period has ended. The Evaluation Committee recommends that programs **continue linking to these PhD students and monitor and document their progress** after completion of the nominal study period.

The future of the Doctoral Schools

National doctoral schools have been funded by EU structural funds. These doctoral schools organizes courses, excursions and scholarships which allow PhD students to participate in conferences and visits at collaborating groups abroad. Over the last decades these schools have provided the means to internationalize PhD education and to provide high-quality training. PhD students and supervisors are very satisfied with the scholarship possibilities and they are used extensively. The PhD students are also well informed about these possibilities. The Evaluation Committee finds these different roles of the schools essential and their achievements important.

Although the doctoral school's funding role is extremely well exploited, the various doctoral programs and universities link differently to the courses and excursions of the doctoral schools. Some universities make relatively little use of the educational possibilities provided by the national doctoral schools. This most often happens for the larger PhD programs with adequate critical mass to organize their own activities. The Evaluation Committee, however, believes that engagement with the opportunities provided by the national doctoral schools should be a priority for Life Sciences PhD programs in Estonia. Besides providing knowledge and skills, they also provide a platform for PhD students and their supervisors to meet and exchange experiences. Such a national network has high value and **participation of all PhD programs and students should be encouraged.**

Unfortunately, the continuation of the national Doctoral School is also vulnerable because it depends on EU structural funds and its consequent project-based structure. These funds will likely decline in the near future, jeopardizing the continued functioning of doctoral schools. This would be unacceptable. The scholarships, courses and excursions and network functions of the schools are important and likely cannot be replaced with local alternatives within individual PhD programs. The evaluation Committee therefore suggests that **the directors of the PhD programs of the different universities develop strategies to hedge against possible decreasing funding of these schools.**

The link between the PhD programs, PhD degrees and society

Among the main issues that the Evaluation Committee encountered were concerns about the career prospects of PhD students, and the possibility for additional research funding sources. Nowadays, most funding comes from internal university funding for research projects (as part of the governmental funding to universities), the Estonian Research Council³, the EU framework programs and, to a lesser extent, the European Research Council (ERC).

Most of the PhD students interviewed by the Evaluation Committee indicated that their future career aspiration focused on academia. Only assistant and associate professors, and full professors in universities must have a PhD. Unfortunately, the availability of such university positions is insufficient to cater for all PhD-qualified applicants. This means that different societal sectors must be mobilized to recognize the value of a PhD. Although Life Sciences PhD graduates generally focus on a detailed or specialized research topic in their thesis, they have had a broader education (see, for example the role of the Doctoral Schools) and have developed many skills. For example, they can quickly analyze, comprehend and understand complex systems, and provide sustainable solutions for problems. They are also trained in the critical evaluation of sometimes conflicting evidence, and in the communication of results and insights. These skills are essential in governments and their agencies, non-governmental organizations (NGOs) and in business and industry (i.e. the private sector). The 'added value' from a PhD training was also highlighted by alumni and their employers. However, in some cases they regretted not to be further involved in the PhD education provided by their former institutions. The Evaluation Committee therefore suggest **to better demonstrate the presence of these high-level skills as the main asset of PhDs to the various societal sectors.** This could serve to broaden career opportunities for PhD graduates.

³ The Estonian Research Council was established by the government to concentrate R&D funding, and supports individual researchers, awards research grants and facilitates applied research in the fields of smart specialization.

Additionally, PhD students should become more aware of job opportunities outside academia. Doctoral School could have a role in organizing this. Routes to broaden career aspirations of PhD students, and to facilitate links to their potential employers, could include careers seminars by representatives of governments, NGOs and the private sector; excursions to business or organizations; and short internships in these organizations. The Evaluation Committee strongly recommends **to explore such possibilities and to develop strategies to pursue them effectively.**

Some universities already stimulate the establishment of spin-off companies. Although not all aspects of Life Sciences research will generate such opportunities, these are likely to be more widespread than imagined and are not limited to technical or engineering fields. For example, PhDs specialized in ecology or conservation can start consultancies which survey or monitor species, communities or landscapes, analyze the resulting data, and help to develop management plans or ecological impact assessments. The Evaluation Committee strongly recommends **to explore the possibilities for such spin-off companies and effectively train the PhD students to pursue them.** Success stories should also be presented to inspire current students.

Funding for PhD projects currently comes mainly from the national Estonian budget to universities and the Estonian Research Council. The Evaluation Committee strongly believes that **funding sources should be diversified** to guarantee adequate funding to top up PhD-student's stipends and to provide them with livelihoods in the last two years of their eligible length/time and beyond (c.f. Figure 1). A diversified funding strategy could also well protect against the likely reduction in EU structural funds flowing to Estonia.

A better connection with society could also help to identify and collect alternative funding sources. For example, the representative of the NGO Environmental Board stated that she already communicated her research questions to the PhD program of the Estonian University of Life sciences. Identification of such societal research questions and a better collaboration with the organizations that pose them could well enhance research funding possibilities. Although Estonia does not have many large industrial companies or other large organizations that could fund PhD research (a comment made by several interviewed representatives), all **possibilities for better funding by larger and smaller companies, governments and NGOs should be better explored.** International possibilities should also be investigated.

1. Assessment report of Study Program Group at the University of Tartu

1.1. Introduction

In 2017, the University of Tartu celebrated the 385th anniversary of its founding. The University of Tartu that was established in 1632 as Academia Gustaviana has been reborn a number of times throughout its history.

According to the University of Tartu Act adopted on 16 February 1995, the University of Tartu is the national university of the Republic of Estonia. Its mission is to advance science and culture, provide the possibilities for the acquisition of higher education based on the development of science and technology on the three levels of higher education in the field of humanities, social, medical and natural sciences and to provide public services based on teaching, research and other creative activities.

Under the structural reform, initiated in 2014, the nine faculties and five colleges of the University of Tartu were consolidated into four fields (Faculties). There are six doctoral programs under evaluation in this report:

- Botany and Ecology;
- Zoology and Hydrobiology;
- Environmental Technology;
- Molecular Engineering;
- Gene Technology; and
- Molecular and Cell Biology.

The curriculum group Bio- and Environmental Sciences comprises five doctoral curricula: Botany and Ecology (program leader prof. Kristjan Zobel, Institute of Ecology and Earth Sciences), Gene Technology (prof. Toivo Maimets, Institute of Molecular and Cell Biology), Molecular and Cell Biology (prof. Toivo Maimets), Molecular Engineering (prof. Marti Karelson, Institute of Chemistry) and Zoology and Hydrobiology (prof. Raivo Mänd, Institute of Ecology and Earth Sciences and Estonian Marine Institute). All of these institutes belong to the Faculty of Science and Technology.

The study program Environmental Technology has been formally classified to belong to the study program group of Engineering in 2016. However, the current assessment report handles the program together with programs of study program group Life Sciences. The nominal period of doctoral studies is 4 years (240 ECTS).

In 2012-2017 the number of PhD students studying at the programs under Life Sciences study program group has been stable, between 182 and 195. University of Tartu accounts for 49 % of all doctoral students in that study program group in Estonian universities.

The number of international students has been 7-9 each year (mostly in the Institutes of Ecology and Earth Sciences (7% of all PhD students) and Molecular and Cell Biology (5%). The number of those working at the university at the same time as studying has been fluctuating between 33-45%.

The number of admitted PhD students has fluctuated over the last years, between 33 (2014/2015) and 18 (2016/2017). This reflects, in part, the decrease in overall number of all students at the University. Most of the PhD students admitted had received their MSC degrees for the University of Tartu (83% last year).

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Each year 17 to 25 students get their PhD degree, the 'in-time' efficiency (students who graduate in 6 years or less) being from 45 to 70% in different years.

According to the statistics, each year 9 to 18 PhD students of the curriculum group disrupt their studies. According to the University of Tartu Self-assessment Report, most of them defend their PhD thesis eventually.

THE NUMBER OF PHD STUDENTS

Curricula	2012/13		2013/14		2014/15		2015/16		2016/17	
	No. of students	including those who work in the university	No. of students	including those who work in the university	No. of students	including those who work in the university	No. of students	including those who work in the university	No. of students	including those who work in the university
Botany and Ecology	54	26	53	20	49	23	50	18	44	15
Gene Technology	22	10	21	12	24	12	26	7	32	10
Molecular and Cell Biology	51	16	53	16	51	18	52	14	47	18
Molecular Engineering	4	1	5	2	4	3	5	2	5	2
Zoology and Hydrobiology	53	27	57	27	60	29	62	25	54	23
The study programme group's total	184	80	189	77	188	85	195	66	182	68
The University's total	1504	502	1457	493	1401	487	1348	380	1258	362

** international students are included

THE NUMBER OF FOREIGN PHD STUDENTS

Curricula	2012/13	2013/14	2014/15	2015/16	2016/17
Botany and Ecology	3	2	2	2	3
Gene Technology	2	2	2	2	2
Molecular and Cell Biology	4	4	4	2	2
Molecular Engineering	0	0	0	1	1
Zoology and Hydrobiology	0	0	0	0	0
The study programme group's total	9	8	8	7	8
The University's total	122	129	139	143	158

THE NUMBER OF ADMITTED PHD STUDENTS

Curricula	2012/13		2013/14		2014/15		2015/16		2016/17	
	No. of students	including those who graduated Master's degree in the University of Tartu	No. of students	including those who graduated Master's degree in the University of Tartu	No. of students	including those who graduated Master's degree in the University of Tartu	No. of students	including those who graduated Master's degree in the University of Tartu	No. of students	including those who graduated Master's degree in the University of Tartu
Botany and Ecology	9	6	8	8	6	6	8	7	5	2
Gene Technology	1	1	3	3	4	4	8	7	7	7
Molecular and Cell Biology	8	8	8	8	6	6	7	6	5	5
Molecular Engineering	1	1	1	1	0	0	2	1	0	0
Zoology and Hydrobiology	8	7	10	7	8	8	8	7	1	1
The study programme group's total	27	23	30	27	24	24	33	28	18	15
The University's total	190	151	179	153	168	137	171	139	177	133

THE NUMBER OF PHD STUDENTS DISRUPTING THEIR STUDIES

Curricula	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	including on the student's initiative								
Botany and Ecology	4	3	3	0	1	0	8	2	5	0
Gene Technology	1	0	2	1	3	0	0	0	2	0
Molecular and Cell Biology	3	2	5	1	2	1	2	0	5	4
Molecular Engineering	0	0	1	0	0	0	0	0	0	0
Zoology and Hydrobiology	3	1	1	1	3	0	4	1	6	3
The study programme group's total	11	6	12	3	9	1	14	3	18	7
The University's total	148	55	128	42	154	40	171	48	146	48

THE NUMBER OF DEFENDED PHD THESES

Curricula	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	including students who graduated in 6 years or less	Total	including students who graduated in 6 years or less	Total	including students who graduated in 6 years or less	Total	including students who graduated in 6 years or less	Total	including students who graduated in 6 years or less
Botany and Ecology	6	3	7	3	7	4	3	2	6	2
Gene Technology	4	3	2	0	4	2	3	2	5	2
Molecular and Cell Biology	5	2	4	1	3	0	8	6	6	4
Molecular Engineering	0	0	0	0	1	1	0	0	1	1
Zoology and Hydrobiology	5	1	4	3	5	3	6	4	7	3
The study programme group's total	20	9	17	7	20	10	20	14	25	12
The University's total	114	57	117	62	107	45	120	75	138	65

Assessment Report on Life Sciences PhD

During the last five years the number of PhD students studying at the program **Environmental Technology** has been quite stable, between 27 and 37 students. The number of those working at the university at the same time as studying has been fluctuating between 42-46%. The number of foreign students has been unchanged through the years.

THE NUMBER OF PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	working at UT								
Environmental Technology	37	17	35	16	36	15	32	13	27	12
UT Total	1504	502	1457	493	1401	487	1348	380	1258	362

THE NUMBER OF FOREIGN PHD STUDENTS

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
Environmental Technology	3	3	3	3	3
UT Total	122	129	139	143	158

THE NUMBER OF ADMITTED PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	Directly from UT MSc								
Environmental Technology	5	4	2	2	6	6	3	3	4	3
UT Total	190	151	179	153	168	137	171	139	177	133

THE NUMBER OF PHD STUDENTS DISRUPTING THEIR STUDIES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	on one's own will								
Environmental Technology	1	0	4	0	3	1	5	1	6	0
UT Total	148	55	128	42	154	40	171	48	146	48

THE NUMBER OF DEFENDED PHD THESES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	within 6 years								
Environmental Technology	6	5	1	0	1	0	3	2	5	3
UT Total	114	57	117	62	107	45	120	75	138	65

During the last five years 16 theses have been defended, 62.5% of them (10) within 6 years (nominal period of studies plus 2 years), which is higher share than at the university in general (50%).

1.2. Strengths and areas for improvement of study programs by assessment areas

The Evaluation Committee has combined the general strengths and improvements for all the six PhD study programs in this section because the interviews with the various representatives (i.e. senior leadership representatives of the university and faculties, faculty involve in program management, academic staff (including supervisors), students and alumni). These general comments refer explicitly to 'resources', 'Teaching, learning, research and/or creative activity', 'teaching staff' and 'doctoral students'. Specific comments on these topics and other comments are presented and discussed in the sections on the specific PhD study programs.

Resources

Comments

With respect to the numbers of supervising staff for the PhD students, the number of research supervisors is adequate. However, the Committee recommends that co-supervision is encouraged. The overall levels of PhD students for the numbers of supervisors is insufficient to support a critical mass of engaged research activities within the evaluated laboratories. Some supervisors are more successful in project awarding and as this results in proportionately more PhD graduates, it further strains the distribution of students through the program. Critical mass within given laboratories is affected by the numbers of personnel, but particularly by the level of skilled individuals to sustain a laboratories technical capabilities and dispersed know-how. Given that several laboratories had only one PhD student graduating per supervisor in the recent five year period, indicates a sub-critical level of human capital. Moreover, the PhD students are unevenly distributed with some supervisors have in inflated numbers of PhD students relative to other supervisors and to their scientific performance. Supervisors access to PhD students was stated to be dependent on availability of the necessary funding (research grants).

The quality of supervisors covers a broad spectrum, ranging from very good to sub-optimal. However, the overall output of scientific quality is sufficiently good. That being said, the time dedicated to supervision of PhD students could be increased, as supervisors estimate that 30-50% of their time is consumed with administrative tasks (grant writing, reporting etc.).

The subject of PhD student stipends has been much addressed elsewhere in this report. The level of present national stipend threatens the viability of PhD programs generally. The University of Tartu has discussed the idea of ensuring that new PhD students accepted to the life sciences programs should be supplemented in their income (combination of stipend and salary) up to level of national average salary. The Evaluation Committee very much favours this suggestion. However, the nuance to this idea, is that projects running times and durations of the PhD often do not match, leaving students with sub-adequate financing with advanced years of study, leading to high drop-out rates.

The career trajectory and perspectives of PhD graduates for all universities examined by this Evaluation Committee are inadequately addressed. The focus of the PhD studies is on the production of 3 papers for graduating, and hence scientific research is of primary important, which it should be. However, the levels of networking with other scientists, research industry actors, or other future employers needs development, both at the student and supervisor levels.

The Evaluation Committee understood that the general availability of resources for foreign travel was adequate. The access to scientific literature and databases is ensured by the national government, and we were informed that all literature is available.

Infrastructure was generally of a good quality with up-to-date buildings and modern scientific equipment. There appears to be a culture of sharing within the University in general, so that access to instrumentation is not a barrier. The Evaluation Committee noted that much of the financing at the faculty level had to be generated by projects with a sub-adequate access to institutional base funding.

In general, the structure of the research groups relies on PhD students to a great extent, with a large vacuum of post-doctoral fellows. Clearly the structure of national financing is at issue, which will continue to threaten the formation of a critical mass within the laboratories. In the absence of outside ideas, usually from post-doc or faculty from abroad, the continuation renewal of ideas will be at issue. The Evaluation Committee was somewhat surprised with the low level of international research personnel for the University of Tartu, which strives for high-levels of competitive research. The present level of international networking and personnel, considering the strain in national funding for science, will further exacerbate the sub-critical mass within laboratories and does not allow for a fully enriching PhD training.

Strengths

- Modern infrastructure;
- Good access to literature sources and databases; and
- Mainly high scientific level of supervisors.

Areas of improvement and recommendations

- The Evaluation Committee recommends that the student income (stipend combined with salary) increase to levels of Estonian average salary should be enforced through an institution-wide policy to guarantee PhD students income through to their study completion;
- The Evaluation Committee recommends that the levels of networking with outside scientists, research industry actors, or other future employers needs development, both at the student and supervisor levels. Increased international networking need attention and will raise the profile of the institute, leading to more invited talks, and common grant applications;
- Collaboration with industry and development of skills to improve entrepreneurship is much needed, and would require, beyond networking, an examination and re-structure of course work to be more impactful. It was noted that some soft skills courses were offered, but were sometimes too time consuming for the value generated. It would be good to foresee funding for practical replacement of PhD students into industry;
- One area for improvement is the availability of reagent money in the form of a bench fee. The Evaluation Committee recommends that bench fee will be used by supervisor and/or PhD student directly. Progress of some experiments was seen by the lack of availability of basic reagents (consumables) for the experiments themselves. It was note that much of the financing at the faculty level, had to generated by projects, with a sub-adequate access to institutional base funding;
- As to the sustainability of infrastructure, it was understood as an important challenge. However, the level of importance was not really taken seriously, and hence a clear strategy to plan for future development from the institute will need to address this issue. Although, the current equipment is reasonably modern, the continuous renewal of instrumentation to stay current and competitive seems not to be considered. The Evaluation Committee recommends that an infrastructure planning committee be

formed at the university level, to formulate a strategy after identifying the areas which should have priority for renewal; and

- The Evaluation Committee commends the University of Tartu for strengthening the existing grant office, introducing the new way of handling EU calls and with a new software to match scientific expertise with the open proposals. This effort should encourage to more submissions for funding to off-set the trend of low national financing of Estonian science.

Teaching, learning, research and/or creative activity

Comments

The comprehensive and candid self-evaluation report reveals a set of programs that are well-managed and that provide a supportive environment within which students enrolled on all six programs undertake their studies. This impression was further confirmed and reinforced during the site visit. While much of the feedback collected by the programs from current PhD students and alumni is relatively informal, the Evaluation Committee did not identify significant sources of dissatisfaction with the approach to supervision and assessment. The major concerns of current students relate to the extended duration of PhD studies, the limited stipend resourcing, and the challenges of finding appropriate employment opportunities following graduation; these are topics that are discussed in detail elsewhere. Examples of good practice include the regular general seminars in English (involving both students and supervisors), the personalized study plans devised for each student, and the credited 'Teaching Practice in Higher Education' course within the Department of Botany.

Strengths

- The atmosphere for graduate studies is supportive and ambitious;
- Interactions between PhD students and their supervisors are positive, reflecting their generally shared interests;
- Procedures for PhD student admissions, while still tending to lead to recruitment from within the university rather than externally, have been appropriately modified in the most recent admissions round in a way that will help facilitate international applicants;
- International study and research placements are encouraged and well-supported, and many students have international (co)supervision; and
- PhD students are encouraged and supported in making use of doctoral schools to enhance their training.

Areas of improvement and recommendations

- The Evaluation Committee felt that award of the PhD is overly focused on quantitative criteria (numbers of papers published, course credits completed etc.) rather than scrutiny of a PhD student's work by the thesis panel and opponents. In combination with a relaxation of the strict application of the "3-paper rule", the assessment process should more fully assess students' abilities to defend their work, both published and unpublished, and to clarify their contributions to multi-authored papers; and
- With other Estonian universities, Tartu faces a sustainability issue in terms of declining enrolments resulting from demographic changes. The University is well placed to recruit international PhD students and should continue to seek ways to remove barriers to international recruitment.

Teaching staff

Comments

In all these six PhD programs, PhD supervisors are carrying out high-quality research that is often internationally competitive. PhD students are fully integrated into this work and often key to delivering it, with the work undertaken by doctoral students forming part of their theses. The programs have made extensive efforts towards internationalisation, and have been heavily involved in the co-ordination of graduate schools which have had positive benefits for multiple students. Allocation of funding for students to supervisors takes into account the supervisors' track records in PhD student supervision, as well as their track records of publication and the availability of resources from research projects which can be used to support the students.

Strengths

- There is a close and collegiate working relationship between supervisors and students;
- Most supervisors have international research experience and are integrated into international networks of collaboration;
- Supervisors work within laboratories that are well-founded, with the latest equipment and facilities; and
- In many research groups, postdoctoral researchers are an integral part of larger research teams, and can contribute to PhD student training.

Areas of improvement and recommendations

- The effective practical requirement for faculty members to teach in the Estonian language act as a barrier to international recruitment. The university is in a strong position to attract international faculty and the Evaluation Committee recommends that **efforts are made to ensure that barriers for internationalisation to doing so are minimised;**
- Teaching staff and program leaders are mostly reluctant to relax the '3-paper criterion, as discussed elsewhere. This can potentially increase conflicts of interest over publication strategies between PhD students and their supervisors. **Changes in publication strategies should thus be well communicated and implemented;**
- Research co-operation and collaboration with other Estonian universities is relatively limited beyond participation in doctoral schools. **This could easily be improved,** for example, through a better collaboration through the national graduate school;
- Although ample opportunities are available, few formal opportunities for supervisors to share innovation and best practice in student supervision exists. **These opportunities should be formalized;** and
- Most publications have multiple authors from a large research group. The university needs to **ensure that the independent contribution of a student is clear and that this aspect is thoroughly assessed during the thesis panel and defence process.**

Doctoral students

Comments

The Evaluation Committee generally found that the PhD students from all programs are very satisfied and content with their study programs. They feel freedom to make their own choices (both in terms of research and study curricula). In addition, the relationship between supervisors and their PhD students has proper and inspiring dynamics. Students are able to spend adequate time abroad and the necessary funding is available. (However,

even more students should be encouraged to spend more time abroad and in different laboratories and research groups.)

PhD students, when admitting students to doctoral study, their suitability for successful completion of their studies is assessed based on transparent criteria. PhD students can plan their studies as well as research activities in collaboration with their supervisor and the evaluation of doctoral students is transparent. Also, PhD students teaching and research activities at the university support successful completion of their doctoral studies and students do not seem to be overloaded.

Strengths

- The relationship between supervisors and their PhD students have very good dynamics;
- Students are able to spend adequate time abroad and the funding for this are easily available;
- Good atmosphere and working environment; and
- Decision of the university to cover stipend on the “Estonian salary average” level.

Areas of improvement and recommendations

- Several general issues should be addressed in future. The main problem is the large dropout, which actually is an issue for all PhD programs at all Estonian Universities. These high dropout rates cannot be fully explained by the available university statistics. In fact, when the dropout actually happens remains unclear (in the eligible length/time or beyond). However, from the discussions with students and other representatives, the Evaluation Committee learned that the high dropout rate is caused by combination of interacting factors, such as economic issues and motivational problems. In addition, many PhD students (and junior researchers) are starting a families and combining research/study and taking care of small children is challenging. The university (and the PhD program) could support this with providing flexible working hours and, if possible, kindergarten or ‘day care’ access within the university. The University of Tartu’s decision to start increasing each PhD stipend towards the Estonian average salary (i.e. 1242 EURO) is applauded by the Evaluation Committee. This certainly will improve the success rate of PhD students and reduce the dropout rate;
- **PhD students should be trained to improve their attractiveness at the labour market outside academia.** They currently see their future only in academia and the majority find it hard to imagine moving outside of academia. However, after their graduation only a few (i.e. approximately 20%) will be able to find a tenured position in University research and education. Therefore, they need to be better prepared to also apply for jobs in business and industry, NGOs and governments. Such training can contain involve teaching soft skills, leadership and entrepreneurship skills and presentation skills. This will broaden the PhDs’ attractiveness for sectors outside academia. Additionally, if more PhDs work outside academic, this will enhance connectivity with, for example, the industry and could well lead to the development of collaborative programs with internships, trainees and maybe even additional PhD funding;
- **Such training should also enhance entrepreneurship.** Its importance is currently generally underestimated at universities. PhDs students should have more opportunities to develop more knowledge and skills that are essential for entrepreneurship. This could help them in creating new business opportunities, which could be supported by the university through the creation of business incubators, start-ups and spin-off companies;
- Generally, the research activities of PhD students are of a very high quality. However, questions were raised on the criterion of three published papers before a PhD student can defend her thesis. Several PhD students believe that this often lead to three

smaller, less significant research papers rather than one major high-impact paper in a renowned international journal. Therefore, **adhering to this 'three-published-papers' criterion must be revisited** by the PhD program and the university. Another possibility is that other output with potentially high impacts (e.g. patents or software) could be allowed as part of a thesis and its defence as well. The program should discuss such possibilities with the university;

- The PhD students were missing enough freedom in choosing their courses and developing their own curriculum. Moreover, they were dissatisfied with some of the obligatory courses. (Also the self-evaluation report mentions that some of the courses receive lower marks from the students.) Therefore, **students should receive more opportunities to select courses and develop their own curriculum according their needs;**
- Students have many opportunities and possibilities to study at an institute of laboratory abroad, but they sometimes miss guidance to select the best place or research group. **The Evaluation Committee would welcome help and guidance** from the PhD-students' supervisors and, if possible, workshop should be organized to make students aware of opportunities and to help them to apply. This could raise success; and
- Finally, potential problems can easily emerge during the studies, research or the PhD-student's life. Currently no procedures seems to be part of the progress-evaluation process to deal with such problems. This is generally left to the discretion and thoughtfulness of an individual supervisor. Better instruments, such as, for example, anonymous feedback from PhD students and independent counseling, could be introduced and implemented.

1.3. Strengths and areas for improvement of study programs for study programs 'Botany and Ecology', 'Zoology and Hydrobiology' and 'Environmental Technology'

Comments

The Evaluation Committee chose to report on these three programs as a group, since the interviews took place collectively and, although each program has its own character, they operate in similar ways, share some supervisors and have similar strengths and challenges. The Evaluation Committee noted that the Environmental Technology program is particularly small and involves a combination of rather different fields, and without its own dedicated Institute. While the Botany and Ecology and Zoology and Hydrobiology curricula are both administered by the Institute of Ecology and Earth Sciences (formed in 2007), these PhD programs retain the names of earlier, smaller institutes, which retain a degree of autonomy as constituent departments within the Institute. All three programs are well-established and well regarded, and based on both the self-evaluation reports (which was extremely comprehensive and helpful) and the site visit, the Evaluation Committee judged that the programs are fully compliant with the necessary standards. At Tartu, all three programs are embedded in a productive research environment, where individual research groups are often working at an internationally competitive level. Considerable effort has gone into supporting students financially and in devising appropriate study plans. Alumni and students both expressed satisfaction with the programs, while clarifying the particular challenges that they face (most of which are shared with other institutions and programs within Estonia).

Strengths

- The three study programs draws on the considerable research strengths in these fields at the University, with internationally competitive research in several areas;
- PhD students are treated as a core component of the research capital of the university and their contributions are valued and supported;
- The PhD student allocation, selection and admission process ensures that the necessary resources are in place to support each student throughout their studies; and
- Doctoral students are satisfied with the doctoral courses offered.

Areas of improvement and recommendations

- Individual study programs are relatively small, mostly for historic and practical reasons. This fine 'slicing' of the PhD offering may contribute to isolation of individual research groups, risks confusing and deterring international applicants, and is likely to lead to some unnecessary duplication of the administrative burden on teaching and support staff. The University is considering plans to consolidate into a smaller number of programs (e.g. one per Faculty). The Evaluation Committee endorses such a move, but this must be done in a way that ensures that resources are distributed fairly, and that retains flexibility for individual research themes to adjust their study programs; and
- As discussed elsewhere in this report, the Evaluation Committee believes that strict application of the '3 paper rule' can lead to some unintended negative consequences. Consideration should be given to modifying criteria to recognize the quantity of publications rather than quality, both for supervisors and students.

1.4. Strengths and areas for improvement of study programs for study program 'Molecular Engineering'

Comments

The aim of this interdisciplinary program is to train new researchers at the frontiers of chemistry, physics, and biology. It has a strong component of molecular modelling and provides courses in various fields such as quantum and molecular electronics, development of new energy sources, materials, biomedicine, molecular biology, genetic engineering, grid computing etc. The program has produced 15 PhDs (and 13 MScs) since its establishment and is hosted by the Chemistry Institute and coordinated by the Chair of Molecular Technology.

The curriculum is built on the standards from higher education that are all provided as links to downloadable documentation in the Self Evaluation Report. The program also meets the good practices for doctorate studies that have been established in a general resolution for Tartu University (19 December 2014). As it can be seen from the program detail given both in the self-evaluation report and its annexes, those requirements are well respected.

In the self-evaluation report, the development of this program is motivated by the "identification of key area that correspond to the University strengths and also to fulfil important societal needs in the field of molecular engineering" and it established to "fulfil the need that students expressed to obtain a PhD degree that would enhance their training in molecular Engineering". However, those are general statements, and the comprehensive set of information that should support these statements is missing. In particular, (i) how many PhDs are expected to be needed both from the industrial and academic sectors in the field? (ii) How many PhD alumni indeed found jobs related to

molecular engineering? (iii) What is the demand of undergraduates (BSc and MSC) for a PhD in molecular engineering?

Information on program implementation is not specifically described but refers to general rules of the University. While the fact that all programs follow homogenous rules, is positive, this does not however enable to obtain a precise idea of the strategy, assets and challenges of this particular program. The analysis of the self-evaluation report and the discussion with students probably shows that **the main function of this program is to shuttle master students for a PhD in the chair's laboratory. While developing excellent students using a highly visible chair is a good idea, having such a univocal matching between a PhD program and a laboratory of rather limited size has several disadvantages.** In particular, this limits the number of students that can be trained through this program and also the possibilities of scientific interactions of the students with other students and scientists during their doctorate work.

The recent actions that have been implemented to develop the program have mostly consisted in the introduction of two new courses: Technology transfer today and Contemporary and future Technologies, as well as of a student seminar that operates in a satisfactory manner from 2017. As this program has large potential for innovative science, industrial applications and collaborations (and a large set of national and international partnerships) it could be made more ambitious in terms of courses. It could also make more use of the excellent infrastructure, industrial contacts and interdisciplinary nature to actively drive more students. For example, these two courses are taught by staff from inside the University while it could be delivered by alumni or persons from the economic sector. Such options are mentioned in the future development of the program but are unfortunately not presented within a comprehensive set of concrete future actions.

The main indicator used to describe the success of this (and other) program(s) is the time required for the completion of a PhD (i.e. successful defence). The goal set is half of all students graduate at an optimal duration of 4 years (+ 2 years; Figure 1). The logic is that this indicator is articulated with the "rule of 3 published articles for a PhD". Hence if one accepts that this rule warrants the quality of a PhD, then the only pertinent indicator is the time to achieve this goal. However, as stated in the general discussion, the Evaluation Committee argues that this three papers rule is now acting as a straightjacket. To summarize, this dispositive detracts from building a set of key indicators that would help to steer the PhD program, especially as PhD needs to become a reference degree out of the academic world in Estonia.

The proportion of research and/or development of creative activity is 75% in the program as one year in the eligible length/time of four years is devoted to courses, while the other are aimed at laboratory research. This amounts to 60 ECTS out of 240. The Evaluation Committee also observed that, as the effective duration of PhD is often of 6 to 8 years, the actual proportion of creative research is likely higher. As in the other programs examined by the Evaluation Committee in this institution, supervision mostly relies on the laboratory staff will teaching is achieved through both the common teaching units of the graduate programs that students can choose with a large degree of freedom and through the courses and summer schools provided by the graduate schools. Besides these very positive points, speciality elective courses could be more developed towards the integration between biology and physical/chemical sciences instead of focusing at these different aspects separately. Another interesting issue that could have been detailed in the self-evaluation report is the guidance offered to the students in the choice of their courses.

The international exposure of students is satisfactory, thanks to different funding possibilities. To attend international conferences or visit foreign institutions the students

make a good use of the Graduate schools fund provided by Europe (DORA, ASTRA) or Estonia (Kristjan Jaak) as well as some funds provided by the institutions in which the students visited. Students have to present their work at least at one international conference, and the report state that they all participated to international conferences and/or courses. It shows 3 examples of very active students within the program. This was confirmed by the interviewed students. Students also have a 3 ECTS oral presentation course to prepare them for these conferences.

Leadership and teamwork is enhanced by the possible participation of all PhD students of this program in elective courses on conflict management (6 ECTS), a management course (6 ECTS) and a network society study (4 ECTS). All these activities could be important for building leadership and teamwork. However, the interviews with the students indicated that these course are most lectures that were felt not to be practically oriented.

Most students within this program have taught and coached Bachelor thesis students and (but more rarely) Master theses. One PhD students has been involved in teaching. This might be an underexploited resource both for training and also for teaching to lower levels. The interviewed students appeared to be very volunteer to be involved more actively into teaching activities, but the Evaluation Committee might have seen some of the more active and outspoken students. The 2017 RAKE survey indicates that 22% of these of the doctoral students that are actively willing to have more lecture and coaching.

Special course for preparation of international conferences are taught in English. In general students are excellent in English. Specialized academic English (6 ECTS) is also taught.

Taken together, the different components of a doctoral program form a coherent whole that is reinforced by the fact that a single institute hosts it. This has however the drawback of making the program relatively closed on itself. Students explained that it tended to limit their scientific life in terms of possibilities of interactions and work. This has to be however nuanced as it was visible the students from Molecular Engineering are quite close with the students from the other study programs in life sciences. As previously mentioned, the doctoral program consistency could be improved by more ambitious approaches towards students' development both in interdisciplinary aspects as well as in transverse skills pertaining to this program. Teaching methods are also robust but very classical in their conception and implementation: Lectures, lab seminars, research seminars. It should be an important suggestion to introduce modern methods that are appropriate at PhD levels: flipped classrooms, problem solving approaches, real life situations. This could provide students with interesting skills that would in particular enhance their employability.

Doctoral feedback from students is collected through online questionnaires and also students state that they can interact with their supervisors and staff in a very fluid manner, in part because the laboratory and program are superposed. In particular the two new courses implemented in the program (see above) have been created following students feedback:

- During the interviews the students indicated that they were aware of a conflict mediation instance at the level of the doctorate program management but that they never had to use it as potential problems were solved before.
In slight contrast, alumni indicated that collecting and using their feedback was not sufficient, despite their will to contribute to the life of the doctorate program, either through advice, possibilities to recruit students in their companies or to establish and give new courses; and

- Doctoral students must pass a progress review once during the academic year. That is based on the fulfilment of the individual study plan that has been previously defined: students must have fulfilled at least 50% of their individual study plan or submitted their doctoral thesis for defence. Students in general find these assessments necessary, open and fair but point room for improvement: such an assessment could be more open and science orientated instead of being a system that aims at providing credits if the right boxes can be ticked. This has already been identified by the responsible of the programs and mentioned in the self-evaluation report.

This PhD program, which is thus highly interdisciplinary, is hosted by the Chemistry Institute and its students perform their research in the Laboratory of Molecular Technology. The ambitions are important as it aims at training the students at the frontiers between molecular modelling, quantum chemistry, drug design, computing and other interdisciplinary challenges.

Strengths

- A program hosted by the Institute of Chemistry, which is an excellent institution, with very good standards for research and teaching;
- Clear rules that are shared at the institutional level;
- Very well equipped laboratories to international standards;
- Aims that are clearly at the edge of a scientific domains with a strong aim at interdisciplinarity;
- A modular program in which the students can choose their training courses to achieve their own individual training;
- Obvious connections with the pharmaceutical industry; and
- International exchange of the students.

Areas of improvement and recommendations

- This PhD program is hosted by one single institute. This reinforces the self consistency and makes the communication very direct but simultaneously limits the students possibilities of development and interactions (both indicated from the self-evaluation report and interviews with the students). **A strategy to more broadly anchor of the program should be developed;**
- A limited number of PhD students (self-evaluation report). **This lack of critical mass and its consequences should be better dealt with;**
- The rule of three published articles for a PhD likely limits scientific ambition and quality, while increasing the thesis duration and dropout (both from the self-evaluation report and the interviews conducted during the site-visit). **New and more effective publication strategies should be discussed;**
- The course program is a mix of pre-existing modules. Each module separately covers different aspects that could be of use in molecular engineering, from physics and chemistry to genetics. The program, however, lacks integrative courses that bridge and integrate the different topics (c.f. program course given in the self-evaluation report). **Courses should also be taught in a more modern and interactive manner** (from the interviews with the students); and
- The program has a very high trend for industrial applications with, for example, the pharmaceutical industry. In this respect, **the connections with the alumni and the socioeconomic sector should be enhanced** both for teaching and students future employability (from the discussion with the alumni).

1.5. Strengths and areas for improvement of study programs for study programs 'Gene Technology' and 'Molecular and Cell Biology'

Comments

The programs of 'Gene Technology' and 'Cell and Molecular Biology' train professionals to the field of biotechnology in a broad sense. They will be discussed collectively below because they are both hosted by the Institute of Molecular and Cell Biology (LTMR), have largely overlapping contents and similar profiles, share the director and program council, and were discussed together in the self-evaluation report.

The programs aim at doctoral education at high international level and while being strongly research-oriented, the curricula include elective courses supporting development of broader general competencies (e.g. management, presentation skills). The content and development of the programs are in line with national laws and regulations and with University-level documents "Statutes of Curriculum" and "Good practise of Doctoral Studies". Formal studies account for 60 ECTS, while the individual research project amounts to 180 ECTS (75%) of the total 240 ECTS doctoral degree.

The students have participated in international conferences and courses, supported by travel grants available from different sources, although not from the study programs. Based on the data in the self-evaluation report (Table B2/3-11), about half of the students attended meetings and courses abroad during the study year 2016-2017, some several times. International visits by the students have, however, dropped after 2015 due to changes at the level of the doctoral school funding. The University also recommends the students to spend a minimum of one semester spent abroad during doctoral studies (self-evaluation report, p. 21). Based on discussions of the Evaluation Committee with students on the site visit, the students are not, however, generally aware of this one-semester recommendation nor have they much used it yet.

According to a recent survey (self-evaluation report, p. 78) and discussions during the site visit, the students feel that their studies promote the development of research skills, but hope for more courses on teaching and supervision. Furthermore, the students expressed their general satisfaction with the content, flexible nature and quality of the courses provided by the programs. The wish list of the students included, for example a course on science-focused academic writing (instead of the current more broad writing course), in addition to pedagogical courses. Feedback from students is also collected at a more individual level in the annual progress reviews.

Feedback from alumni and employers, obtained mostly through personal contacts of the directors and staff, has indicated a need for developing competencies related to starting biotech companies (self-evaluation report, p.78). The need for including generic and soft skills not directly related to research in the doctoral studies was further strengthened during the site visit. In the meeting that the Evaluation Committee had with a group of alumni and employers, international experience of the students was also regarded as highly valuable for employment in the R&D sector. Also, stronger contacts and connections with the programs were wished.

Strengths

- Doctoral studies have a solid structure consistent with international standards and based on clearly stated documents;

- LTMR with its neighbouring institutes Estonian Biocentre and Estonian Genome Center provides excellent facilities for high-quality research and an inspiring environment for doctoral studies;
- A strong feeling of collegiality and congeniality among the staff and healthy pride over University of Tartu PhD graduates was sensed during the site visit, facilitating further improvement of the programs; and
- Doctoral students are generally satisfied with the courses and with the support they obtain from the supervisor and from the study program.

Areas of improvement and recommendations

- The curricula are strong in scientific training in molecular biosciences, but competencies important for postdoctoral career and employment have received less attention. **Inclusion of more courses related to entrepreneurship, pedagogical and communication skills, scientific writing, intellectual property etc. in the programs would better prepare the students for life outside academia;**
- **The programs of Gene Technology and Molecular and Cell Biology differ only by a few courses and could be easily combined into one** with potential benefits in terms of marketing and administration. According to self-evaluation report (p. 79), this kind of merger is already being planned, and the Evaluation Committee fully endorses such a move; and
- The **programs should strengthen their contacts with alumni and with employers**, especially the biotechnology sector to better adjust the curricula to current and predicted future needs in the society.

Specific comments on teaching and learning for the Gene Technology and Molecular and Cell Biology programs

The extensive and well-crafted information in the self-evaluation report shows curricula that support the professional education of the doctoral students with relevant courses and study environment. This impression was confirmed during the site visit. The elective courses in the curricula allow the students to strengthen their areas of interest and specialization in an individual manner and following a Personal Study Plan, confirmed each year by the student and supervisor. Most students obtain experience on teaching and supervising during their studies (self-evaluation report, Tables B2/3-5 and B2/3-6), important competencies in the job market. Student also receive study credits from teaching and supervision. Another example of good practise is the annually organized meeting which brings together all doctoral students and their supervisors and provides a forum to facilitate monitoring of scientific and academic progress and to give mutual feedback.

Individual feedback from students is obtained, beyond regular discussions with the supervisor, in the annual review meetings. According to the self-evaluation report, the feedback has been generally positive, which was also the impression of the Evaluation Committee based on their discussions during the site visit. However, based on Evaluation Committee's discussions with the students, the annual review meetings are often felt as formalities without much scientific discussion or genuine opportunity for analysis of the students' situation.

The doctoral theses are required to include at least three publications. The strict adherence to this three-paper rule may contribute to unnecessary extension of studies and is not always a guarantee of quality. These problems have been recognized and are under discussion in the study programs.

Strengths

- The study programs provide an inspiring, scientifically ambitious and supporting environment for teaching and learning;
- There is friendly relation between students and supervisors and other staff; and
- Clear protocols for individual study plans and annual progress review have been established.

Areas of improvement and recommendations

- The international dimension of the study programs could be strengthened by **offering more courses in English and by inviting more international visiting lecturers;**
- The annual progress review of the doctoral students seems to be focused on checking the number of papers and study credits rather than assessing the student's progress in a more comprehensive manner. **Scientific content and transparency of the review have room for development;**
- The adherence to three-paper requirement for the PhD Thesis leads to unnecessary extension of doctoral studies. The Evaluation Committee recommends that **more flexible measures to achieve the scientific maturity expected from PhDs should be adapted;**
- The courses largely use traditional teaching methods. Although these work in a satisfactory manner, the Evaluation Committee recommends the programs to **incorporate more flipped classroom and/or problem solving types of pedagogical approaches to bring more diversity to teaching methods and teaching staffs' skills;**
- The effective practical requirement for faculty members to teach in the Estonian language act as a barrier to international recruitment. The university is in a strong position to **attract international faculty, and the Evaluation Committee recommends that efforts are made to ensure that barriers to doing so are minimised;**
- Teaching staff and program leaders are mostly reluctant to relax the '3-paper rule', as discussed elsewhere, and there is the potential for conflicts of interest to arise between PhD students and their supervisors over publication strategies;
- Research co-operation and collaboration with other Estonian universities is relatively limited beyond participation in doctoral schools. **Such co-operation and collaboration should be improved;**
- There are few formal opportunities for supervisors to share innovation and best practice in student supervision; and
- Most publications have multiple authors from a large research group. The university needs to **ensure that the independent contribution of a student is clear and that this aspect is thoroughly assessed during the thesis panel and defence process.**

Specific comments on teaching staff of the Gene Technology and Molecular and Cell Biology programs

The key component of the doctoral studies consists of research conducted in the laboratory and under supervision of an officially nominated supervisor, selected mainly on the basis of academic competence and earlier success in PhD training. The supervisors are active scientists, generally at internationally competitive level and reasonably funded and connected to other research groups in the University and elsewhere in Estonia and abroad. Often the supervisors hold positions of professors in the University and give lectures. Almost all other lecturers have a PhD degree as well (a formal requirement from the beginning of 2018) and participate regularly in pedagogical training along with research

staff. Tartu University offers courses for the teaching staff to develop their supervisory competences.

Strengths

- The doctoral students are fully immersed in scientific research which - in the form of publications - also constitutes the key result of their studies;
- The supervisors are active scientists pursuing research at high international level and have opportunities to support the projects of the doctoral students; and
- The supervisors participate in the formal teaching helping to bridge the gap between topical research and basic scientific theories.

Areas of improvement and recommendations

- There is little international staff which prevents development of a truly international study and research environment. Although this may be largely due to uncompetitive salaries and unlikely to change very rapidly, the Evaluation Committee recommends that the **programs should actively pursue possibilities to fund more visiting professors and researchers.**

2. Assessment report of Study Program Group at Tallinn University

2.1. Introduction

Tallinn University is the third largest public university in Estonia, focusing primarily on the fields of humanities and social and natural sciences. They have about 7500 students and over 800 employees.

The University is a merger of several higher education and science institutions (e.g. Tallinn Pedagogical University, Academy Nord, Estonian Institute of Humanities, Institute of History of Estonian Academy of Sciences, Academic Library of Estonia) into a single institution, which resulted in the founding of TU as a public university on 18 March 2005.

In 2015, a significant structural and management reform took place whereby 26 existing units were merged into just nine: six academic units (Baltic Film, Media, Arts and Communication School; School of Digital Technologies (DT); School of Educational Sciences; School of Governance, Law and Society; School of Humanities; School of Natural Sciences and Health); two regional colleges (in Haapsalu and Rakvere) and the library. In addition, five centers of excellence, nine research centers and fifteen support units were formed.

The vision of the University is to play a leading role in promoting and developing intelligent lifestyle in Estonia, thus contributing to Estonian sustainability and to self-actualization of individuals.

The objective of TLU for 2015–2020 is to consolidate activities into five main focus fields: educational innovation; digital and media culture; cultural competences; healthy and sustainable lifestyle; society and open governance.

Two programs are currently offered within the Biosciences and Environment Study Program Group at the doctoral level (with active admissions) at Tallinn University: Analytical Biochemistry and Ecology.

The Ecology study program was launched in 1992, and the Analytical Biochemistry study program was launched at the doctoral level in 2012. As a result of the structural reform, the programs were moved to the School of Natural Sciences and Health (SNSH) in 2015. The nominal period of studies is 4 years (240 ECTS).

In academic year 2016/2017 there were 363 doctoral students in TLU, of which 29 studied at the Life Sciences study program group. TLU accounts for 6 % of all doctoral students in that study program group in Estonian universities.

During the last 5 years the number of PhD students studying on the Life Sciences programs have been relatively stable from 25 in 2012 to 29 in 2016.

THE NUMBER OF PHD STUDENTS

	2012/13	2013/14	2014/15	2015/16	2016/17
Curriculum	Total	Total	Total	Total	Total
Ecology	20	21	23	23	20
Analytical Biochemistry	5	6	6	10	9
TLU Total	377	370	378	386	363

THE NUMBER AND PROPORTION OF INTERNATIONAL PHD STUDENTS

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
Ecology	1	1	1	1	1
Analytical Biochemistry	-	-	-	-	-
TLU Total	6,6%	8,1%	10,9%	12,4%	13,2%

THE NUMBER OF ADMITTED PHD STUDENTS

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
	Total	Total	Total	Total	Total
Ecology	4	3	3	2	1
Analytical Biochemistry	2	1	1	3	1
TLU Total	46	44	46	42	50

THE NUMBER OF PHD STUDENTS DISRUPTING THEIR STUDIES

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
	Total	Total	Total	Total	Total
Ecology	2	1	1	1	2
Analytical Biochemistry	-	-	-	-	-
TLU Total	32	31	23	23	53

THE NUMBER OF DEFENDED PHD THESES

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
	Total	Total	Total	Total	Total
Ecology	1	1	-	-	1
Analytical Biochemistry	-	1	-	1	3
TLU Total	12	23	16	25	19

2.2. Strengths and areas for improvement of study programs by assessment areas

The Evaluation Committee has combined the general strengths and improvements for both PhD study programs in this section because the interviews with the various representatives (i.e. senior leadership representatives of the university and faculties, faculty involve in program management, academic staff (including supervisors), students and alumni). These general comments refer explicitly to 'resources', 'Teaching, learning, research and/or creative activity', 'teaching staff' and 'doctoral students'. Specific comments on these topics and other comments are presented and discussed in the sections on the specific PhD-study programs.

Resources

Comments

The lack of a critical number of students within the current broad areas of subject matter, and to find synergy, is the major concern. The Evaluation Committee is concerned that the wide range of subjects in both programs for so few supervisors lacks the levels of concentrated efforts to be competitive. There are notable exceptions to this over-arching claim, with some very productive investigators, however we see this as isolated cases. Although the numbers of supervisors is small, as is the numbers of students, the breadth of subject matter is too broad to be sustained. The university has solved the problem by having co-supervisors from other countries, in the extreme cases of the complete outsourcing of supervision.

The subject of PhD student stipends has been much addressed elsewhere in this report. The level of present national stipend threatens the viability of PhD programs generally. At present, the PhD student must supplement their wages with either funding from projects or from outside labour agreements, at times unrelated to their studies. Moreover, the student join laboratories which do not have project money to support students nor the execution of experiments through bench fees, or reagents.

The career trajectory and perspectives of PhD graduates for all universities examined by this Evaluation Committee are inadequately addressed. The focus of the PhD studies is on the production of 3 papers for graduating, and hence scientific research is of primary important, which it should be. International networking was witnessed at the student level, but is seemed more out of necessity, as the local supervisors did not match well with the interests of the students.

Tallinn University does seem to place a good deal of emphasis on soft skills offering. The focus on chemistry, as well as ecology would lend themselves to connecting with potential employers, through either students working with companies as part of the doctoral training or having company scientists be physically present and collaborate with laboratories on campus.

Infrastructure was generally of a good quality, with modern buildings and modern scientific equipment. Although, the continuous renewal of instrumentation to stay current and competitive seems not to be considered.

The Evaluation Committee understood that the general availability of resources for foreign travel was adequate. The access to scientific literature and databases is ensured by the national government, and we were informed that all literature is available.

In its present form, the programs are probably not sustainable. To start the selection of PhD students is not always matching the supervision offered. The students are of course attracted to the program because they can formulate their own thesis topic, however this does not guarantee sufficient supervision. As a consequence supervision is at times, outsourced to other universities internationally, which brings little to the program overall.

Strengths

- Modern infrastructure;
- Individual and flexible approach;
- Good access to literature and databases; and
- Start to develop collaborations with enterprises.

Areas of improvement and recommendations

- The Evaluation Committee recommends that the **student income (stipend combined with salary) increase to levels of Estonian average salary** should be enforced through an institution-wide policy to guarantee PhD students income through to their study completion;
- The Evaluation Committee recommends that **the levels of networking with other scientists, research industry actors, or other future employers needs development**, both at the student and supervisor levels. International networking was witnessed at the student level, but is seemed more out of necessity, as the local supervisors did not match well with the interests of the students;
- The Evaluation Committee feels that the opportunity to **strengthen relationships with industry will need more effort, and should prove worthwhile**. We recommend the establishment of program track to develop entrepreneurship skills in ecology, which should fit with a strength in the program and a societal need. It would be good to foresee funding for practical replacement of PhD students into industry;
- The Evaluation Committee recommends that **an infrastructure planning committee be formed at the university level**, to formulate a strategy after identifying the areas which should have priority for renewal. The planning of equipment renewal is important, however priority should be given to restructuring the program, and have the equipment purchase align with the new strategy;
- The Evaluation Committee recommends that the university and the both programs **formulate an identity, to develop a brand and niche to be competitive**. Once this niche is found, it can be used as an advertising tool to recruit students. The sub-critical mass of personnel, and broad subject areas, needs a re-thinking. The investigators must find complementary in order to attract PhD students, and to develop a profile nationally and internationally, and to compete for grants. One notion, could be to find the areas of interdisciplinarity from the existing faculty, and put small institutional money there to develop co-supervision of PhD students. This interdisciplinary or focus areas, should align with current and important future growing areas of science;
- The Evaluation Committee strongly suggests that **the life sciences programs develops a business plan for the next 5-10 years and examines the different financing scenarios**. Relying on the national government to sustain this program, is not a viable option. Some alternative revenue sources should be found. This is a departure from traditional funding streams. The business case must be considered seriously, and possibly by a business faculty or professional organisation; and
- The Evaluation Committee encourages the university to **strengthen its research administration office with a centralized grant office handling, for example, EU and ERC calls**. This effort should encourage more submissions for funding to off-set the trend of low national financing of Estonian science.

Teaching, learning, research and/or creative activity

Comments

A main challenge is critical mass, with small cohorts of students enrolling on the program. Overall, the program shows good practice in terms of teaching, learning and research, with regular self-evaluation and opportunities to gather, reflect on and act on feedback from students with respect to the quality of supervision and other aspects of students' experience. Perhaps reflecting the small size of the program, relations with industry and the labour market, and public engagement activities, are less well-developed than for PhD programs in other Estonian universities. Some students interviewed by the Evaluation Committee expressed concern that parts of the study program were general topics that

were not necessary or helpful, but this was not a view shared by all students. The process for managing any disagreements between students and their supervisors appears to work well.

Strengths

- The programs are well-organized with a friendly, 'family' atmosphere linking students and staff at all levels;
- Despite (or perhaps as a result of) the relatively small size of the programs, there is a high degree of interdisciplinarity and overlap in research activities between groups spanning Ecology and Analytical Biochemistry, linked by a common set of analytical techniques;
- International study and research placements are encouraged and well-supported; many students spend valuable study periods in leading international research-intensive universities;
- Presentation of research findings at international conferences is encouraged and facilitated; and
- International expeditions have been valuable in generating links to foreign researchers and widening PhD student perspectives.

Areas of improvement and recommendations

- The relatively small size of the program can lead to academic isolation, for both PhD students and their supervisors. To overcome issues of critical mass, **additional steps could be taken to build cross-cutting, joint initiatives with other Estonian universities**, especially with the neighboring Tallinn University of Technology through, for example, shared seminars and training or Knowledge Exchange activities; and
- Feedback to students from the Annual Progress Review is oral rather than in writing. This limits opportunities to formalize the process and to monitor progress each year towards rectifying gaps or limitations. The program should consider **introducing processes and paperwork that make the evaluation process less focused on meeting quantitative criteria, and more formative, seeking to monitor and enhance the research progress of individual PhD students.**

Teaching staff

Comments

The Evaluation Committee's interviews with staff showed a very positive and dedicated attitude towards PhD students and science. The management has a clear vision of the evolution of the program and is well aware of its difficulties. Taken together, interview with staff reflected both the quality and commitment of individual members as well as clear rules and operative procedures at the institutional level.

The rules for teaching staff at the PhD level are clear and well in line with international standards:

- All PhD supervisors must have a PhD themselves and have an independent research experience that follows their thesis work and is attested by at least three research articles. Furthermore, any first-time supervisor has to start as a co-supervisor; and
- The self-evaluation report's annexes provide useful information and links to the PhD supervisors' webpages that contains their CV, publications, research projects and activities. From this, the above-mentioned rules are certainly well followed: the staff delivers PhD courses well within its research field and is also active and publishing in the field when supervising PhD students.

The structural reform that took place since 2015 was described to have positive effects to strengthen the research and its funding, while the only potential risk that was cited was the increase in administrative burden that would detract from hiring and supervising PhD students.

The staff number for this programs is 14 members. This is well in line with the rather limited size of the program and somehow may limits the diversity of courses. As already mentioned, a potential weakness is that this rather small number is paralleled with a wide diversity of thesis subjects within the field. The average age for the staff is 52 years old, and age distribution is evenly spread between 69 and 34 years. 5 staff members are born in or before 1958 and consequently there will be a need to renew a significant part or the staff. This requires to secure both the financial instruments and to define a very strong policy.

Finally, PhD supervisors are assessed every year by an interview and every five years through a more formal evaluation. Those review different topics (research, supervision, mobility etc.) and staff is offered different actions for improvement (e.g. an annual course for PhD supervision).

Numerous PhD students have supervisors at other universities abroad, which is a positive aspect; frequently these links and networks are initiated by the students. Tallinn University then provides the infrastructure for a PhD student's work, although many students also spend extensive periods embedded within international research groups abroad. The Evaluation Committee were pleased to see that PhD studies are incentivised and encouraged by a strategy to pass on 100% of the Doctoral Performance Reward to individual units, and to give units the freedom to pay performance-related rewards to supervisors of graduating PhD students.

Strengths

- Appropriate training opportunities are in place for PhD supervisors, including training relating to course design and supervision skills; and
- Laboratories are well-founded, with the latest equipment and facilities.

Areas of improvement and recommendations

- There are negative outcomes and potential conflicts between students and supervisors in terms of quality and quantity of papers. The Evaluation Committee recommends that **quality and impact of papers should trump quantity and that more flexibility is introduced in applying the '3-paper rule'**.
- The institution should develop a mid-long term strategy to expand the staff number. It may also reinforce its collaborations with other Universities to expand the repertoire of dedicated courses and of PhD subjects.

Doctoral students

Comments

The Evaluation Committee learned from the site visit and discussions, that generally the PhD students are very satisfied and content with their studies. They feel freedom in making their own choices (both in terms of research as study curricula). In addition, the relationship between supervisors and their PhD students have proper and stimulating dynamics. Students are able to spend adequate time abroad and the funding for this can easily be obtained (even though more students should be encouraged to spend time abroad in different laboratories and research groups).

When students are admitted to a doctoral study, their suitability for successful completion of their studies is adequately assessed using transparent criteria. The accepted PhD students can plan their studies and research and development activities. Also, PhD students teaching and research activities at the university support successful completion of their doctoral studies and students are probably not overloaded with too ambitious tasks.

Strengths

- Satisfaction of students with their study programs;
- Feel of freedom in making their own choices; and
- Easily available funding to spend adequate time abroad.

Areas of improvement and recommendations.

- Several general issues should be addressed in future. Specifically, the too high dropout rate is a major problem. This is an issue at all of the programs and generally at all PhD studies in Estonia. The Evaluation Committee's discussions with students and other representatives showed that dropout is caused by combined factors, such as economic constraints, motivational problems and family issues (e.g. starting a family). Although dropout rates are high, the available university statistics do not clearly indicate in which years this happens. **Therefore the PhD program should monitor this in more detail to address the cause and better cope with this challenge;**
- The Evaluation Committee also recognized a potential weakness for future research development and PhD-student support. This involves the lack of strong research groups and very fragmented research activities. More excellent research groups that incorporate PhD students, could create a better environment for sharing ideas, multidisciplinary and interdisciplinarity, and especially through more inspiring daily interactions. This could also lower the PhD-student dropout rates and simultaneously create better motivated PhD students;
- A specific problem is the feedback survey from the PhD students. This survey has a very low response rate because it probably is too long and too complicated. Therefore, the **feedback survey should be reorganized to increase response rates and to receive better and representative reactions** to effectively deal with immediate emerging issues. Asking appropriate and timely questions is a difficult balancing act, but creating specific questions with a clear objective should not be too complicated;
- The current process of attestation could also be improved. Attestation should not only be a formal process; it should also focus on research progress and encouragement of the students with their future ambitions in mind;
- Other issue is the number of PhD students, which are currently very low. A clear vision on increasing the number of PhD students should be developed. The current number of PhD students is too low to create a critical mass. **Activities to stimulate applications should be organized to increase the number of PhDs;**
- **PhD students should be trained to improve their attractiveness at the labour market outside academia.** They currently see their future only in academia and the majority find it hard to imagine moving outside of academia. However, after their graduation only a few (i.e. approximately 20%) will be able to find a tenured position in University research and education. Therefore, they need to be better prepared to also apply for jobs in business and industry, NGOs and governments. Such training can contain involve teaching soft skills, leadership and entrepreneurship skills and presentation skills. This will broaden the PhDs' attractiveness for sectors outside academia. Additionally, if more PhDs work outside academic, this will enhance connectivity with, for example, the industry and could well lead to the development of collaborative programs with internships, trainees and maybe even additional PhD funding;

- **Such training should also enhance entrepreneurship.** Its importance is currently generally underestimated at universities. PhDs students should have more opportunities to develop more knowledge and skills that are essential for entrepreneurship. This could help them in creating new business opportunities, which could be supported by the university through the creation of business incubators, start-ups and spin-off companies; and
- Generally, the research activities of PhD students are of a very high quality. However, questions were raised on the criterion of three published papers before a PhD student can defend her thesis. Several PhD students believe that this often lead to three smaller, less significant research papers rather than one major high-impact paper in a renowned international journal. Therefore, **adhering to this 'three-published-papers' criterion must be revisited** by the PhD program and the university.

2.3. Strengths and areas for improvement of study programs for study program 'Ecology'

Comments

Tallinn University is a young institution and the Ecology program is particularly small in terms of student enrolment, resulting in a unique environment for doctoral students. Historically, Tallinn University has done little to encourage applicants to PhD programs from overseas, but the Evaluation Committee was pleased to see that this is changing. While most PhD students are still drawn from continuing masters students previously enrolled at the university, steps are being taken to enhance recruitment of students internationally. The Evaluation Committee was pleased to note that a regular program of feedback collection from PhD students has been introduced recently; however the small numbers of students on the programs and the low response rates to surveys makes it difficult to draw firm conclusions about student satisfaction with respect to individual programs (as opposed to general levels of satisfaction across the university).

Despite its name, the Ecology Program includes supervisors and students whose research areas fall outside the tradition disciplinary definition as it conventionally is defined, including (for example) hydrology, mineralogy and other non-biological aspects of environmental science.

Strengths

- The program was particularly praised by students for its flexibility; students have substantial input into the direction and topics of their projects and the university is open to student who arrive with their 'own' project idea;
- The study program has a desirable level of flexibility: individual customized study plans are possible, work well, and are appreciated by PhD students;
- The program makes extensive and appropriate use of overseas co-supervisors, enhancing internationalization opportunities for PhD students; and
- Doctoral students are generally satisfied with the doctoral courses offered.

Areas of improvement and recommendations

- The title of the course as 'Ecology' is a little misleading, since PhD studies include hydrology, mineralogy and other topics that have little or no biotic component. While the title may be seen as relatively important, it does provide a label which stays with a student after they graduate, and may act as a source of confusion in international recruitment. **Consideration should be given to choosing a more appropriate title**, for example 'Environmental Biology' or 'Environmental Science';

- The goal that at least half of the PhD students should complete their studies within six years appears to be insufficiently ambitious. **Additional flexibility around the rules concerning publications (while maintaining standards for award of the PhD) could facilitate a more timely completion of studies;**
- **Provision of courses and materials in English should be enhanced;** and
- **Links to the private sector, and outreach and engagement activities could be strengthened.**

2.4. Strengths and areas for improvement of study programs for study program 'Analytical Biochemistry'

Comments

The aim of this program is to train PhD students to operate in research and industrial sectors that require high-level skills in biochemistry, with a special focus on high-sensitivity analytical chemistry methods and/or high throughput techniques applied to biological samples.

This program started in 2012 in order to give a follow up to the Master program in Molecular Biochemistry and Ecology, for the students who wanted to continue in biochemistry. Its number of students rose from 5 in 2012 to 9 in 2016, for a total of around 360 graduate students at Tallinn University. It admits between one and three students per year and noticeably, no dropouts have been reported since its creation. Between zero and one thesis is defended per year.

The self-evaluation report is very well written and shows that the program is built on higher education standards and governance schemes, that are all available online (e.g. <http://www.tlu.ee/en/university/governance>). The interviews confirmed that higher education requirements are taken very seriously and that the procedures for implementing and assessing the outcomes of the graduate program are well established. PhD research and teaching are conducted in Tallinn University modern buildings, which have limited, but well organized space for the program. The equipment is of good quality. It has been acquired through European Funding and also through University funding, consistent with the aim of the institution to develop its scientific research sector.

The strategic aim of the University for the 2015-2020 Period is to "play a leading role in promoting and developing an intelligent lifestyle in Estonia, thereby supporting both Estonian sustainability and the self-actualisation of individuals." In conjunction with the modest size of the scientific part of this institution, this translates by a strong will to develop interdisciplinarity, to be innovative in teaching and to find a trademark in the way to develop the program. Interview with the vice rector and senior specialist of Doctoral studies confirmed that a large part of this vision is fuelled by the will to shift the University from a teaching to a research-based institution. This is implemented by a structural reform that reduced the number of departments in order to concentrate financial means and created excellence centres aimed at promoting interdisciplinarity. This transition is still ongoing as this University still has most of its activity towards social sciences and humanities. The development of this program mirrors the general aims of the institution: it clearly searches for a niche at the edge of analytical chemistry and biology and while having a limited but consistent course offer, it welcomes very diverse research subjects.

The basis for program implementation is the European 3+2 and ECTS system and follows the regulations for Doctoral Studies (which is one of the rare documents not to be available due to a server problem). Students have to follow 60 ECTS of courses. Those are split between (i) General courses, and compulsory courses aimed at providing skills for the PhD

(identification of research problems in modern and natural exact sciences, research methods in the natural sciences) and (ii) elective courses, the first half being mostly methodological (Language, Public Speaking, Academic Writing...) and the second half being thematic (biochemistry, Analytical chemistry, Separation).

Taken together, the program would benefit from a larger offer of specialty courses: a too large part of the 60 ECTS is used for methodological courses aimed more at developing general skills than at developing a large scientific education on analytical methods. Further implementing the teaching of such methods could help this program to meet its aims at filling an original niche both nationally and internationally.

The next 180 ECTS are provided by the PhD work itself, which is assessed by the PhD defence. To be granted the authorization to implement a PhD subject, supervisors have to ensure that the whole research work will be fully funded for the duration of the Thesis work. Students' recruitment follows an original procedure in which students can propose a research subject of their interest in the field and search for a supervisor. This very unusual manner of elaborating PhD subjects is very much appreciated by the students who feel that they are the actors of their own research. This also tends to attract students with somewhat atypical profiles. On the other hand, this system has two significant drawbacks: (i) As supervisors obtain funding on their own programs, the match between those and the students scientific wishes is not always obvious and (ii) this results in a very broad spectrum of completely different PhD research topics within an unique and rather small PhD program.

One major planned improvement will be to develop a data analysis course. This is extremely important as more and more analytical techniques produce large datasets. They plan also to develop a specific module for natural sciences. Taken together those are important planned improvements but as previously mentioned, developing a larger and innovative course core could be an asset for the future of this program.

The main indicator used to describe the success of this (and other) program(s) is the time required for the completion of a PhD. The goal set is 50% of the students at optimal duration 4 years + 2 years. The logic is that this indicator is articulated with the "rule of 3 published articles for a PhD". Hence if one accepts that this rule warrants the quality of a PhD, then the only pertinent indicator is the time to achieve this goal. However as stated in the general discussion on the PhD programs examined by this Evaluation Committee, this three papers rule is clearly mostly insufficient, especially if a PhD aims at becoming a reference degree out of the academic world. Furthermore, trusting this dispositive exclusively detracts from building a set of key indicators that would help to steer the PhD program.

The proportion of research and/or development of creative activity is said to be superior to 70%. This is well-reflected in the fact that total courses are 60 ECTS out of 240, which leaves 180 ECTS for research. The Evaluation Committee also notes that a large part of these 60 ECTS courses is aimed at providing skills for the students' self-expression, choice of problems and scientific creativity. Taken together, this reflects the large focus that is placed on creative research at the level of the institution. As commented elsewhere, this could be reinforced by a limited set of high-level speciality courses.

The internationalisation of doctoral studies has been notable due to funds that support the mobility of PhD students (e.g. the European Social Fund's Doctoral Studies and Internationalisation Program (DoRa) and the Kristjan Jaak Scholarship programme). The persons in charge of the program are clearly making a very good use of the graduate school system, while they are in the meantime actively committed to participate in its actions.

The self-evaluation report is very clear on the programs ambition to develop transverse skills such as leadership and teamwork. This is clearly supported by the strong accent placed on corresponding courses in the program. From the interviews, it appeared that students are very lively and nice and seem to be very well motivated in particular due to the fact that they had the responsibility to propose their own subjects and therefore feel very engaged in their research. This self appropriation of the PhD research project is very interesting in terms of assuming its leadership. Teamwork is not facilitated by the diversity of the subjects but can be enforced by the use of common equipment core and the common participation to high level teaching modules.

Coaching and teaching skills are developed through specific courses but also through the fact that the laboratories are concentrated and that the students have the opportunity to interact with undergraduate students.

English is taught in the module "English for Academic Purposes". Furthermore, students have to present their work each semester at a PhD Thesis seminar and at least one of these seminars has to be in English. Furthermore, the final defence has to be in English as well. Students are also exposed to English when attending the different doctoral school events. Taken together, the need for scientific English appears to be well implemented within this program.

Taken together, the different components of a doctoral program form a coherent whole with an inherent logic that takes into account the specificities of the institution. The limited scientific perimeter is however impacting the program by limiting the critical mass of students and staff. This leads to a limited proportion of highly specialized courses and to some dispersion of PhD subjects.

Feedback on PhD progress

Tallinn University organizes regular surveys for PhD students. As an example, the self-evaluation report contains a very well detailed analysis of feedback results from 2016/2017. The general responses were that a quarter of the students participated. This is not representative but in line with the general percentage. The results of this survey are presented in a very compact but yet comprehensive manner in the self-evaluation report. The main points are:

- A general satisfaction of the student with their PhDs;
- A strong motivation toward self-development and positive experiences with the different aspects of a PhD student's life (research, interaction with fellows and staff, publication, conferences, summer and winter schools, international mobility);
- Negative feedback concerning the teaching, both pertaining to the general subjects that did not seem to feed their needs and for completion and other courses and quality of some lecturers; and
- The length of the PhD, in conjunction with the poorly paid PhD allowance and the economical, personal and familial constraints that it produces.

Taken together the feedback system for collecting and analysing information is therefore functioning in a satisfactory manner. This points however to the need for a large change in the courses of the study programs, which might be difficult to operate with a small critical mass of teaching staff.

These conclusions were largely echoed during the interviews with the students who provided a rather mitigated feedback on the usefulness and / quality of some courses, while they appreciate the dedication of supervisors. In the meantime the course University Practice uses teaching methods that include interdisciplinary projects that should be

supervised by the students themselves and problem-based learning. This effort should be further continued and supported at all University levels.

Doctoral students must pass a progress review once during the academic year. The review committees are well in place and fully operative but both reading of the self-evaluation report and interviews highlighted the fact that these committees are still too formal and not enough science driven. Students would strongly benefit of presenting data in a format that would allow scientific discussion as well as suggestions and constructive criticisms by the Evaluation Committee members.

Strengths

This PhD program takes place in Tallinn University, which is reinforcing its orientation towards science. It is very focused on biochemistry with a strong expertise in analytical chemistry applied to biology and to molecular biology. It dispenses both transferable and disciplinary courses and uses the different possibilities of additional courses and internationalization offered by the Estonian graduate schools. The research strongly involves the students who have a large latitude to choose their PhD research subject that they will implement in the University laboratories. The strengths include:

- A very strong motivation to implement a PhD program together with transforming the institution into a scientifically active place;
- A clear view of the situation and of the aims that leads to logic of niche and original actions;
- No reported dropouts within this program;
- Clear rules that are shared at the level of the institution;
- The laboratories are limited but appear to be active and well-equipped;
- A very good potential for connections with the industry;
- Very good use and participation to the graduate school actions; and
- Opening to public: weekly seminar institutes, a YouTube channel for popular sciences.

Areas of improvement and recommendations

- The number of PhD students is limited;
- The possibility for the students to choose their PhD leads to some dispersion in an already undersized program (both from self-evaluation report and Interviews);
- The rule of three published articles for a PhD that limits scientific ambition and quality;
- As seen both from the self-evaluation report and the discussion with students, **more specific courses should be added to make the students more motivated and more competitive**. In particular the future data treatment course should be available rapidly;
- Assessment of PhD progresses should be more open and science oriented; and
- **Connections with the alumni and the socioeconomic sector should be enhanced and made more operational**, in particular as this program has obvious opening towards the private sector (Both from self-evaluation report and Interviews).

3. Assessment report of Study Program Group at Tallinn University of Technology

3.1. Introduction

The formation of Tallinn University of Technology (TUT) can be traced back to 1918 when the Estonian Engineering Society opened an engineering school called 'Special Engineering.' Qualification of the university was granted to 'Tallinn University of Technology' in 1936. The status of a university, in public law, was granted in 1995 by the Universities Act. The role of TUT in the Estonian education and research landscape, as well as the institutional management structure, was defined in the 'Tallinn University of Technology Act', effective from 1 September 2014. TUT is recognized as a research university, providing research-based education at all cycles in the areas of natural and exact sciences, engineering, manufacturing and technology, social sciences and in related areas. The PhD students benefit from studying at TUT as 'the leading engineering R&D institution in Estonia', building on two decades of transformation from a focus on the academic formation of engineers to a research-active institution, underpinned by a clear strategy. The strategic aims for 2020 include three main goals:

- Internationally outstanding university of engineering and technology, responding actively to the needs of the rapidly developing society;
- Being involved in tackling the challenges of the digital era; and
- Contributing to knowledge and welfare in the society through cooperation between the university, enterprises and the public sector.

The Life Sciences study program group consists of one doctoral study program – Chemistry and Gene Technology. Chemistry and Gene Technology study program is managed by the School of Science. The nominal period of studies is 4 years (240 ECTS).

In academic year 2016/2017 there were 644 doctoral students in TUT, of which 99 studied at the Life Sciences study program group. TUT accounts for 27 % of all doctoral students in that study program group in Estonian universities.

During the last 5 years the number of PhD students studying on the Chemistry and Gene Technology program has been decreasing from 114 in 2012 to 99 in 2016.

THE NUMBER OF PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	working at TUT								
Chemistry and Gene Technology	114	42	104	39	103	35	105	28	99	32
TUT Total	794		782		762		737		644	

THE NUMBER OF FOREIGN PHD STUDENTS

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
Chemistry and Gene Technology	3	4	4	5	8
TUT Total	55	62	93	107	112

THE NUMBER OF ADMITTED PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	Directly from TUT	Total	Directly from TUT						
Chemistry and Gene Technology	11	9	14	10	16	15	13	10	15	9
TUT Total	128		122		117		112		71	

THE NUMBER OF PHD STUDENTS DISRUPTING THEIR STUDIES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	on one's own will								
Chemistry and Gene Technology	9	5	10	5	10	6	4	3	12	8
TUT Total	78		75		91		76		97	

THE NUMBER OF DEFENDED PHD THESES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	within 6 years								
Chemistry and Gene Technology	9	7	13	6	10	6	7	3	12	9
TUT Total	67	49	54	32	57	39	62	41	75	53

3.2. Strengths and areas for improvement of the study program by assessment areas

Resources

Comments

The ratio of supervisors to students is very good by Estonian and international standards. On average there about three students per supervisor, which fairs better than other life sciences programs seen by this Evaluation Committee. With this arrangement, adequate supervision can be achieved, with sufficient interaction among the students. Moreover, the organisation of laboratories having complementary scientific areas of specialization, enhances the potential for collaboration within the university. Laboratories are active and productive, with good potential to further critical mass.

The subject of PhD student stipends has been much addressed elsewhere in this report. The level of present national stipend threatens the viability of PhD programs generally. The Tallinn University of Technology has encouraged the policy of ensuring that new PhD students accepted to the life sciences programs should be supplemented in their stipends up to Estonian average salary.

The focus of the PhD studies is on the production of 3 papers for graduating, and hence scientific research is of primary important, which it should be. Nevertheless, the career

trajectory and perspectives of PhD graduates for all universities examined by this Evaluation Committee are inadequately addressed.

The university is open, and very positive about entrepreneurship, and could be very amenable to connecting with solutions for societal challenges. The university has pointed out that they have a strategy to encourage PhD students to take research subjects from industry.

The infrastructure and instrumentation of the University was at an excellent level. Critical mass of the laboratories was very good, with the area for improvement being the recruitment of foreign post-doctoral fellows. As to the sustainability of infrastructure, it was understood as an important challenge, and stated that it was being looked into, but without details. The university seems to operation from a very centralize and systematic manner, to ensure tracking of resources and distribution of financing across laboratories. Also, open access principles were applied to the equipment usage.

The Evaluation Committee understood that the general availability of resources for foreign travel was adequate. The access to scientific literature and databases is ensured by the national government, and we were informed that all literature is available.

Strengths

- Modern infrastructure;
- The ratio of supervisors to students is very good;
- Critical mass of the laboratories is very good; and
- Developed collaboration with enterprises.

Areas of improvement and recommendations

- The Evaluation Committee recommends to **develop the laboratories further through the recruitment of post-doctoral fellows from abroad**, which would enhance the PhD student experience, and potentially the level of scientific impact.
- The Evaluation Committee recommends that **the levels of networking with outside scientists, research industry actors, or other future employers needs development**, both at the student and supervisor levels. Increased international networking need attention and will raise the profile of the institute, leading to more invited talks, and common grant applications;
- The Evaluation Committee recommends that **the development of skills for entrepreneurship is much needed, and would require, beyond networking, an examination and re-structuring of coursework** to be more impactful. It was noted that some soft skills courses were offered, but were sometimes too time consuming for the value generated. It would be good to foresee funding for practical replacement of PhD students into industry;
- The sustainability of infrastructure was understood as an important challenge. During the interviews, it was stated that this was being looked into but without details. The Evaluation Committee recommends that **a central infrastructure planning committee is established to help track demands for new equipment purchases**; and
- As the university is moving to greater levels of internationalization, including the **steps of recruiting faculty from abroad, some process changes, such as a tenure track system, will need implementation**. These will include the systemization of the career track for the supervisors and faculty, which will demand criteria for the determination of promotion or termination. With new outside supervisors joining, a clear start-up package must be stipulated with rights to the supervision of students and access to teaching classes. The university should further establish a space (laboratory and office) allocation and planning committee for changes in research demands. Along

the points of internationalization, a seminar series with outside speakers will enhance the community within the programs. It has the added benefit of increasing the prospect of international collaboration. The levels of outside collaboration is below what would be expected for the level of scientific quality Tallinn University of Technology produces. An increase in international networking will also help graduates find their next positions, and encourage increased participation within the EU framework program.

Teaching, learning, research and/or creative activity

Comments

The progress of PhD studies and projects is followed in research group meetings and seminars, regular departmental seminars, and more formally, at an annual meeting of attestation committee, where the students give a presentation of their project and progress to an attestation committee. The procedures regarding the roles and responsibilities of the supervisor and the attestation committee are currently being revised in TTÜ (for more stringency in setting of goals and monitoring of progress; self-evaluation report, p. 15). All 59 PhD theses defended between 2012 and 2017 have had two opponents, at least one of them stems from abroad.

The program offers a possibility to do an 'industrial PhD' in which the research work performed in private companies and connected with or integrated in real R&D projects. Student pursuing industrial PhD have a local supervisor in the company but are subject to the academic standards applied to 'normal' doctoral degrees. This study track is clearly popular. The Evaluation Committee, for example, met with one former student, who did an industrial PhD and was satisfied with it. This is an excellent example of a good practise or policy that also helps to build bridges between academia and industry.

Three publications are required for the PhD Thesis. This strict policy often leads to unnecessary extension, and sometimes even cessation, of doctoral studies. In the discussions the Committee had with the supervisors, students and alumni, the majority regarded the three-paper rule as too rigid and as an impediment rather than asset in the doctoral studies, although there was also a minority view supporting the policy as a guarantee of quality. A large number of doctoral students have continued their earlier Bachelor's and Master's studies in the doctoral program, most often in the same research group. As a result, they may well have already one article (or even two) published when starting their doctoral studies. While this may alleviate the problem arising from the three-paper rule, it puts students who come from outside of TTÜ at disadvantage and does not encourage recruitment of doctoral students from elsewhere in Estonia or from abroad.

Representatives of students, alumni and employers were satisfied with the scientific training obtained in the program but also stressed the importance of having international experience and generic and soft skills not directly related to research for employment outside the University.

Strengths

- The doctoral students are well-integrated in scientific research;
- Industrial PhD provides an excellent way to build closer ties with private companies;
- Clear protocols for feedback and progress review have been established.

Areas of improvement and recommendations

- **The strict requirement of three publications for the PhD thesis needs to be reconsidered.** The Committee recommends that this rule should be abandoned and replaced by alternative, more flexible policy to ensure the quality of the degrees and fulfilment of expected goals of doctoral education;

- A majority of students see their future in academic research only with little consideration of other possibilities. **Introduction of career planning and more 'soft skill' courses in the formal studies and development of internships outside the University (companies, government agencies) are possibilities which could give the students a wider view of prospects outside the University** and increase the societal impact of the program; and
- There is very little competition for student positions. **More active recruitment of students from outside of TTÜ and from abroad would attract more talent** to the program.

Teaching staff

Comments

Research conducted in the laboratory and under supervision of an officially nominated supervisor, selected on the basis of academic performance, earlier success in PhD training and number of current doctoral students. The supervisors are active scientists, generally at internationally competitive level and reasonably funded and connected to other research groups in the University and elsewhere in Estonia and abroad. This ensures a productive and supportive environment for the students' research projects. Often the supervisors hold positions of professors in the University and give lectures. All 18 teachers/lectures (self-evaluation report, Appendix 2) in the study program have PhD degree and most of them are professors or associate professors at TTÜ. Most teachers are also active in scientific research. The number of younger and foreign teaching staff is quite low: average age is 61 years, and all lecturers employed by TTÜ are Estonian (self-evaluation report, Appendix 2), although foreign scientist are actively used as opponents in the PhD defences.

TTÜ supports the development of pedagogical and supervising skills of the staff by offering courses on these topics. Feedback on the teaching and supervision is collected in systematic fashion through an on-line system (courses) and annual review meetings (research), and analysed in discussions with the program director.

Strengths

- There is a friendly and collegiate atmosphere among the staff;
- Supervisors and teachers are active scientists pursuing high quality research in their respective fields;
- Development of staff's skills in supervision is supported by the University; and
- Doctoral students become integrated in the program and gain valuable experience by teaching and supervising undergraduate students.

Areas of improvement and recommendations

- For long-term vitality of the program, active recruitment policy is needed. The Evaluation Committee recommends that recruitment policy should focus on younger scientist and on international recruitments.

Doctoral students

Comments

The Evaluation Committee generally found that the PhD students are very satisfied and content with their study programs. They feel freedom to make their own choices (both in terms of research and study curricula). In addition, the relationship between supervisors and their PhD students has proper and inspiring dynamics. Students are able to spend adequate time abroad and the necessary funding is available. (However, even more

students should be encouraged to spend more time abroad and in different laboratories and research groups.)

PhD students, when admitting students to doctoral study, their suitability for successful completion of their studies is assessed based on transparent criteria. PhD students can plan their studies as well as research activities in collaboration with their supervisor and the evaluation of doctoral students is transparent. Also, PhD students teaching and research activities at the university support successful completion of their doctoral studies and students do not seem to be overloaded.

Strengths

- The relationship between supervisors and their PhD students have stimulating dynamics;
- Good sense of internationalization and its importance;
- The quality of research activities is excellent; and
- Students are satisfied and happy with their studies.

Areas of improvement and recommendations

- Several general issues should be addressed in future. The main problem is the large dropout, which actually is an issue for all PhD programs at all Estonian Universities. These high dropout rates cannot be fully explained by the available university statistics. In fact, when and why the dropout actually happens remains obscure (in the eligible length/time or beyond). However, from the discussions with students and other representatives, the Evaluation Committee learned that the high dropout rate is caused by combination of interacting factors, such as economic issues, motivational problems and family issues (i.e. starting family). Coping with such complexities can be difficult but should be tried. **Therefore the program should analyze the dropout cause more in detail to better cope with this challenge;**
- **PhD students should be trained to improve their attractiveness at the labour market outside academia.** They currently see their future only in academia and the majority find it hard to imagine moving outside of academia. However, after their graduation only a few (i.e. approximately 20%) will be able to find a tenured position in University research and education. Therefore, they need to be better prepared to also apply for jobs in business and industry, NGOs and governments. Such training can contain involve teaching soft skills, leadership and entrepreneurship skills and presentation skills. This will broaden the PhDs' attractiveness for sectors outside academia. Additionally, if more PhDs work outside academic, this will enhance connectivity with, for example, the industry and could well lead to the development of collaborative programs with internships, trainees and maybe even additional PhD funding;
- **Such training should also enhance entrepreneurship.** Its importance is currently generally underestimated at universities. PhDs students should have more opportunities to develop more knowledge and skills that are essential for entrepreneurship. This could help them in creating new business opportunities, which could be supported by the university through the creation of business incubators, start-ups and spin-off companies; and
- Generally, the research activities of PhD students are of a very high quality. However, questions were raised on the criterion of three published papers before a PhD student can defend her thesis. Several PhD students believe that this often lead to three smaller, less significant research papers rather than one major high-impact paper in a renowned international journal. Therefore, **adhering to this 'three-published-papers' criterion must be revisited** by the PhD program and the university.

3.3. Strengths and areas for improvement of study programs for study programs 'Chemistry and Gene Technology'

Comments

The study program of Chemistry and Gene Technology is housed by the School of Science. The content and development of the program are in line with national laws and regulations and with University-level documents (e.g. "Strategic Plan of Tallinn University of Technology", "Academic Policies of TTÜ" and "Good Practise of Doctoral Study in TTÜ").

The program is strongly research-oriented and aims at doctoral education at high international level. Formal studies account for 60 ECTS, while the individual PhD Thesis research project amounts to 180 ECTS (75%) of the 240 ECTS doctoral degree. The courses have clearly defined goals and expected study results consistent with doctoral education in the field of life sciences. The three specialization tracks include gene technology, chemistry and molecular medicine, which share modules of general PhD studies (8 ECTS) and University teaching methodologies (10 ECTS), to provide the students with some general skills beyond the otherwise science/research-based curriculum.

The total number of students was 99 in 2016, which includes 8 international students. The annual drop-out rate is around 10 %. One quarter of students (23 out of 99) have participated in international conferences and courses in 2016 (self-evaluation report, Table 3), supported by grants available from Dora, Kristjan Jaak and other sources. The program has also international students, 8 in 2016 (out of 99). Feedback on the courses and study environment is collected regularly by using an on-line system (ÕIS) and has been generally positive; for example, satisfaction with the organization of courses was graded 4.7 in the study year 2016/2017 (self-evaluation report, Table 4; scale 1-5). Feedback on research supervision is obtained in annual meetings of the review committee.

Strengths

- The program has a clear structure and content and policies that support successful conduction of doctoral studies;
- The students are generally satisfied with the organization and content of the study program;
- The doctoral students receive good training in research in internationally competitive research environment; and
- The student participate in international mobility.

Areas of improvement and recommendations

- The number of international students is low, at least partly due to scarcity of teaching in English. The international dimension of the study program could be strengthened by offering more courses in English.

4. Assessment report of Study Program Group at Estonian University of Life Sciences

4.1. Introduction

The Estonian University of Life Sciences (EMÜ), one of six public universities, was registered as a public legal entity in 2003 and the current name dates from 2005. The university origins date back to the Tartu Veterinary School of 1848. EMÜ is the only university in Estonia providing higher education in agriculture, veterinary medicine and forestry. The main field of activity is research concerning bio-economy and the studies based on this research. The research focuses on serving the society and increasing its competitiveness by promoting innovation in all of the interdisciplinary fields related to rural life, the rural economy, sustainable use of primary resources and preservation of the environment. To this end the University promotes collaboration in six focal areas – agriculture, environment, forestry, food and health, engineering and technology and rural economy. Today, the University comprises five R&D institutes.

The doctoral program in Environmental Sciences and Applied Biology (ESAB) belonging to the study program group of Bio- and Environmental Sciences was approved by the EMÜ Council on March 17, 2005. The curriculum has been led by Prof. Kalev Sepp since the beginning. The doctoral program is administered by the Institute of Agricultural and Environmental Sciences. The nominal period of studies is 4 years (240 ECTS).

EMÜ accounts for 17% of all doctoral students in the Life Sciences study program group in Estonian universities.

During the last five years the number of PhD students studying at the program Environmental Sciences and Applied Biology has been stable (i.e. between 59 and 62 students). The number of those working at the university and at the same time studying has been fluctuating between 49-61%. The number of international students increased from 6 in 2012 to 22 in 2017. The number of students in the ESAB study program constitute a quarter of EMÜ's doctoral students.

During the last five years 19 theses have been defended, 53% of them (10) within 6 years (nominal period of studies plus 2 years). According to the statistics, each year 2 to 6 PhD students of the study program group disrupt their studies.

THE NUMBER OF PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	working at EMU								
ESAB	59	36	55	27	55	24	57	28	59	29
EMU Total	216	130	216	130	219	116	216	104	214	102

THE NUMBER OF INTERNATIONAL PHD STUDENTS

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
ESAB	6	7	11	14	19
EMU Total	19	21	25	28	38

THE NUMBER OF ADMITTED PHD STUDENTS

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	Directly from EMU	Total	Directly from UT EMU	Total	Directly from EMU	Total	Directly from EMU	Total	Directly from EMU
ESAB	5	3	6	5	8	3	8	5	8	2
EMU Total	25	19	33	24	31	20	29	20	35	22

THE NUMBER OF PHD STUDENTS DISRUPTING THEIR STUDIES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	on one's own will								
ESAB	4	2	3	0	4	2	2	1	6	2
EMU Total	12	7	15	5	14	3	27	7	15	4

THE NUMBER OF DEFENDED PHD THESES

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total	within 6 years								
ESAB	7	4	7	6	4	2	2	0	3	0
EMU Total	18	10	20	12	13	5	17	8	16	5

4.2. Strengths and areas for improvement of study programs by assessment areas

Resources

Comments

With respect to the numbers of supervising staff for the PhD students, there is an adequate number of research supervisors which covers a broad spectrum of fields within the life sciences area. The overall levels of doctoral students for the numbers of supervisors is however insufficient to support a critical mass of engaged research activity within some laboratories. An additional concern is the in adequate interactions between the research groups. The closer the physical location of laboratories with complementarity would enhance the potential for collaboration. The critical mass within given laboratories and by extension the entire PhD program is impacted by the numbers of skilled personnel, but particularly by the level of speciality-trained individuals to sustain a laboratory's technical capabilities and dispersed know-how.

The availability of international investigators with access to PhD students is very much welcome, bringing in outside perspective. Moreover, some of the supervisors were highly cited, including those which have ERC grants. The case can be made for **pockets of excellence** being found with the life sciences program, an effort should be made to build on this success in a more systematic manner.

The subject of PhD student stipends has been much addressed elsewhere in this report. The level of present national stipend threatens the viability of PhD programs generally. At present the PhD student must supplement their wages with either funding from projects or from outside labour agreements, at times unrelated to their studies. Moreover, the student join laboratories which do not have project money to support student nor the execution of experiments through bench fees, or reagents.

The career trajectory and perspectives of PhD graduates for all universities that were examined by this Evaluation Committee, are inadequately addressed. The focus of the PhD studies is on the production of 3 papers for graduating, and hence scientific research is of primary importance, which it should be. However, the levels of networking with other scientists, research industry actors, or other future employers needs development, both at the student and supervisor levels.

The university is open, and very positive about entrepreneurship, and could be very amenable to connecting with solutions for societal challenges. University is pointed out that they have strategy to encourage PhD students to take research subjects from industry.

The Evaluation Committee understood that the general availability of resources for foreign travel was adequate. The access to scientific literature and databases is ensured by the national government, and we were informed that all literature is available.

Infrastructure was generally of adequate quality, with some need for improvement. The evaluation Committee noted that much of the financing is distributed to the chairs of the department, leaving centralized financing at a minimum. This, at times can be seen as a good use of resources, however we did notice that although the university has a clear mission, "Green University" the implementation of this concept was not coherent nor implemented effectively. The Evaluation Committee sees that the overall branding of the university in this light, as a tool, not only from the promotion of students, but also the recruitment of other research personnel.

Maintaining the sustainability of infrastructure is as an important challenge. The current equipment is reasonably modern, the continuous renewal of instrumentation to stay current and competitive is needed. The University of Life Sciences has established a Depreciation Fund, which amount is 250,000 EUR annually. There is the idea to increase the annual amount of the fund to 500,000 EUR. This is the present need for keeping existing infrastructure updated. The University also should have a Development Fund for supporting research initiatives.

Some notable EU grants, such as the ERA Chair, and an ERC Advanced Grant have been awarded. This is an excellent foundation. However, a greater systemization of seeking external money will greatly build on earlier successes, including the promotion of Erasmus and Marie Skłodowska-Curie Actions.

Strengths

- Modern infrastructure;
- Existing groups with very high scientific level;
- Depreciation Fund for updating infrastructure;
- Good access to literature and databases; and
- Good scientific collections.

Areas of improvement and recommendations

- The Evaluation Committee recommends that the **student income (stipend combined with salary) increase to levels of Estonian average salary** should be enforced

through an institution-wide policy to guarantee PhD students income through to their study completion;

- The **levels of networking with outside scientists, research-industry actors or other future employers needs development**, both at the student and supervisor levels. Increased international networking need attention and will raise the profile of the institute, leading to more invited talks, and common grant applications;
- The Evaluation Committee recommends that **the development of skills for entrepreneurship needs improvement**, and would require, beyond networking, an examination and re-structure of course work to be more impactful. An effort to encourage graduates to found companies and NGOs related to life sciences, ecology, and forestry would be welcome. It would be good to foresee funding for practical replacement of PhD students into industry;
- The **building configuration and proximity of the labs need to be more open** (doors and passageways) with personnel situated closer together to encourage interaction. Common rooms (shared coffee rooms etc.) will encourage interaction between people and exchange of ideas;
- The Evaluation Committee sees that the overall branding of the university as 'Green University' as a major tool, not only from the promotion of students, but also the recruitment of other research personnel needs strengthening. **A strategic approach with implementation should be developed** to build on the pockets of excellence. Bring in more PhD students from outside under the label of the 'Green University';
- The University has taken steps to ensure sustainability and updating of equipment. In addition to these steps, the Evaluation Committee recommends that **an infrastructure planning committee is formed** at the university level, to formulate a strategy after identifying the areas which should have priority for renewal; and
- The Evaluation Committee recommends that the Estonian University of Life Sciences needs **to strengthen its centralized grant office**, with the unit handling EU calls at the pre-award level (grant writing etc.) and with software to match scientific expertise with the open proposals. This effort should encourage more submissions for funding to off-set the trend of low national financing of Estonian science. Moreover, many of EU grants come with travel money for bringing in outside speakers to establish a seminar series, and summer and winter school. These activities will help to overcome the fragmentation of scientific activities and bring together a commonality within the Life Sciences programs.

Teaching, learning, research and/or creative activity

Comments

The development and the study process of environmental sciences and applied biology is in accordance with the regulations of higher education in Estonia, the EMÜ development plans and regulations coordinating the study process and curricula development in the University. The procedures for doing a PhD are clear. The Academic Committee reviews on basis of a set academic criteria the different research themes that are suggested by (future) supervisors. The approved themes are published and PhD students are selected and admitted. This means that most students are well linked to ongoing research projects. At the start of the PhD project, each student, in close collaboration with his/her supervisor, develops an individual study plan and, annually, a PhD evaluation and progress report. The PhD study is finalized with a thesis that is defended before an international opponent and an exam committee.

The progress of doctoral studies and the PhD project is followed in research group meetings and seminars and more formally, at an annual meeting of an evaluation

committee, where the students present their progress. Three publications are required for a PhD Thesis. This consequences of this 'rule' are discussed earlier in the "General findings and recommendations" section (Pages 9-11). The Evaluation Committee recommends that **this rule is reconsidered.**

Representatives of students, alumni and employers were satisfied with the scientific training obtained in the program and stressed the importance of having international experience and generic and soft skills not directly related to research to better prepare for employment in governments and society. Several of the alumni developed successful consultancy positions in nature-conservation NGOs and governmental research institutes. However, they also explicitly stated that the university could better respond to their needs, as they often identified research questions or topics, that could lead to fundable, societal relevant and innovative research projects.

Strengths

- The PhD students are well integrated in scientific research projects;
- The PhD student is reasonably well trained for jobs in and outside academia. This is illustrated by the diversity of alumni, and the establishment of small consultant companies by former PhD students; and
- Clear procedures for feedback and progress review are established.

Areas of improvement and recommendations

- Most students see their future in academic research and only few consider other possibilities. **Advice on career planning and more 'soft skill' courses and development of internships outside Academia are possibilities, which could give the students a wider prospects to excel outside academia** and increase the societal impact of the program.

Teaching staff

Comments

Doing research, write a thesis and successfully defend it, requires a strong continuous support of the supervisor(s). When discussing the program with the supervisors, the Evaluation Committee met an enthusiastic and ambitious team, whose members were all extremely motivated to accomplish this. The university leadership also stimulates this by providing small incentives, such as bonuses for each successfully defended PhD thesis, and increasing the quality of the teaching and supervising staff that are active in the program. For example, by 2020 all these staff members should have obtained their own PhD. Thus the university has set clear indicators to improve the academic education within the various programs.

Strengths

- The quality of doctoral studies has been enhanced over recent years due to competition among supervisors and a broad and flexible set of PhD courses;
- Many doctoral students are involved in projects;
- The PhD students' evaluation system is transparent and effective;
- Doctoral students are involved in supervising several BA and MSc students; and
- The program and PhD projects collaborate, if possible, with experts from other universities or organisations.

Areas of improvement and recommendations

- Although all the PhD courses and speciality courses are taught by the teaches with PhD, PhD students have the right to take the optional courses from other levels as well.

The Evaluation Committee suggests that **the staff members are released from other duties to finish their PhD in a timely manner** (i.e. before 2020). This is stimulated by the university now, but the progress towards obtaining a PhD is often too slow; and,

- The program consists of a group of excellent academically trained docents and supervisors. However, this could jeopardize the link to research opportunities outside academia. The Evaluation Committee believes that **the university or/and program management should invest in increasing collaboration with industry and consultancy companies, and (non-)governmental organisations.**

Doctoral students

Comments

The Evaluation Committee generally found that the PhD students are very satisfied and content with their study programs. They feel freedom to make their own research choices. In addition, the relationship between supervisors and their PhD students has proper and inspiring dynamics. Students are able to spend adequate time abroad and the necessary funding is available. (However, even more students should be encouraged to spend more time abroad and in different laboratories and research groups.)

PhD students, when admitted to a doctoral study, are assessed on their suitability to successfully complete their studies based on transparent criteria. PhD students can plan their studies as well as research activities in collaboration with their supervisor and the evaluation of doctoral students is transparent. Also, PhD students teaching and research activities at the university support successful completion of their doctoral studies and students do not seem to be overloaded.

Strengths

- The relationship between supervisors and their PhD students have very good dynamics; and
- Students are able to spend adequate time abroad and the funding for this are easily available.

Areas of improvement and recommendations

- Several general issues should be addressed in future. The main problem is the large dropout, which actually is an issue for all PhD programs at all Estonian Universities. These high dropout rates cannot be fully explained by the available university statistics. In fact, when or why the dropout actually happens remains unclear (in the eligible length/time or beyond). However, from the discussions with students and other representatives, the Evaluation Committee learned that the high dropout rate is caused by combination of interacting factors, such as economic issues, motivational problems and family issues (i.e. starting family). **Therefore the program should better analyze the actual dropout cause to cope with this important challenge.** Coping with such complexities can be difficult but should certainly be tried. In addition, many PhD students (and junior researchers) are starting a families and combining research/study and taking care of small children is challenging. The university (and the PhD program) could support this with providing flexible working hours and, if possible, kindergarten or 'day care' access within the university;
- PhD students feel that their salaries should be better covered by funds from their supervisors' research projects. Receiving additional salary to add to their stipends helps them to achieve an 'Estonian average salary' and maybe could remove an economic cause of the high dropout rate;

- **PhD students should be trained to improve their attractiveness at the labour market outside academia.** They currently see their future only in academia and the majority find it hard to imagine moving outside of academia. However, after their graduation only a few (i.e. approximately 20%) will be able to find a tenured position in University research and education. Therefore, they need to be better prepared to also apply for jobs in business and industry, NGOs and governments. Such training can contain involve teaching soft skills, leadership and entrepreneurship skills and presentation skills. This will broaden the PhDs' attractiveness for sectors outside academia. Additionally, if more PhDs work outside academic, this will enhance connectivity with, for example, the industry and could well lead to the development of collaborative programs with internships, trainees and maybe even additional PhD funding;
- **Such training should also enhance entrepreneurship.** Its importance is currently generally underestimated at universities. PhDs students should have more opportunities to develop more knowledge and skills that are essential for entrepreneurship. This could help them in creating new business opportunities, which could be supported by the university through the creation of business incubators, start-ups and spin-off companies;
- Generally, the research activities of PhD students are of a very high quality. However, questions were raised on the criterion of three published papers before a PhD student can defend her thesis. Several PhD students believe that this often lead to three smaller, less significant research papers rather than one major high-impact paper in a renowned international journal. Therefore, **adhering to this 'three-published-papers' criterion must be revisited** by the PhD program and the university; and
- The PhD students were missing enough freedom in choosing their courses and developing their own curriculum. Moreover, they were dissatisfied with some of the obligatory courses. (Also the self-evaluation report mentions that some of the courses receive lower marks from the students.) Therefore, **students should receive more opportunities to select courses and develop their own curriculum according their needs.**

1.3 Strengths and areas for improvement of study programs for study program 'Environmental Sciences and Applied Biology'

Comments

The study program's content and development are in line with national laws and regulations and with University of Life Sciences' regulations and traditions. The program has from its start in 2005 had a strong multi- and interdisciplinary research-orientation. It aims to train competent, internationally recognized researchers, teachers and top experts in the environment and applied biology. The graduates of the programme are shown competent and skilled to work in universities, research and development institutes, governmental authorities and the private sector, although the latter can be improved.

Formal PhD courses account for 60 ECTS, while the individual PhD Thesis research project amounts to 180 ECTS (i.e. 75%) of the 240 ECTS doctoral degree. The program has many courses to choose from. All these courses have clearly defined goals and expected study results are consistent with doctoral education in the field of environmental sciences. The university promotes a better international imbedding of the doctoral research by actively stimulating participation in and presentations at scientific conferences. This now has

become a compulsory part of the curriculum. Doctoral students are encouraged to participate in international courses or part-time work in a foreign lab and collect at least 18 ECTS for these activities. These foreign visits are supported by the university's language classes. Internationalization of doctoral studies is also promoted by the Doctoral Studies and Internationalization Programme (DORA) and the Estonian inter-university doctoral schools. The Doctoral School of Earth Sciences and Ecology and the ASTRA interdisciplinary doctoral schools are most relevant for this program and they have provided ample scholarships and travel stipends. However, as these inter-university schools largely depend on EU-interregional funds, future continuation of these resources could be jeopardized.

Strongly stimulating international experience is excellent. However, as many PhD students have a job besides their research position (because the current PhD stipend is too meagre) and family responsibilities, going abroad is not always possible. This could be mitigated by increasing the stipends and guaranteeing a research position in a project, which is synergetic with the PhD research.

PhD students also indicated that it sometimes was difficult to participate in necessary courses or seminars due to the lack of child care. Such absence limits the flexibility to choose the most appropriate courses. Establishing a day care at the university grounds could ease the need to discard courses. Having such facility will likely be highly appreciated by many.

The University of Life Sciences has a strong 'green' signature (i.e. agriculture, forestry and environmental sciences) and its Development Plan aims to strongly foster a sustainable and environment-friendly way of living. The University's "Green University" concept indicates that the institution follows the principles of sustainability in all its aspects (i.e. environmental, social and economic). The Evaluation Committee appreciated this vision but when representatives were explicitly asked how this vision was implemented in the study program, few concrete examples emerged. As the program's research focus is extremely relevant for sustainability, the committee therefore recommends that this overarching vision is better incorporated in the program's courses and research. This will also enhance possibilities to link education and research with society.

The program has also relative many international students compared to other programs (c. 10%; pages 13 and 27 of the self-evaluation report) and their number increased towards 30% recently.

The university's leadership indicated that research funding currently is below the EU norm of 1% of GDP. This means that there should be an effective lobby to increase basic funds for the universities. Such increase could also improve the incentives to graduate within the eligible length/time (Figure 1) and lower drop-out rates. For example, this could be done by increasing the financial bonus for the department.

Feedback on the courses and study environment is collected regularly by using an on-line system and results show that the program is generally appreciated. Feedback on research supervision is obtained in annual meetings of the review committee and the PhD candidate, who submits a standardized progress report and research plan. The University has developed a diverse system to support students. Besides the immediate supervisor, advice on international travel and stipends is given; counseling possibilities exist for emotional and psychological problems; and a career specialist offers support to better manage time and plan the PhD's career.

Strengths

- The program potentially has much to offer in sustainability research, which is a major part of the University's development plan;
- The program has a clear structure, ample courses and procedures that support successful completion of doctoral studies;
- The students are generally satisfied with the organization and content of their study program;
- The doctoral students receive good training in research in an internationally competitive research environment;
- Almost all students participate in international mobility by working in foreign laboratories or presenting at international conferences; and
- Some successful PhD students obtained excellent employment opportunities in academic and research institutes, governmental departments and NGOs.

Areas of improvement and recommendations

- Although the program is highly relevant for accomplishing sustainability research as part of the University's development plan, this potential is not yet realised in the PhD research topics. The Evaluation committee recommends that **strategic sustainability projects are initiated to better fulfil the university's mission.**
- The Evaluation Committee recognized that the different groups and laboratories were rather independent and that relatively little collaboration occurred. The Committee therefore recommends that **synergy between groups and laboratories is stimulated** to develop a better academic critical mass.
- The university tries to stimulate employment of their successful PhD candidates in governments and the private sector (e.g. industry and consulting). Some successful cases exist. The Evaluation committee recommends to **develop a clear strategy to achieve this, if possible, in collaboration with potential employers** and by selecting PhD research topics that are relevant to these employers. This could also decrease their science illiteracy.