

Assessment Report
Physical Sciences
PhD studies
University of Tartu
Tallinn University of Technology
Tallinn University

2018

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Introduction

Quality assessment of a study programme group involves the assessment of the conformity of study programmes 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 programme group is supporting the internal evaluation and self-development of the institution of higher education. Quality assessment of study programme groups is not followed by sanctions: expert assessments should be considered recommendations.

Quality assessment of a study programme group takes place at least once every 7 years based on the regulation Quality Assessment of Study Programme Groups at the Level of Doctoral Studies approved by the Quality Assessment Council for Higher Education of the Estonian quality assurance organization for higher and vocational education EKKA.

The aim of the assessment team was the evaluation of the Study Programme Group (SPG) of Physical Sciences at the level of doctoral studies in three universities: University of Tartu, Tallinn University of Technology and Tallinn University.

The team was asked to assess the conformity of the study programmes belonging to the study programme 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 following persons formed the assessment team:

Bob Munn (chairman)	Professor Emeritus, University of Manchester, U.K.
Christian Enss	Professor, Heidelberg University, Germany
Anna Geppert	Professor, Sorbonne University, France
Lars Erik Holmer	Professor, Uppsala University, Sweden
Juha Karhu	Professor, University of Helsinki, Finland
Jürg Luterbacher	Professor, Justus Liebig University of Giessen, Germany
Risto Nieminen	Professor, Aalto University, Finland
Jakob Johansson	PhD student, Lund University, Sweden

The assessment process was coordinated by Hillar Bauman (EKKA).

After the preparation phase, the work of the assessment team in Estonia started on Monday, 23 April 2018 with an introduction to the Higher Education System as well as the assessment procedure by EKKA. The members of the team agreed the overall questions and areas to discuss with each group at the three institutions that 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 University of Tartu (Tuesday 24 April and Wednesday 25 April), Tallinn University of Technology (Thursday 26 April) and Tallinn University (Friday 27 April). In all cases, the schedule for discussion on site for each of the various study programmes allowed only short time slots for team members to exchange information, and discuss conclusions and implications for further questions.

On Saturday 28 April, the team held an all-day meeting, during which the structure of the final report was agreed and the findings of team meetings were compiled into 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 summarizes general findings, conclusions and recommendations that are relevant across the whole SPG. In so doing, the team provides an external and objective perspective on the programmes 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 programmes 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

General background

Several conditions need to be fulfilled in order to provide vigorous PhD programmes in the physical sciences. The first and most important is a strong and sufficiently broad basis of research to support the programmes. After that, there is a need to recruit enough students, and this depends on both structural and societal factors. Strong BSc and MSc programmes are required from which PhD students can be recruited. Since only a minority of PhD graduates in the physical sciences can continue in universities and research institutes, there is also a need to raise awareness of the contribution they can make in employment outside academia. This is helped by the courses in transferable skills that the universities expect students to take, but also requires efforts to make PhD graduates more valued in society and help them adjust better to the job market.

The low recognition of the PhD in Estonian society and the job market is a major challenge. Alumni and employers told the team that, most of the time, holding a PhD has little or no impact on employability, and may even be counterproductive if a PhD holder is considered overqualified. A PhD does not increase the salary. In the public sector, there used to be a 20% bonus, but it has been stopped, and the team was told that it is “a luxury” to do a PhD. However, the team has noted some positive signs. Some employers do value PhDs, and exposure to international environments where a PhD is valued tends to increase this. As a consequence, there seems to be a slow but positive evolution. Outreach activities by universities to society would help to catalyse better appreciation of the value of a PhD, most notably the problem-solving skills that the degree engenders.

Industrial placements and industrial PhD schemes provide opportunities to enhance the appreciation of the value of the PhD among employers and of employment outside academia among students. Few students take up such opportunities, and the schemes do not appear to be systematically exploited. Students told the team that they would welcome more ways of linking with industry, which might also facilitate the increase in industrial income that many programmes cite as an aim, though staff said that policies on intellectual property rights (IPR) can obstruct industrial collaboration. Students expressed an interest setting up companies, but apparently do not benefit from any inventions or patents that arise from their research. In other countries, industrial collaboration flourishes, and universities encourage inventors – including students – to disclose and exploit intellectual property they generate by rewarding them financially. The team believes that, subject to the constraints of Estonian law, universities should revise their IPR policies to foster industrial collaboration and disclosure of inventions. Mechanisms to promote a start-up culture and an entrepreneurial mind-set among doctoral students should also be further developed. During the team’s visit to Estonia, *Times Higher Education* published its ‘New Europe Ranking’,¹ covering universities in the 13 countries that have joined the EU since 2004. The University of Tartu was first, ranking first for research, and Tallinn University of Technology was equal eighteenth. Although the team does not give undue credence to such rankings, nevertheless the results show that for a small country Estonia has universities that readily stand comparison with others in countries with some similarities of background. This provides a sound basis for PhD programmes in Estonia.

¹ *Times Higher Education* No. 2354 (26 April – 2 May 2018)

The team saw very well equipped research laboratories and facilities that support PhD projects, typically funded by EU structural funds, but it appears that funds to maintain and replace equipment are not readily available. Moreover, within a few years the EU funding will cease in its present form, and there is no guarantee whether it will be replaced, or if so, in what form. These issues need to be addressed by suitable planning before they become more urgent.

This point has been stressed by university leaders from other countries in central and eastern Europe. At the *Times Higher Education* Research Excellence Summit: New Europe² they argued that relatively easy access to structural funds had reduced universities' need and dulled their appetite to compete for funding. This in turn had led to low rates of success in winning European Research Council (ERC) grants, while those who won ERC starting grants had less incentive to seek advanced grants. This chimes with the team's observation that many academic staff did not seem to appreciate fully the advantage they enjoyed compared with areas not eligible for structural funds. Academic staff were also pessimistic about applying for grants with low success rates, from Estonia or from the EU. The same is true in other countries, where applying for grants can feel like a lottery (but with extra paperwork) and so universities employ support staff who work with applicants to improve their bids and submit only the best.

Students

PhD students receive a stipend at a level that is fixed and funded nationally through an allocation to each university. The level of stipend had fallen well below half the national average salary, but it has been increased for this year, and the team was told that it was likely to increase further next year. Students, staff and university authorities agree that the total stipend that students receive needs to be high enough for them not to need to supplement it by taking paid work (inside the university or outside), or indeed abandoning the PhD programme completely to take up full-time employment. The increase in the nationally funded stipend is welcome, and some universities and units guarantee to make the total up to the national average salary, a move that the team endorses.

Funding for students to travel abroad is readily available and well used. There is also some mobility among universities and with companies in Estonia. As already noted, preparation for employment outside academia showing the value of a PhD for that purpose would be improved by systematic development of internship or placement opportunities that are recognized as an integral part of the PhD programme.

The team saw various initiatives to attract international students to PhD programmes and met a number of international students. A major barrier to recruiting and retaining students from abroad is insufficient use of the English language, which is mandatory in all the programmes but not normally in all courses. Websites at all levels from the university down need to have comprehensive information in English, and courses taken by doctoral students need to be in English in order to be accessible by students from outside Estonia. Estonian students, staff and other stakeholders also pointed out that English is the international language of the physical sciences, so that Estonian students also need advanced courses in English.

The team heard about various kinds of group activities for PhD students, but these varied significantly between programmes. The team believes that a regular programme of departmental seminars and colloquia with external speakers is an important part of the PhD experience that should support all programmes alongside

² *Times Higher Education* No. 2355 (3 – 9 May 2018)

regular group seminars, journal clubs and student presentations. Some students felt rather isolated, and it is desirable for programmes to organize some initial activities so that the student cohort can get to know one another; PhD students need activities suitable for young adults rather than younger students.

Doctoral theses are governed by a national agreement under which students are normally required to have at least three suitable articles published or accepted, one of which may be a patent or invention, before submitting their thesis. The team heard that this requirement has the advantage of reflecting practice in neighbouring countries; it makes clear that the PhD research is publishable and hence of sufficient standard; and it provides a good basis for PhD graduates to apply for postdoctoral study as a step towards an academic career. However, the number three is arbitrary, and leads to a bias in favour of quantity of publication rather than quality. Since publication activity on these programmes is generally high anyway, this bias risks doing more harm than good: students should be trained to produce publications of the most suitable length and number to present the research properly. In any case, well under half of PhD graduates secure academic or other research positions, and for the others the number and quality of publications may be less critical.

In their self-evaluation reports, all the programmes said the requirement for three publications could be a problem for more demanding projects, including those with extended fieldwork, which might push students beyond the four-year nominal period when they lose their stipend and finding work takes priority over writing up. Nearly everyone who met the team said this was not a problem in practice: the required number of publications was simply produced sooner in groups with larger and better-established research programmes, especially for students who did their BSc and MSc work in the same group, although some external opponents said that students who published many more than three papers produced unnecessarily long theses. If the requirement for three publications is not in fact a problem, it is not clear why it should be retained. If it is ever a problem, then university funding for the writing-up period would help, and the alternative of requiring one publication and submitting a substantial monograph may also offer a solution. More emphasis on the quality of publications is required, together with flexibility in when the thesis is submitted and in what form.

Graduates who seek an academic career are usually expected to take a post-doctoral period abroad first. This is desirable to broaden their experience, especially in a small country like Estonia, and speakers at the Research Excellence Summit: New Europe meeting mentioned earlier commented that the low level of circulation of academics between universities was leading to "inbreeding". However, some people who met the team argued that working abroad disrupts family life and risks losing young talent if they stay abroad in countries where salaries are higher. These worries are partly offset by the national scheme that guarantees a position back in Estonia after the post-doctoral period.

Staff

PhD projects are approved on the basis of the supervisor and the resources available. All three universities use a formula to evaluate supervisors that depends on their publication and grant records and on previous success in supervision measured by PhD completions. This is biased against new staff, who necessarily lack a supervision record. They can acquire experience and show success by becoming co-supervisors with a more experienced supervisor. Co-supervisors also provide students with a valuable alternative source of advice and support, and internationally it is common to require students to have a co-supervisor.

For each successful PhD completion on time, supervisors receive not only extra points to support their next PhD project proposal but also a significant one-off cash bonus. This counters any tendency for supervisors to discourage submission because students are still producing useful results. On the other hand, it risks biasing supervisors in favour of premature submission, and for that reason is not usual in other European countries, where guiding students to submission is simply a contractual obligation (although a record of successful supervision may be rewarded by a salary increment or contribute to a case for promotion).

The team endorses moves to institute a tenure-track system to attract new staff, for whom PhD students are a valuable resource to help establish their research. For this reason, internationally it is common to allocate new staff a research studentship. In that case the co-supervisor can be an experienced member of staff to advise not only the student but also the inexperienced supervisor. However, the tenure track system should be managed carefully to minimize resentment among current staff who are subject to less favourable conditions of appointment.

Other issues

In addition to issues common across all programmes in all universities, there were some issues common across all universities but not across all programmes.

Students on the chemistry, materials and physics programmes reported that when they were delivering lectures, or supervising BSc and MSc projects near the deadline for submission, they had little time for any other activities. As a result, their teaching duties interrupted the continuity of their research, often for several weeks at a time. This is undesirable: the focus of any PhD programme should be the research project.

Each university has a programme in the area of physics. These differ in size, but in each of them most of the academic staff who met the team seemed rather passive in their attitudes. A few had positive ideas about how their programme might develop and improve, but most simply argued that more funding was required to enable more of the same provision. The team believes that it is strategically important to continue offering PhD degrees in physics in Estonia, but ensuring this will require clear vision at both university and subject level.

Areas of improvement and recommendations

- The three universities should develop a campaign to improve recognition of the value of a PhD outside academia.
- Within two years the three universities should formulate plans (preferably coordinated with one another) to fund the maintenance and replacement of research equipment in the mid and long term.
- All PhD students should be guaranteed personal funding equivalent to the national average salary. This should preferably be done by adjusting the national PhD stipend, but if not, then the universities should supplement it.
- All PhD students should have a co-supervisor in addition to the main supervisor.
- To broaden appreciation of their subject, departments should fund regular programmes of departmental seminars with outside speakers that PhD students are expected to attend. There should also be opportunities for the student cohort to get to know one another outside the narrow research environment.

- To facilitate international recruitment, programmes should provide better online information in English and should offer a wide range of doctoral courses taught and resourced in English.
- Universities should develop policies and systematic plans to encourage students to spend significant periods of time outside the university doing relevant work as part of their PhD programme.
- Programme directors should ensure that students have teaching duties that permit reasonable continuity in their research.
- Complaints about the adverse effect of the requirement for three publications before the thesis can be submitted appear to be exaggerated; where the problems occur, universities can most easily counter it by more flexibility in applying the requirement and by funding an extension of the stipend.
- The argument for paying supervisors extra for successful PhD submissions should be reviewed.
- The physics-based units within each university should consider how best to strengthen PhD degrees in physics, to include making staff appointments to inject new vigour.

1. Assessment report of the SPG at the University of Tartu

1.1. Introduction

The year 2018 marked the 386th anniversary of the founding of the University of Tartu (UT). It was established in 1632 as Academia Gustaviana, and has been reborn a number of times throughout its history.

The University of Tartu Act adopted on 16 February 1995 designates the University of Tartu as the national university of the Republic of Estonia. The mission of the University 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 a structural reform initiated in 2014, the nine faculties and five colleges of the University of Tartu were consolidated into four faculties.

According to a contract of 19 January 2016 between the Ministry of Education & Science and Estonian universities, the curriculum group Physical Sciences falls within the field of responsibility of UT. The PhD level curricula (doctoral programmes) of UT within Physical Sciences are doctoral programmes in Chemistry (80341), Geography (80347), Geology (80346), Materials Science (80340) and Physics (80342). The programmes are coordinated by the institutes of the Faculty of Science and Technology as follows:

- The Institute of Chemistry (IC) – Chemistry);
- The Institute of Ecology and Earth Sciences (IEES) – Geography and Geology); and
- the Institute of Physics (IP) – Physics and Materials Science.

Doctoral studies at UT are governed by its regulation 'Good Practice of Doctoral Studies', which defines the goals and general principles of doctoral study. The University has appropriate technical and regulatory mechanisms in place to counteract academic malpractice, which are implemented initially at Faculty level.

UT has processes to evaluate doctoral study including an internal study every three years, the last being in 2014. Doctoral students are surveyed regularly; the 2017 survey showed that a good proportion of students admitted were proceeding to submit their theses and were doing so sooner than in the rest of UT, but with more students than in the rest of UT finding their study not what they expected. There are arrangements for feedback not only from students but also from alumni and employers.

1.2. General findings and recommendations at study programme group level

Overview of programmes

Numerical data for students on the various programmes are given below.

Number of PhD students by programme, including international students

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	Total no. of students	No of students working at UT	Total no. of students	No of students working at UT	Total no. of students	No of students working at UT	Total no. of students	No of students working at UT	Total no. of students	No of students working at UT
Physics	56	25	54	22	54	19	54	12	47	11
Geography	47	15	46	15	42	16	41	12	34	10
Geology	23	9	25	7	24	7	19	1	22	5
Chemistry	58	30	56	29	54	29	55	28	55	31
Materials Science	30	22	31	24	33	24	33	15	29	13
Total Physical Sciences	214	101	212	97	207	95	202	68	187	70
Total UT	1504	502	1457	493	1401	487	1348	380	1258	362

Number of foreign PhD students by programme

Curriculum	2012/13	2013/14	2014/15	2015/16	2016/17
Physics	8	9	11	10	11
Geography	0	0	0	2	3
Geology	1	2	0	0	0
Chemistry	5	6	3	2	3
Materials Science	3	3	5	3	3
Total Physical Sciences	17	20	19	17	20
Total UT	122	129	139	143	158

Number of PhD students admitted

Curriculum	2012/13		2013/14		2014/15		2015/16		2016/17	
	No. of students	Directly from UT MSc	No. of students	Directly from UT MSc	No. of students	Directly from UT MSc	No. of students	Directly from UT MSc	No. of students	Directly from UT MSc
Physics	11	6	9	8	9	8	6	4	7	4
Geography	4	3	4	4	5	5	7	5	3	2
Geology	4	4	5	4	3	2	2	1	4	4
Chemistry	9	7	13	11	11	11	12	11	10	10
Materials Science	10	9	3	3	5	3	4	4	5	5
Total Physical Sciences	38	29	34	30	33	29	31	25	29	25
Total UT	190	151	179	153	168	137	171	139	177	133

Number of PhD students interrupting their studies

Curriculum	2012/2013		2013/2014		2014/2015		2015/2016		2016/2017	
	Total	On student's initiative	Total	On student's initiative	Total	On student's initiative	Total	On student's initiative	Total	On student's initiative
Physics	5	0	7	2	4	0	6	1	4	1
Geography	5	0	6	2	6	1	9	1	10	3
Geology	3	1	1	0	5	1	1	1	2	1
Chemistry	7	3	4	1	2	0	2	1	4	2
Materials Science	4	1	1	0	3	1	7	1	2	1
Total Physical Sciences	24	5	19	5	20	3	25	5	22	8
Total UT	148	55	128	42	154	40	171	48	146	48

Number of PhD theses defended

Curriculum	2012/2013		2013/2014		2014/2015		2015/2016		2016/2017	
	Total	Graduated in 6 or less years	Total	Graduated in 6 or less years	Total	Graduated in 6 or less years	Total	Graduated in 6 or less years	Total	Graduated in 6 or less years
Physics	6	5	5	4	5	1	9	7	11	8
Geography	1	0	4	3	6	1	2	1	3	0
Geology	1	1	4	1	3	2	0	0	2	2
Chemistry	9	8	12	7	6	6	10	10	7	7
Materials Science	0	0	3	2	2	1	3	3	5	4
Total Physical Sciences	17	14	28	17	22	11	24	21	28	21
Total UT	114	57	117	62	107	45	120	75	138	65

Over the past five years, the total number of PhD students in physical sciences at UT has declined by more than 10%, but this matches a decline over the same period in those working at UT while they are studying. The number of international students has fluctuated around 20. About 10% of students interrupt their studies each year, but 80% of them do eventually submit their theses.

Admission to PhD programmes

PhD students are admitted only to the strongest projects, such that all students are employed or otherwise engaged in the research projects of their supervisors. For each student an agreement sets out what material resources will be needed for their research, who will provide them, and how they will be funded. The suitability of supervisors is assessed by a formula that is transparent but acts against new academic staff by weighting previous supervisory success.

Students may also have a co-supervisor, typically a more junior staff member who provides more detailed day-to-day support, which students told the team they appreciate. The overall quality of supervision would be enhanced if appointing a co-supervisor was mandatory for all students. Co-supervision also gives new staff experience and the opportunity to improve their standing in competing for students. However, new staff would be supported more positively by preferentially awarding them research studentships from the Faculty's allocation; they could be supported by an experienced mentor to help maintain the quality of supervision.

Completion of PhD programmes

In the context of the requirement for three published papers, the team heard suggestions from a few supervisors and students that papers based on BSc and MSc work could count towards the three publications and so help to secure the necessary ECTS credits. This appears to go against the principle that work done during study for one qualification should not normally be submitted for a higher qualification, because that constitutes double counting.

The team learned that the decision to allow a student to submit the thesis requires a recommendation from the supervisor, with no apparent way of handling any

disagreement between the student and supervisor. Although the team heard no evidence of any such disagreements, they note this as a possibility. Elsewhere, the recommendation is made by an internal assessor who is independent of the project and can hear the separate views of the student and supervisor if they differ.

Elective courses in generic skills

The curricula all include 12 ECTS credits of elective courses. These cover a very wide range of topics across the whole University, but the majority are delivered in Estonian, so that the choice available to international students is very limited. Partly in response to this, the University is reducing the available electives to a small set of courses designed to help students develop soft transferable skills of use in research and teaching and in later employment. Students who met the team thought this was a positive development, and the team agrees that it promises to be valuable in enhancing the value of the PhD in employment and self-employment.

1.3. Strengths and areas for improvement of study programmes by assessment areas

1.3.1. Chemistry

The Institute of Chemistry (IC) comprises about 160 FTE employees, comprising ten chairs and the accredited Testing Centre. The five research themes of IC are Physical Analytical Chemistry, Fundamental & Applied Electrochemistry, Physical Organic Chemistry & Biochemistry, Molecular Technology, and Computational Chemistry & Material Science. The PhD programme in chemistry is the only one in Estonia, and so is of national strategic importance. Even so, a single programme cannot cover all specialisms, being dependent on the interests of the academic staff at any one time. The team noted that synthetic organic chemistry is not among the main research themes of IC, and some external stakeholders who met the team agreed that this leaves a significant gap in the supply of PhD graduates.

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

The doctoral programme in Chemistry is soundly based on UT regulations that expect candidates to acquire a suitable range of skills to reach an appropriate international standard. The curriculum, approved by the UT Senate, comprises 60 ECTS credits for doctoral courses plus 180 ECTS credits (75% of the total) for research work. At least part of the study must be in English. Students have an approved supervisor, and possibly also a co-supervisor.

The programme is managed by a programme director and overseen by a programme council, each with a clear remit. The curriculum is designed to favour applied research and collaboration with business and government, consistent with the current national

strategy for a knowledge-based society, although external stakeholders who met the team felt the curriculum still favours the theoretical side. It is reviewed internally and can be adjusted accordingly. The required doctoral courses span four specialities, in collaboration with other UT institutes in the Faculty of Science and Technology and beyond, and there are various optional courses. Students must take courses in each speciality and select options according to their prior preparation and research needs, guided by their supervisors and the programme director. Courses can be taken from other institutes where necessary, and these still carry credit.

However, students who met the team indicated that the range of courses was more extensive and flexible on paper than in practice, with many courses not available in any given year, partly because of small student numbers. Some supervisors who met the team similarly complained that the available courses were not well targeted at the more specialized needs of their students. It appeared to the team that other credit-bearing means of providing specialized support (such as weekly journal clubs in which one or two research group members present and discuss a recent paper from the literature) were not being fully explored.

Students are encouraged to attend conferences and courses abroad, but there is no internal budget for this. Nevertheless, students do secure external travel grants and they are given training in making conference presentations. Doctoral schools provide international contacts.

The curriculum includes various elements that support the development of soft transferable skills relevant to research and professional practice, including a rotation among different research groups that broadens students' experience and fosters collaboration. The provision of general courses in English for international students is limited, and a wider range would be welcomed by Estonian students as well as international students, but the working language in the laboratories is English. Estonian and international students who met the team requested more specialist courses in English, and external stakeholders who met the team agreed that this was desirable for the PhD graduates they might recruit. Supervisors also indicated that preparing lectures in English is easy because of the wealth of material available; in practice, advanced lectures in Estonian are translated from largely English sources.

Feedback from students is obtained formally through surveys and also in the course of other contacts. A majority of the students believe their studies have contributed to the skills they need. The usefulness of some industrial practice was criticized, and the requirement has therefore been modified to suit students' needs better, although external stakeholders who met the team had not been involved in this activity. Feedback from employers to faculty members has led to more courses on intellectual property and computing.

Strengths

- The PhD programme is supported by a very strong cadre of experienced researchers.
- Students rotate among different research groups, broadening their experience and fostering collaboration.
- Participation in international conferences and courses is encouraged by the University and supported by the availability of grants for travel. This helps with internationalization of research and enables international collaborations and contacts.
- Most students readily exceed the required minimum of three publications

Areas of improvement and recommendations

- Although the team was told that there is a programme council comprising external members, none of the external stakeholders who met the team were aware of this. Estonia is small enough for significant feedback to be collected by personal contact, but the programme could be strengthened by collecting feedback from alumni and employers more systematically.
- The catalogue of courses should be realistic for the next year and should enable students to plan for later years. As the SER indicates, there is also scope for continuing development and diversification of courses to enhance the skills students need to acquire. Both of these could be helped by the new set of courses on soft skills.
- More of the specialist courses should be offered in English.
- Good practice in developing specialist knowledge and skills (for example through weekly journal clubs) should be shared more widely.

Resources

Standards

- ✓ In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme.
- ✓ Universities shall ensure that sufficient funds are available to conduct doctoral studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.
- ✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.
- ✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.

Comments

Doctoral students receive a stipend from the state, subject to satisfactory progress, though only for the nominal study period. Although the stipend has increased for 2018, it is still little more than half the national average salary, and the SER argues that this is insufficient to motivate students, and IC will use its own funds to augment the stipend to match the average salary. Meanwhile, students need additional funding from joining a research project, so that supervisors must have enough resources to support the student for the duration of the research (which is gauged by the supervisor's previous successes), although the amount a project pays can vary markedly.

Students who met the team reported that they were expected to undertake an initial amount of teaching (including lectures, laboratory supervision and supervising BSc and MSc dissertations) without payment, though further teaching was paid. In

addition, the concentrated volume of teaching they undertook interrupted the continuity of their research work at certain times of the year.

Thus IC enables students to pursue their studies in principle without needing an outside job, but there are some conflicts between their internal duties and their research. Many doctoral students do take an outside job, and cite it as the main problem in completing their PhD. Even so, the main reason students give for dropping out is low income, especially when labour market demand means that salaries for technical positions are high.

The SER asserts that "students and academic staff are satisfied with the facilities and equipment provided by the institute", and the team was able to verify that the IC enjoys a high level of provision of equipment in attractive modern laboratories. As noted earlier, the resources required for each research student are established at the outset of the project, and equipment is shared between research groups; where major equipment is necessary, it is made available by collaborations within Estonia and abroad. Sustainability is inevitably dependent on success in raising funds from state and private sources, but the IC's recent record in securing funding gives it grounds for optimism. The SER considers that the best way to increase its resource base is to increase income from private sector contracts, but the team was not able to establish how realistic that ambition is.

Strengths

- The IC provides very comprehensive listings of the resources required for each PhD project.
- The IC uses its own funds to ensure that all students have a stipend equivalent to the national average salary.
- The IC has very well equipped research laboratories and is able to secure time at other facilities when needed.

Areas of improvement and recommendations

- Currently there can be big differences in income for students depending on which project they work in and what grants they are given. This is not obviously fair, and might create a difficult work environment where students only want to work in some projects that give them a higher income.
- The stipends remain low compared to the average salary in Estonia. Though tax free, they are too little for most students to live on and so they have second jobs. To recruit and retain the most ambitious students, the salary offered should stand comparison with what industry can offer.
- The team endorses the IC's intention to increase income from non-governmental sources; this would be helped by developing a systematic strategy of interaction with external bodies to secure external funding.

Teaching, learning, research and/or creative activity

Standards

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| ✓ | Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses). |
| ✓ | Doctoral studies support students' personal and social development, including |

<p>creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.</p> <ul style="list-style-type: none">✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.
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Comments

Doctoral students have flexible individual study plans compiled with their supervisor. The plans are updated annually at the annual review with details of studies and research for the coming year. Supervisors must have a doctoral degree, and the volume of their recent publications, together with their success in PhD supervision, determines how many PhD students they may supervise at one time. Teaching on the doctoral programme is carried out by academic staff with a PhD and by senior research fellows (whose workload is restricted).

Regulations determine that one ECTS credit corresponds to 26 hours of student effort including assessment (which may range from a simple pass for completing an activity to a formal examination on a taught course). The SER says the adequacy of the workload is assessed by the experience of lecturers and the director of the programme, but the criteria used are not stated. Some seminars are now being extended to the joint Estonian graduate school in functional materials. What the SER calls a "small problem" with the workload is that international thesis opponents complain that PhD theses are too long if students actually publish two or three times the required three papers.

Each student's study plan depends on their prior study and the specific demands of their research, typically to provide more physics or more chemistry and sometimes biology. Teaching is predominantly traditional, though the SER argues that the end results justify this, regarding as the most innovative approach to teaching the rotation between different research labs. Nevertheless, use of newer techniques such as the flipped classroom and online learning could yield even better results and show students more approaches they could use in their own teaching activities.

The SER recognizes that the interests of supervisors and PhD students are not identical: supervisors favour ambitious projects that may not readily produce the three publications that students need. This is partly mitigated by paying a cash bonus to the supervisor when a thesis is submitted within the nominal time. The system of co-supervisors may also help here.

PhD students are not required by the regulations to teach, but a majority choose to supervise BSc and MSc students and to present lectures and seminars, especially if it suits their intended career path. Some 20% would have liked to do more teaching and supervising. IC is considering how to offer more diverse teaching for PhD students, but

there is a need to ensure that the teaching load does not take too much time from the student's research.

Recognition of prior learning (RPL) is governed by regulations and overseen by designated members of IC. RPL appears to be readily available, but is controlled to prevent students from avoiding general broadening courses.

Students are surveyed every year; one issue for international students relates to accurate description of the language of instruction for courses. Otherwise, students believe the most important parts of supervision are providing financial support and discussing the research. The SER describes feedback about supervision as "a sensitive matter, because it involves meddling into the research projects of research fellows as well". This seems not to focus on the core issue of how the supervisor manages the research project and the associated research fellows while ensuring that there are no obstacles to the PhD student's research; the most junior and least powerful people need the most protection.

Strengths

- Supervisors must have a good record in research and in prior supervision (though this acts against new staff).
- Students present seminars at a joint Estonian graduate school of functional materials where relevant.

Areas of improvement and recommendations

- The proposal in the SER to provide a co-supervisor for all PhD students should be progressed as a priority.
- Student theses take too long when projects are over-ambitious; the new system of co-supervisors could help to ensure that sufficient publications for the thesis are achievable within the expected four years.
- Methods of teaching and learning on doctoral course work could helpfully include more newer techniques such as online learning.

Teaching staff

Standards

- ✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.
- ✓ Teaching staff develop their supervisory competences and share best practices with one other.
- ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).
- ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.
- ✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.
- ✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their

international mobility.

Comments

PhD supervisors must have a PhD, and from 2018 so will all new lecturing staff. Lecturing staff are expected to update their teaching skills, and the proportion who do so is monitored. Feedback between teachers is mostly delivered and discussed in the council of the institute. The teaching staff are well qualified and have pedagogical training, though interest in pedagogy seems to be variable. Many of them are active researchers.

IC expects a doctoral student to attend at least one international conference per year and have one longer stay at foreign university per study period. Students may experience a variety of collaborations that involve external and international staff, facilitated by IC staff links. Students may also spend periods in laboratories elsewhere and some take courses at other universities. The SER argues that four years after MSc does not prepare students adequately to be competitive with the best universities in the world and suggests more focus on quality rather than process and formal targets. The team agrees that better outcomes would be helped by more stress on the formation of the student, which could usefully be expressed in the intended learning outcomes for the programme.

Strengths

- The teaching staff are very active researchers with good publication records and large networks of national and international contacts.

Areas of improvement and recommendations

- As suggested in the SER, additional pedagogical training would broaden staff skills in teaching doctoral students, and those skills should be evaluated. There should be an expectation that all teachers will regularly develop their teaching skills.
- Industrial collaboration and co-supervision of PhD students should be developed further.

Doctoral students

<u>Standards</u>
<ul style="list-style-type: none"> ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria. ✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives. ✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses. ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers. ✓ Doctoral students’ extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies. ✓ Doctoral students participate in international mobility programmes or take

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| advantage of other opportunities for learning or research at foreign universities and/or research and development institutions ³ . |
| ✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates. |

Comments

The SER says that admission of PhD students depends on the doctoral project and assessment of its feasibility (70%) and the average grade of the student at the previous level of study (30%). It also says that the UT admissions process until this year made offers too late to compete with international competitors, but this has now changed. It further notes that because the level of international students is harder to assess before admission, some turn out to lack the necessary educational background. It seems desirable to increase the proportion of international students, so it would be valuable to develop improved evaluation of students and to require an initial period for settling in and catching up where necessary. Overall, the student body appears active and motivated.

A formal committee reviews student progress annually on the basis of documentary submissions against set criteria clearly related to the needs of the eventual thesis. Students find the process thorough and constructive, but too formal and lacking in feedback. The IC and the programme director also find the process too rigid, and would prefer more ongoing evaluation, including the chance to interview students and possibly obtain more evidence if necessary, aided by the new co-supervisors. The team supports these ideas, which do not appear to conflict with any regulations.

Students who interrupt their studies mostly do so because of insufficient financial support for a reasonable standard of living, though for international students inadequate preparation can be an issue. Interruption can also prolong studies beyond the four-year target. Overall, 85% of students eventually proceed to defend their thesis, and the average duration with the defence is 4.7 years. In general, the duration is shorter if the PhD research continues the MSc research; changing topic takes longer, in which case IC may allow an extension of one or two years.

RPL advice is provided by a designated counsellor, and career advice is provided by the supervisor, while higher bodies may also advise, up to the UT Office of Academic Affairs. Most PhD students acquire jobs at a suitable professional level, typically in academia or business.

Strengths

- Comprehensive and clear study plans for the students.
- The admission process has been updated to compete more effectively with other universities for international students.

Areas of improvement and recommendations

- As the SER suggests, improved interviewing and testing of applicants for admission (especially international students) should be developed to help ensure that they are ready for PhD study and so reduce drop-out and delay.

³ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

- The annual progress review should be made more interactive by including a meaningful interview with the student to give feedback; other less formal reviews should be introduced between annual reviews.

1.3.2. Physics; Materials Science

The Institute of Physics at UT (IP) comprises 13 laboratories in 5 departments: Materials Science, Bio- & Environmental Physics, Experimental Physics, Theoretical Physics, and Physics Education. Currently IP employs about 200 people, of whom two-thirds are academic staff.

IP is responsible for two modest-sized PhD programmes, in Materials Science (jointly with IC) and in Physics. Because both programmes are the responsibility of IP under the same director, many aspects are common. They are treated together here, explicitly identifying aspects that are distinct because the programmes have different curricula and students.

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

The doctoral programmes are each based on UT regulations that expect candidates to acquire a suitable range of skills to reach an appropriate international standard. The curriculum, approved by the UT Senate, comprises 60 ECTS credits for doctoral courses plus 180 ECTS credits (75% of the total) for research work. At least part of the studies must be in English. However, it is not always clear to students whether any given course is entirely in English or whether some parts are in Estonian. This makes it difficult for international students to find enough suitable courses, and Estonian students suggest that since all scientific work will, in general, be done in English, then all PhD courses should be entirely in English. Students are offered courses to improve their English in writing and in oral communication.

The SER remarks that international students who join the PhD programme are often insufficiently prepared. As a way to ensure a basic minimum level of preparation, a three-credit book course is mandatory for all students (home and international). In this, students read and are then examined on a general undergraduate textbook in either Physics or Materials Science. General knowledge of the field is important and a refresher course may be helpful, but students should have such background knowledge before they enter the PhD programme (especially if they enter having progressed through UT BSc and MSc programmes in the same discipline), so the practice of giving credits for this is questionable. Other suitably advanced texts can be studied for credit in the same way, and this is not a problem.

The need for the programmes is derived from the national strategy, and the Materials Science curriculum focuses on the thematic priorities from that strategy: Information & communications technology, environmental technologies, and effective use of resources. The Physics curriculum is similarly motivated but with different emphases that include nanotechnology topics such as graphene, but otherwise the curriculum does not say what specialized elective courses are offered. Both curricula make use of collaborations within UT and beyond. Overall, both programmes are soundly based, with an extensive and coherent curriculum offering, with contributions from the national Doctoral School in Functional Materials and Technologies. However, some of the Materials Science speciality electives do not look attractive to external students; for example, Electrochemistry III and Surface Chemistry III each presumably build on two prior courses that external students will lack, and otherwise the titles say nothing about the content. The Physics curriculum does not specify the speciality electives.

An apparent weakness in the administration of courses is that although for efficiency courses may be scheduled to run only every two or three years given the rather small student cohort, the UT Study Information System cannot show courses beyond one academic year. As a result, students cannot plan their courses across their whole PhD programme.

Recently more emphasis has been put on transferable skills useful outside the university, such as entrepreneurship and leadership. This is achieved by adding elective courses in, for instance, business administration and pedagogy. As another way of preparing students for a career outside academia, internships for PhD-students have been established. These can also serve an important role in strengthening the bonds between academia and the rest of society. However, students who met the team did not seem aware of possible internships, so they should be emphasised more if they are to be successful. It is also important that enough time is given for internships since there is very often a start-up period associated with a new work environment.

Students have personal study plans based on their prior preparation and the needs of their research. The plans are reviewed and modified as necessary in discussion with the supervisor and the director, and in progress review meetings. Students feel that the study plan is well suited for their need and flexible enough to take account of their current situation. It was not clear to the team how changes to the study plan are made, other than in discussion with supervisors, and how much influence the student actually has on the content of the study plan. Although there are no Institute funds for international travel, students do obtain external funding, and all take part in international conferences, doctoral courses and summer schools to some extent. Students are recommended to spend at least one semester at a foreign university or research institution.

The programme is overseen by a programme council (which also decides on the award of the PhD) with suitable terms of reference, and is managed by a director. The Materials Science council is joint between IC and IP, and cooperation appears to be good, but since IP has lead responsibility for management of the programme it appoints the director from its own staff. A problem with completion within the nominal time is the requirement to publish at least three papers, which for the more ambitious projects proves challenging.

The curriculum is evaluated by feedback from a range of stakeholders, which is analysed to guide improvements to the programme. For instance, surveys indicate that most students are satisfied with the general competencies curriculum, but the two specialized book courses were changed after suggestions from students.

Strengths

- The programme changes in response to feedback from students and employers.
- Participation in international conferences and courses is encouraged by the University and supported by the availability of grants for travel. This helps with internationalization of research results and enables international collaborations and contacts.

Areas of improvement and recommendations

- For clarity the Physics curriculum should specify what speciality elective courses are offered, at least provisionally.
- To enable students to plan their studies through their whole PhD programme, the UT Study Information System should show planned courses beyond one academic year and allow students to register for them.
- If industrial experience is a normal part of the programmes, even if it is not compulsory, then that should be mentioned in the curriculum in order to inform students and increase take-up.
- Students who lack basic knowledge of the subject should be required to take a preparatory course that does not carry credit towards the requirements for the PhD.
- To make the PhD programme more attractive to international students and more useful as preparation for a professional career, the general courses should be delivered in English.
- Particularly to help international students, speciality elective courses should all be self-contained, with self-explanatory titles.
- Feedback from alumni and employers could be gathered more systematically than just by personal contact.

Resources

Standards

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| ✓ | In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme. |
| ✓ | Universities shall ensure that sufficient funds are available to conduct doctoral |

<p>studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.</p> <ul style="list-style-type: none">✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.
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Comments

The Physicum building, opened in 2014, provides a good base for research activity and equipment. Other funding and facilities are obtained through collaboration with a range of universities, institutes and companies, and this seems to most likely source of more resources. The IP also participates in the European Graphene Flagship Initiative. Research also benefits from access to facilities in the Estonian Research Infrastructure Roadmap, and additional such facilities would help.

Core facilities are crucial for successful research and consequently for the success of PhD training, and overall, resources appear adequate. The laboratories are well equipped and in general equipment does not appear to be used so intensively that it slows down students. Maintenance can be an issue when service contracts for new equipment run out since there appear to be few technicians. Personnel for running the most advanced equipment, such as the transmission electron microscope, was a limiting factor in the materials science laboratory. The Faculty requires applications for doctoral study to specify the resources required for the proposed project. In general, staff and students agree that the necessary equipment is available, and use is optimized by sharing according to agreed procedures.

The state doctoral allowance is not attractive to students, being well below the national average salary despite a sizeable recent increase and so students have their income supplemented by joining research projects. This involves a judgement as to how sustainable the funds are, based on the supervisor's previous record. Otherwise as many as 30% of students have to take an extra job, and this interferes with their studies.

Strengths

- Research students have good access to excellent research and teaching facilities both in the Physicum and outside through collaboration with partners in UT and national and international partners.
- The sharing of infrastructure beyond individual groups and institutes seems to work well and is commendable.

Areas of improvement and recommendations

- The sustainability of the infrastructure seems questionable: the number of laboratory technicians is low and funds should be secured for maintenance of equipment.

- To help make doctoral research less financially unattractive, external organizations could be approached to fund bursaries to supplement the doctoral allowance.

Teaching, learning, research and/or creative activity

Standards

- ✓ Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses).
- ✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.
- ✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.
- ✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.
- ✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.
- ✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.

Comments

As already noted, students have personal study plans that are revised as necessary during an annual progress review. Recognition of prior learning (RPL) is applied appropriately, subject to a few restrictions designed to prevent exploitation of the system; each programme is overseen by a committee and has a counsellor to help students with RPL. Doctoral students are taught by staff and senior research fellows whose loads ensure that they can give enough time to the task. Student workloads are specified by regulations as 26 hours per ECTS credit. Teaching methods are traditional, but the SER argues that they work.

Supervisors must have a doctoral degree, and are allowed up to four students, depending on their record in research and doctoral supervision. When applying for new students, supervisors are ranked on their previous supervision and publication record. Other criteria were also mentioned; these were not very clear, but it does seem important that other skills should be taken into account when appointing supervisors, such as leadership, project management, and the care they take of students as attested by student feedback.

The SER neatly summarizes what it calls the "diverging interests of supervisors and doctoral students": supervisors may value PhD students as cheap labour, and are interested in ambitious projects where publications may be slow in coming, whereas students need three publications before they can submit their thesis, and beyond the nominal four-year duration their state allowance stops. UT pays a bonus to the supervisor of a successfully defended PhD thesis, which introduces a bias towards submission; supervisory success is a criterion in allocating research students to

supervisors; and the university is now launching a system for one or two mentors or co-supervisors to take the student's interests more explicitly into account. Students who met the team valued the contribution of their co-supervisors.

Inadequate supervision is said to occur, and feedback to staff on their supervision takes place in the form of collegial discussion, which the SER says is sensitive "because it involves meddling into the research projects of research fellows as well". It is understandably a sensitive matter to confront colleagues if their supervision is not working well, but it is necessary for fairness to students. Co-supervision may be one way to ensure good supervision, but poor supervision should always be addressed.

Students may choose to deliver lectures, run seminars and supervise BSc and MSc theses, with mutually beneficial results. They also give seminars to their research groups and some general seminars. The teaching duties of students are not evenly distributed; some students told the team they had major duties in lecturing and supervising BSc and MSc students when others who wanted to teach had none. A more even distribution would be preferable to reduce the impact on research time and for fairness; if this is not possible, it should be clearly justified to the students.

Strengths

- Supervisors are well qualified and active researchers, and student surveys indicate that supervision generally works well.
- Feedback on lectures and seminars is predominantly positive.

Areas of improvement and recommendations

- Restricting the number of PhD students per advisor is not ideal because it restricts student choice; students should be free to select the supervisor and topic they want to work on, provided the necessary resources are available.
- Publication numbers are a crude benchmark indicator of research quality, especially when the system does not evaluate the relative contribution of students and supervisors to the published work.
- All students should have a co-supervisor or mentor to represent their interests in case these diverge from those of the supervisor and the wider research project.
- Teaching is an extremely good way of understanding the subject more deeply and furthering various general competences, so making teaching optional for students is not optimal. Teaching should be divided fairly among the students.

Teaching staff

Standards

- ✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.
- ✓ Teaching staff develop their supervisory competences and share best practices with one other.
- ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).
- ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.

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| <ul style="list-style-type: none">✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility. |
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Comments

Most teaching is delivered by staff who hold PhDs, and new staff must now all have a PhD. Teaching staff are expected to update their teaching skills, supported by the centre for excellence in teaching and learning. The percentage who do so is monitored, but the SER says more training is desirable. Teaching and supervision performance are evaluated during professional reviews. No specific training seems to be given to new supervisors, which is problematic, especially if they have no experience from co-supervision.

Doctoral students are exposed to international influences by various means, including visiting foreign researchers as supervisors in doctoral schools. However, students across UT thought cooperation with a foreign supervisor had little impact, and were critical of the competence of foreign supervisors, though the reasons were not explored. Under UT rules, normally at least one opponent of a PhD thesis must be from outside Estonia.

Strengths

- Overall, teaching staff are suitably qualified.
- There are strong incentives for teachers to be active in research and publish articles.
- The number of researchers involved in teaching appears to be at a good level.

Areas of improvement and recommendations

- Establish a specific programme to attract foreign lecturers in order to widen the colloquium programme
- Explore the reasons behind negative student views on foreign visitors.
- Require more pedagogical training to broaden staff teaching skills, and provide supervisory training.

Doctoral students

Standards

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| <ul style="list-style-type: none">✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria.✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their |
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- ✓ studies on time and successfully defend their doctoral theses.
- ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.
- ✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.
- ✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁴.
- ✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates.

Comments

Students are admitted to suitable research projects with "capable supervisors". The timing of the process has been a problem, with decisions made too late for many international students, but a more flexible UT system is now in place. Evaluating the prior education of international students has also sometimes been a problem compared with Estonian students.

Progress against each student's study plan is reviewed once a year, and expressed as credit points. Students appreciate the review but would like more feedback from it. At the moment, the yearly attestation of the student's work seems to be a bureaucratic procedure rather than a true evaluation. The attestation can be an opportunity to do an outside review of the student's progress, not restricted to the views of the supervisor and the student. This could also pick up any problems in the relationship between the student and supervisor.

Doctoral students are recommended to participate in foreign conferences, seminars, training courses and research visits, and to study at a foreign university or education institution for a total of at least one semester during their studies. The experience gained abroad and the progress of research are evaluated annually during the progress review of doctoral students. Most PhD students do take part in training courses and present their results at scientific meetings abroad, usually towards the end of their of studies when more results are available. Mobility is supported by Estonian grant programmes and sometimes by foundations in the country visited. The proportion of foreign students is modest.

Some 80% or more of students eventually defend their theses, taking an average of 5.4 years to complete. Longer times to completion are often associated with a research topic not directly related to the MSc work, when an extension of time is understandable. Interruptions of course are possible, mainly for financial reasons, or for foreign students with inadequate prior preparation. The long completion times are the result of a number of factors, including students working inside and outside the university as well as the practical demands of conducting and publishing their research, but ways of shortening them should be explored.

Students are supported by their supervisor with career advice. Some advice is also available in the Faculty but is not well used by the students, being not perceived as helpful since the advisers do not have expert knowledge. Alumni and employer networks need to be developed as a valuable source of practical advice on careers,

⁴ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

and indeed on the programme. Most graduates secure professional jobs, over half in academia and others in business. International mobility is encouraged and facilitated as far as possible.

Strengths

- Admission rules have been updated to compete more effectively with other universities and so recruit better international students.

Areas of improvement and recommendations

- More close evaluation of the prior knowledge and skills of foreign students should be performed to ensure that they are suitable for the work before admitting them into the study programme, where necessary after a preparatory period additional to the programme itself.
- Reviews of student progress should be made more frequent than once a year and more interactive, including feedback to the student.
- Alumni and employer networks should be developed as a source of advice and practical support to the programme and the students.

1.3.3. Geography

The Department of Geography is part of the Institute of Ecology and Earth Sciences (IEES), which is a leading centre for research and teaching in ecology and earth sciences. It also includes the Departments of Zoology, Botany, and Geology. Overall IEES employs about 240 people. It houses a successful centre of excellence. The Department shows a very high potential in research: an outstanding research infrastructure; high metrics of publications; and a very good ability to attract research funding.

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

Geography has four specializations: Landscape Ecology and Environmental Protection; Physical Geography; Human Geography and Regional Planning; Geoinformatics and Cartography. This is a very broad definition of the field, overcoming the division between physical and human geography common around Europe. Staff and students who met the team are very satisfied with this broad definition, which they consider a strength. Indeed, the team learned about PhD projects with interesting interdisciplinary combinations (e.g. geomatics and archaeology) and comprehensive approaches (e.g. ecological engineering). In the case of the specialization in Human Geography and Regional Planning, the strategy of the programme is to focus on niche topics that combine geography and IT and to collaborate with social sciences outside the IEES. The team encourages the Department to continue such developments, supported by courses in geographical information systems, data processing and programming.

The doctoral programme in geography is a relatively small, with 19 PhDs completed from 2012 to 2017, which equals 3.2 new PhDs per year. The number of students on the programme has declined from 47 to 34 over the last five years; the numbers for the last two years include two or three international students. This development follows the national trend, and financial conditions do not allow more PhD positions to be opened. However, supervisors indicate that this number, albeit modest, is sufficient for the needs of the Estonian job market.

They collaborate well with other departments of the IEES, through joint projects and joint supervisions. The panel was presented examples such as Landscape Ecology & Environmental Protection with Botany and Geology; Physical Geography with Physics and Geology. Collaborations also reach out beyond the IEES, for instance Human Geography & Regional Planning with the Faculty of Social Sciences and Tallinn University, and Geoinformatics & Cartography with the Institutes of Mathematics & Statistics and of Computer Science and Tartu Observatory.

The programme complies with the standards established at both national and University level. The University has set clear general requirements for doctoral studies. In addition to professional skills, doctoral students are enabled to acquire general skills. The structure of the curriculum gives the volume of the PhD studies to be 240 ECTS credits, of which 60 ECTS credits (25% of the total) come from doctoral courses and 180 ECTS credits (75% of the total) from the thesis.

The Procedure for Awarding Doctorates prescribes requirements for the dissertation. At least three suitable research publications (published or accepted) are required in order to submit a PhD thesis, with the candidate the first author of at least one paper. If the thesis is a monograph, one paper is required instead. A large majority of theses are not in Estonian, but they then must have a summary in Estonian.

In practice, an overwhelming majority of students publish three or more high-quality papers. However, the requirement to publish three papers in international journals can increase the duration of the PhD studies beyond the nominal duration of 4 years, after which the national stipend ceases. Supervisors and alumni report that this induces a high number of interruptions (in 2016-17, as many as 10 out of 34 students interrupted). Students start jobs outside academia to support themselves and, in some cases then abandon their PhD studies.

The participation of students in international conferences reported during the interviews is impressive. Most students attend several international conferences per year in the main networks of the discipline. In addition, a PhD school and conference *Mobile Tartu, Mobile Data, Geography, Location-Based Services* is organized biennially by the Department of Geography.

Student feedback reveals good satisfaction with the transferable skills gained during the programme, but students have questioned the usefulness of industrial practice, and so the arrangements have been made more flexible. Feedback from employers asks for more technical skill training. Students and alumni who met the team expressed a high level of satisfaction with the courses. In particular, students appreciated the flexibility that allows them to assemble a tailor-made programme fitting their research project, using the various courses in the Department of Geography as well elsewhere in IEES. The SER notes a need for the University systems to allow students to plan courses more than a year ahead. A weekly seminar brings together all PhD students and supervisors in the Department. Students are satisfied that it helps them to grasp the broad view of the field.

The PhD programme performs very well in terms of the number and quality of publications. However, the standard research-directed PhD model is at risk of becoming an ivory tower, which could be why a PhD is not valued in society, ministries and business. Alumni who met the team emphasized that critical thinking and methodology are the most important soft skills to be acquired in the course of PhD study. In addition, students, supervisors and alumni unanimously suggested that more should be done to develop entrepreneurship skills in areas such as law, project management, teamwork, coaching, communication and IT. The team learned that the Department intends to change towards a more career-oriented approach, with plans to incorporate new courses in transferable skills in the programme.

The curriculum may be studied in a blend of Estonian and English or totally in English. The SER reported some complaints that courses marked as being given in English were actually given in Estonian, with only the literature in English. However, students who met the team stated that the language of the course usually depends on the presence of international students in the group. The SER notes a need to provide more general courses in English for international students, although the issue was not raised by those who met the team and so may not be too serious.

Strengths

- The programme is at a high level, with all PhD students undertaking strong projects within the research groups of their supervisors, giving the students good opportunities to find external supervisors and increase their mobility.
- The curriculum benefits from the broad strengths and collaborative attitude in the IEES, with enough flexibility to enable student to create a tailor-made programme, by choosing courses from the Department, IEES, and beyond.
- The curriculum continues to develop in response to feedback from stakeholders.
- The IEES is introducing co-supervisors or mentors for PhD students conducting PhD studies in industry.
- Publications and excellent in quantity and in quality, and PhDs typically have a good publication record that compares well with that in other countries.

- Graduate employment rates are high.

Areas of improvement and recommendations

- Industrial practice varies according to whether students have purely academic ambitions or more applied interests, but moves to adapt it to the individual needs of students should be developed further.
- While providing sufficient courses in English for all students, the programme should also ensure that geography can be studied in Estonian.

Resources

Standards

- ✓ In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme.
- ✓ Universities shall ensure that sufficient funds are available to conduct doctoral studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.
- ✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.
- ✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.

Comments

The Department of Geography is well staffed. All supervisors fulfil the University requirements: they hold a PhD, they have a good record of international publications, and they have the necessary funding. Staff who met the team said that the availability of research funds is the most critical factor in having projects approved.

The research infrastructure is of very high quality. It has been substantially improved and renewed, in particular thanks to European funds for the current programme period 2014-2020. However, so far there are no plans within the university system to provide resource to maintain and replace this infrastructure. A specific fund or mechanism should be created to ensure financial sustainability.

Through IEES, students have access to more specialized analytical laboratories and observatories. They can also access facilities in other Institutes and at Tartu Observatory. IEES is also engaged in a number of large projects with partners from Estonia and abroad.

Resource development is achieved through successful applications for research grants. According to the SER, the Department of Geography does very well with research grants, but less so in attracting private funds. Staff told the team that there is little chance to improve the situation in the short term outside the IT sector, because Estonian companies have no tradition of supporting research financially, and alumni confirmed this.

This situation could be countered by more communication targeting the public and private sector, to make visible the usefulness of research in geography. Some outreach activities to the private sector have started recently, and alumni suggested participating in TV programmes and relevant stakeholder conferences and submitting papers and PhD research reports to popular Estonian science journals and webpages.

Research development remains heavily time and energy consuming. Supervisors appreciate the very professional support provided by the financial office within its field of expertise, but more help in finding opportunities and writing proposals would be useful. In Europe, a growing number of universities have specific offices or hire consultants for such purposes.

Future financial resources for PhD schools and for research in Estonia are not clear. The rules for the next round of EU finding are not yet known, but the team was told that EU funding is likely to be lower, so that alternative resource will have to be found.

The programme also faces other important challenges. Nationally, the pool of potential PhD students is decreasing for demographic reasons, but a further reason is believed to be the inadequate national stipend, which despite a recent increase and another planned soon, will remain below the average salary in Estonia. Another possible reason is insufficient career opportunities after the PhD. In academia, PhD graduates are expected to go abroad for post-doctoral experience, with the risk of not coming back to Estonia, while outside academia, the PhD is not valued sufficiently, and holding a PhD does not improve employment prospects compared with an MSc.

Strengths

- The Department of Geography is well staffed with highly qualified and highly motivated academics who readily collaborate with one another.
- IEES has excellent research infrastructure and is well equipped with laboratory and field studies technology.
- The Department and IEES are successful in securing research grants for infrastructure development.

Areas of improvement and recommendations

- Ring-fenced resources should be allocated for maintaining and updating laboratory equipment.
- Resource development and project management should be supported by a specialist office, presumably at University level, or by external consultancy.
- Outreach activities should be undertaken to foster links with civil society and the private sector, where contract research is underdeveloped.
- In order to help counteract the decrease in the number of PhD students, more funding should be provided to level up the PhD stipend to the national average salary.

Teaching, learning, research and/or creative activity

Standards

- | | |
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| ✓ | Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and |
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<p>assuring the quality of the doctoral studies (including supervision of doctoral theses).</p> <ul style="list-style-type: none">✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.

Comments

Uniform principles governing the programme are set by the University study regulations. The rules governing the approval of PhD projects and the allocation of students favour more productive researchers and supervisors, but in practice the critical issue is the funding. A mentoring system is being developed.

The PhD study process is comparable to that at most other European universities. Individual study plans are approved by an attestation committee at the start of study, after each semester in the first year, and then annually. The team was told that the main basis for attestation is production of scientific papers, but other elements may be taken into account. There are also plans for a more flexible and interactive review process during the year. How each student is supervised varies depending on the nature of the project.

The number of students is small, which allows intensive communication between teachers and students. The student feedback is very positive, in particular with respect to the quality and commitment of the teaching staff. Internationalization is encouraged and at least one opponent of a doctoral thesis must come from outside Estonia.

The SER reports that several opponents have complained that doctoral theses are too voluminous. This is consistent with the publication list of PhD graduates given in the SER. Only a few students have the minimum of three publications, whereas most have four to six or even more. The SER argues that the study time should be extended beyond the nominal four years, but given that most students publish more than required for the PhD degree, the case for extending the study time is not well founded. Either the thesis work is too extensive or the students are doing additional work on projects outside their thesis subject.

The University carries out regular self-evaluations, both of the results and efficiency, and implements a feedback system for monitoring possible deviations from the standards. Within IEES, student feedback is sought through the student's progress review council and by personal communication with students. The feedback has led to improvements in the organization of industrial practice, differentiating between the

needs of academically oriented students and those with more applied interests. The IEES council processes feedback from academic staff, which has inspired the new system of mentors or co-supervisors.

The SER notes that the teaching methods used in the curriculum are predominantly traditional, but argues that the academic results and the number of students who have succeeded in the defence of their theses indicate that the methods work very well.

Strengths

- PhD research is carefully monitored throughout the programme.
- Students have easy direct access to their supervisors.
- The programme is monitored regularly by the programme council, making changes in response to feedback from stakeholders.

Areas of improvement and recommendations

- The size of doctoral theses should be limited by encouraging students to submit their theses as soon as they have published the required three papers.

Teaching staff

Standards

- ✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.
- ✓ Teaching staff develop their supervisory competences and share best practices with one other.
- ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).
- ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.
- ✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.
- ✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility.

Comments

Teaching staff participate actively in research. Their achievements, as measured by published research, are very good. Teaching and supervision skills are evaluated during professional reviews, although it is not clear how supervision is evaluated. The Department wishes to develop further the pedagogical skills of staff, which supervisors told the team would help them to develop new interactive teaching methods.

From 2018, lecturers must hold a doctoral degree. Considerable effort is devoted to obtaining input to PhD supervision from foreign researchers, on tailor-made arrangements, sometimes informal. Students attend courses and undertake parts of their research abroad.

The team observed very collaborative attitudes among the staff and among the students. These attitudes lead to a good distribution of tasks between members of the teaching team, and to the frequent (albeit not mandatory) use of co-supervisors.

Strengths

- Supervisors are highly active researchers who are very effective in fostering the research and the publications of PhD students.
- Teaching and supervision tasks are distributed effectively among the members of the pedagogical team, facilitating a focus on the PhD students supervised.

Areas of improvement and recommendations

- As the SER notes, pedagogical training should be provided in new, interactive educational methods to help the staff to perform even better.

Doctoral students

Standards

- ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria.
- ✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.
- ✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses.
- ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.
- ✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.
- ✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁵.
- ✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates.

Comments

The admission process is transparent. All positions are advertised, in a fair competition. The number of applicants is relatively modest, so that in many cases staff have to search for good candidates. When international candidates are involved, Skype meetings may replace on-site interviews. About 10% of the students are from abroad, but in a small cohort that is only two or three, though in some years there

⁵ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

have been none. In rare cases, the previous education of candidates has proved inadequate for PhD studies. Overall, the admission process is fair as well as reliable.

More than half of PhD students graduate in the nominal period of four years. Students taking up new and challenging topics including field work that is not related to their MSc typically take longer than four years, but in the absence of specific problems, extension for one or two years is regarded as acceptable. Due to the low and uneven level of funding, many students have to work, either on other projects at the university or outside academia. It is not exceptional for them to work full time on issues not related to their PhD research. This, of course, increases the duration of their studies and the risk of dropping out, which occurs mainly for financial reasons. Overall, 80-90% of PhD students do graduate and the average length of doctoral studies is 5.1 years, both figures being better than the faculty average.

Career opportunities in academia are not sufficient. The unwritten rule which pushes young researchers to go abroad for post-doctoral work is questioned, both by students and alumni. Given that Estonia is small, this is a good opportunity to increase the internationalization of its research, and there is funding to support mobility.

However, compatibility with family life, at an age when many people have small children, may prove difficult (as in other countries). There is also the risk that those who decide to go abroad may settle abroad, in particular when they are successful in high-salary countries. Hence this rule may contribute to a brain-drain and be counterproductive in the mid to long term. At the same time, faculty reported that in Estonia, post-doctoral positions are not numerous enough for research purposes. Hence, the panel considers that a more diversified and flexible approach would be highly suitable.

There is no counselling on completing PhD studies. Students and alumni have suggested that advice or courses about getting research grants would be helpful. Alumni and employers are members of the programme council and thus could provide advice and feedback.

Strengths

- The admission process is efficient, directing students to suitable projects and as a result enrolling good, motivated students.
- The graduation rate and average length of doctoral studies are both better than the faculty average.

Areas of improvement and recommendations

- The number of students should be increased overall, and international recruitment should be increased given that the admission calendar is now more flexible to permit competition with other universities for students.
- Provided the length of theses is limited as recommended earlier, the university should provide a full stipend beyond the fourth year to students who need more time for good cause, for example because of undertaking lengthy field-work or developing new methods.
- In addition to offering tenure-track positions, as recommended earlier, more post-doctoral positions should be made available to encourage young researchers.

- Advice on career development and research funding opportunities should be made available to PhD students.

1.3.4. Geology

The Department of Geology is part of the Institute of Ecology and Earth Sciences of UT (IEES), which is a leading centre for research and teaching in ecology and earth sciences. It also includes the Departments of Zoology, Botany, and Geography. Overall IEES employs about 240 people, of whom 51 are geology academics.

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

Since 1992, the University of Tartu has been the only institution in Estonia where it has been possible to take a full advanced course in geology at all levels (BSc, MSc and PhD). The situation has changed recently, and the BSc and MSc programmes in Earth Science and Geotechnology and the PhD programme in Earth Sciences at Tallinn University of Technology now cover a comparable scope. The present version of the doctoral programme was approved in 2006. The structure and content of the programme is also largely comparable to that in other European programmes.

The programme is important in training highly qualified specialists in geology to meet the needs of Estonia. The number of active students in the programme is comparatively small, but not unreasonably so considering the size of Estonia. In recent years there have been about 20 students, occasionally with one or two international students, but none for the last three years.

The programme comprises a total of 240 ECTS credits – a thesis corresponding to 180 ECTS credits and 60 ECTS credits of coursework. Course work includes both specialized geology courses as well as elective courses of transferable skills, including also a foreign language. The languages of the courses are Estonian and English. Comments from the students who met the team varied considerably, but it is clear that the flexibility of the programme was appreciated by most, and the team noted that the specialized international courses like the GIS training schools for PhD students are positive developments.

Admission to the PhD-programme has now clear regulations and seems to work well with the strongest and best-funded PhD projects approved. The projects are assessed for their feasibility (70% of the result) along with the average grade of the student from the undergraduate level (30% of the result). The supervisory staff must have strong and active research backgrounds, and the system of project allocation favours experienced supervisors. However, it is important to ensure that junior research staff are not hindered from getting experience of supervision. Student progress is reviewed by a council.

The programme is governed and coordinated by a programme director who leads the programme committee including a professor, senior researcher and a PhD student. Importantly the committee also includes an external member from one of the leading companies in engineering geology.

The team noted that the students have been extremely active in attending international conferences and foreign courses and although there is no internal budget for this, they have been successful in getting external travel grants. The students receive training in making conference presentations. Supervisors are also active in providing international contacts and opportunities for work in foreign labs. However, there is seemingly a lack of a regular seminar series where PhD students and research staff can interact, discuss and present their research on a more regular basis.

Feedback from students is obtained formally through surveys and also in the course of other contacts. A majority of the students believe their studies have contributed to the skills they need, although academic staff at all levels and the external stakeholders who met the team all agreed that it is important to further increase the training in transferable skills in the programme. The usefulness of some industrial practice has been criticized, and the requirement has therefore been modified to suit students' needs better, although external stakeholders who met the team had not been involved in this activity.

The time taken to complete the PhD is often affected by a need to devote time to field work during the summer. The SER observes that the time needed to acquire results and obtain three publications is made worse by long publication cycles in high-ranking journals. Moreover the research is often rather specific and applied (consistent with the National Strategy 2014–20), which the SER argues makes it more appropriate to publish in relatively low-ranking journals that offer a quicker turnaround.

Strengths

- Supervisors have strong and active research backgrounds.
- The curriculum takes account of the requirements of the labour market, given that geology and natural resources are national priority areas.
- PhD students benefit from international GIS training schools.

- PhD students report positively on the programme.
- The integration of the former Institutes of Zoology and Hydrobiology, Botany and Ecology, Geology and Geography provides additional possibilities for interdisciplinary research and joint PhD projects, while the opportunity to cooperate with the new Estonian Geological Survey and more external research institutes and private companies promises to be very important for the development of the programme.
- A high level of external funding in geology gives strong support to the programme; in particular, the department has actively and successfully used pan-European EU projects such as the Erasmus+ Strategic Partnership project 'European Astrobiology Campus'.

Areas of improvement and recommendations

- The number of foreign PhD students has always been small (much less than on most European programmes) and has decreased to zero in recent years; a sustained effort should be made to recruit international PhD students.
- Changes to make the programme more job-oriented should be actively continued.
- The programme should seek to teach even more transferable skills in order to increase the potential for PhD students to pursue careers outside academia.
- An introductory programme for new PhD students should be established as well as a regular seminar series where PhD students and research staff can interact, discuss and present their research more regularly.
- Collaboration with the Estonian Geological Survey and other potential external partners, such as the Estonian Land Board should be developed and the possibility of establishing special joint PhD-projects and/or internships could be further explored.
- The self-evaluation report indicates that the requirement to publish a minimum of three peer reviewed papers within a four-year period is problematic for many students; in such cases a more flexible requirement could be applied.
- Although the level of the official state scholarship for PhD students has been increased, for social and equality reasons the possibility of having extra salaried positions should be explored.

Resources

<u>Standards</u>	
✓	In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme.
✓	Universities shall ensure that sufficient funds are available to conduct doctoral studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.
✓	Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning

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| and research at the level of doctoral studies. Resource development is sustainable. |
| ✓ Trends in the numbers of current learners, learners admitted and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability. |

Comments

The Geology department is located in the Chemicum building within the University Science Campus, built in 2009. The PhD students have rooms, with 2–5 persons sitting together. The programme has access to a range of analytical laboratories and specialized laboratories relevant to geology. According to a student survey in 2015, the majority of the students are satisfied with the working conditions and equipment, with 73% of the students finding the department to be well-equipped and working conditions to be very good. The students have daily access to their supervisors in a friendly and informal atmosphere.

However, changes in government and EU funding are a concern for future grant income to support research, which will need to be addressed by the establishment of either national or local infrastructure funds. There is easy access to the University's Natural History Museum collections and exhibits. The content of the geological collections is fully searchable on the internet, which is an excellent resource for PhD students and researchers.

The laboratory facilities benefit from active cooperation with the Institute of Chemistry. The instruments are mostly new, covering the general needs for mineralogical and geochemical analyses. The excellent instrumentation creates high potential for external use of the facilities, providing possibilities to increased collaboration between universities and research institutes (e.g. the Estonian Geological Survey). Compared to the average European unit, the instrumentation of the Department is new, and it covers most of the needs.

A survey in 2013 showed that doctoral students needing a regular job outside University was a major obstacle for the successful completion of the degree, but according to the SER the situation is now better owing to an increase in the stipend, and this was also the general impression from the PhD students who met the team. According to the SER the research staff are also active in joint supervision with Archaeology and Geography.

Strengths

- The laboratory facilities and instrumentation are excellent and well appreciated, benefit from active cooperation with the Institute of Chemistry and could be valuable to external users.
- Students have good access to research infrastructure and easy access to the University's Natural History Museum collections and exhibits.
- Students are generally very satisfied with their working conditions and equipment, and can access their supervisors daily within an informal and friendly atmosphere.

Areas of improvement and recommendations

- In order to solve the future needs for upgrade and maintenance of the infrastructure, it will be necessary to work towards the establishment of a national and local infrastructure funding system.
- To help with budgeting, the separate contributions of teaching and research to laboratory expenses should be clarified.
- The potential for increased external and possibly commercial use of the excellent facilities should be further explored in order to generate income to cover running costs.

Teaching, learning, research and/or creative activity

Standards

- ✓ Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses).
- ✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.
- ✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.
- ✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.
- ✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.
- ✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.

Comments

The PhD study process in the doctoral programme is comparable to that at most other European universities. Individual study plans are approved annually by an attestation committee, but it is clear that it would be helpful to have the opportunity to update the study plans more frequently if necessary.

The way each student is supervised varies depending on the nature of the project. A co-supervisor is sometimes appointed, but this is not the rule. Most PhD students are employed within the centres of excellence and have research projects that are partly financed by the projects, and the majority of students find their working group to be important. However, there does not appear to be any general introduction to the department and the programme or other way of integrating the PhD community. Most students find the supervision of their PhD studies to be good as well, and the strong and active research background of the supervisory staff is a very positive factor. The SER refers to the possibility of introducing an external review process to support supervision.

The Estonian Graduate School in Earth Sciences and Ecology is important and includes cooperation with other universities in Estonia (Tallinn University of

Technology, Estonian University of Life Sciences, and Tallinn University) as well as with several other national and international partners.

The amount of teaching by PhD students (lectures, laboratories, supervision etc.) is comparatively small, but is at a moderate level that almost never involves additional financial support. However, it would be beneficial to consider offering students paid teaching to give them more experience and support an extended study period. The load would need to be manageable, perhaps up one day per week, to include preparation, teaching and assessment.

Strengths

- The Department has very extensive foreign partnerships, which scientifically increases the ability of the PhD students to interact with other European geology institutions, while visiting professors also contribute to an international environment.
- The strong and active research background of the supervisory staff is a very important positive factor.
- Most PhD students are employed within the centres of excellence.

Areas of improvement and recommendations

- A co-supervisor should be appointed for each new PhD student.
- One or more days of general introduction should be introduced for new PhD students entering the programme.
- All PhD students should have the option of taking part in regular paid teaching.

Teaching staff

Standards

- ✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.
- ✓ Teaching staff develop their supervisory competences and share best practices with one other.
- ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).
- ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.
- ✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.
- ✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility.

Comments

The Department of Geology has three professor positions (one vacant at the time the team visited) and two guest professors, along with eight senior researchers, nine researchers and two international postdocs/researchers. The teaching staff have been highly productive and scientifically very active. At least one opponent of a doctoral thesis is required to be from outside Estonia, in order to further secure the scientific quality of the PhD thesis, as well as to increase international cooperation. Staff have extensive international contacts, which helps their PhD students to interact scientifically with other European geology departments.

Supervisors are required to be sufficiently active in research, and previous supervisory success makes PhD project proposals more likely to be accepted. Most supervisors meet the target of 1.3 publications per year. Academic staff are subject to various University requirements; some of the factors quoted in the SER (such as contribution to university administration) are not obviously directly relevant to PhD supervision and teaching, but others (such as professional engagement) are more valuable. Many of the staff have served on elected bodies, professional societies and other groups in Estonia and abroad. This is important for raising awareness of the subject and helping to give PhD students a broader view that will be important for their careers.

The SER says that the majority of academic positions are funded from competitive research funding, which does not readily support strategic development of the programme. A tenure-track system for teaching and research staff would provide more strategic flexibility. It would also provide an opportunity to make pedagogic skills a requirement. The system of favouring experienced supervisors in allocating PhD studentships works against new staff; in other systems new staff are given a PhD student to help them establish their research, typically with an experienced co-supervisor or mentor.

Teaching and supervision skills are evaluated regularly and will be strengthened by requiring the development of a personal portfolio. However, few staff have attended the training courses that the University provides. If these courses are valuable, then staff should be encouraged to attend them.

Strengths

- Staff have a strong and active research background, and most are involved in supervising PhD projects.
- Members of research staff have served on elected bodies and professional bodies in Estonia and abroad.
- Staff have very extensive foreign partnerships, and several visiting professors have contributed to an international environment.

Areas of improvement and recommendations

- A tenure-track system with clear guidelines should be introduced.
- The recruitment of staff should consider not only their international scientific reputation but also their pedagogic merits.
- The rules to ensure that only the best PhD projects are accepted should not prevent junior staff from getting experience in supervision.
- Staff members should be required to develop a personal teaching portfolio and to improve their teaching supervisory skills through attending courses.

Doctoral students

Standards

- ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria.
- ✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.
- ✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses.
- ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.
- ✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.
- ✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁶.
- ✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates.

Comments

All but one of the students who met the team had their MSc from the University of Tartu; more diversity of PhD recruitment would benefit the programme. The number of international students has been kept low because they are more likely to drop out. Ways of increasing the number safely would be a welcome improvement.

The majority of PhD students are employed and their activity is linked to the topic of PhD thesis. All have financial support in addition to the national stipend.

PhD students participate in foreign conferences and seminars, take courses and go abroad for research visits, so their mobility is high. There is good support for international mobility from different sources, and students appreciate it.

Progress reviews take place once an academic year and twice during the first academic year. The SER notes the inflexibility of having only one attestation review meeting a year, as for other programmes at UT, but this time showing how it can also disadvantage the University: payments to an international student who left the country could not be stopped until the scheduled meeting, months later. This is clearly a loophole in regulations that the team learned is being filled.

The success rates for students in the nominal time of four years are at best moderate: 10 out of 19 in 2007–13, but with as many as 6 having interrupted, leaving only 3 continuing; and only 38% according to a 2017 survey, when the average length of studies to thesis defence was 5.6 years. The Department says it is satisfied with completion within three additional years, though other PhD programmes use the rate of completion within two additional years as the benchmark.

⁶ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

Feedback from alumni and employers indicates that approximately a third of PhD graduates obtain academic positions at universities, a third continue in post-doctoral studies abroad, and a third work in private companies. Employment prospects could be enhanced if there were more PhD projects with external bodies.

Strengths

- The PhD students benefit from international contacts at the University and abroad and are highly mobile.
- Graduates of the curriculum are successful in the labour market.

Areas of improvement and recommendations

- The number of international PhD students should be increased, while strengthening screening of applicants to ensure that those admitted have a good prospect of succeeding.
- The University should suspend registration and stipend payments to students who are absent from the programme for an extended period once sufficient evidence of absence is provided, without having to wait for the annual review.
- Joint PhD projects should be developed through closer contacts with the Estonian Geological Survey, other external agencies and private employers.

2. Assessment report of SPG at Tallinn University of Technology

2.1. Introduction

The formation of Tallinn University of Technology (TTÜ) can be traced back to 1918 when the Estonian Engineering Society opened an engineering school called Special Engineering. Recognition as a 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 TTÜ 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. TTÜ was also given institutional accreditation for seven years in 2014.

TTÜ is recognized as a research university, providing research-based education for all cycles in the areas of natural and exact sciences, engineering, manufacturing and technology, social sciences and in related areas. It believes that its PhD students benefit from studying at what it calls “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:

- Being an 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.
- Contributing to knowledge and welfare in the society through cooperation between the university, enterprises and the public sector.

These forward-looking strategic goals provide a good guide for developing PhD programmes.

The Physical Sciences study programme group at TTÜ consists of two doctoral study programmes: Earth Sciences (YAMD06/09) and Engineering Physics (YAFD06/09), both managed by the School of Science.

Overview of programmes

According to the Estonian Education Information System, the students on these two programmes form 22.7% of all the PhD students involved in the Physical Sciences study programme group in Estonian universities in the academic year 2017–18. Numerical data for students on the two programmes are given below.

Earth Sciences	2013	2014	2015	2016	2017
Doctoral students	34	34	30	26	26
Doctoral students working in TTÜ	27	23	21	18	20
International doctoral students	3	3	2	3	2
Admissions	3	3	3	3	4
Enrolled from TTÜ 2 cycle	1	3	1	1	3
Dropouts	3	3	2	2	1
No of dropouts upon personal request	1	3	1	1	0
Graduates	2	2	5	5	2
Graduates in nominal + 2 years	2	1	4	1	2

Engineering Physics	2013	2014	2015	2016	2017
Doctoral students	31	33	33	27	26
Doctoral students working in TTÜ	16	15	11	8	5
International doctoral students	2	5	5	5	4
Admissions	3	6	5	4	6
Enrolled from TTÜ 2 cycle	3	2	3	3	2
Dropouts	3	2	4	5	2
Dropouts upon personal request	1	0	2	1	0
Graduates	3	2	2	5	3
Graduates in nominal + 2 years	2	2	1	3	3

With 53 students between them, these two PhD programmes constitute just under 9% of the total at TTÜ. This figure has been steady for the last two years, but has declined by 15–20% from the three years before that, slightly less than the overall decline in PhD students across TTÜ in the whole five-year period. Roughly 10% of the students have come from abroad. The graduation rate within the four-year nominal period of study is 40%, above the current TTÜ average but below the university's target of 50% by 2022.

The doctoral programmes benefit from membership of three project-based doctoral schools for the Estonian universities, in Earth Sciences & Ecology, Mathematics & Statistics, and Functional Materials & Technologies, each led by the University of Tartu. These doctoral schools support winter and summer schools, help to develop curricula, facilitate collaboration among the partners and outside, and support scientific language and terminology in Estonian.

Admission of students

Students are admitted according to set procedures that evaluate the proposed supervisor's ranking for research and supervision and ability to guarantee a salary for the student. The number of students per supervisor is limited to allow adequate attention to each student. International joint supervision is possible, and even the dual award of doctoral degrees. Applicants must have a master's degree and a good command of English. The SER says that the university aims to increase the quality of supervising and of evaluating doctoral students. Quality of supervision is measured by student success rates; the team was also told that programme directors know how good supervisors are at looking after their students, and use this knowledge when they allocate studentships.

Once admitted, doctoral students are treated as early-stage researchers employed by the University and paid a salary designed to equate to the national average wage. This is intended to remove any need for students to take additional employment to support themselves, although employment does remove their entitlement to free social security benefits as students. It evidently treats all students equally and quite generously, which the team endorses as a positive strategic choice.

Regulation of study

Doctoral study is governed by a set of regulations that cover all relevant aspects: organization, good practice, admissions, study plans, and theses. The website has clear information for applicants. The regulations for theses require at least three publications before submission, although with only one publication a more substantial monograph can be submitted instead. Theses are given a preliminary internal review and defence before the real thing. There are plans to increase the volume of individual

studies of doctoral students in order to broaden them and make them more interdisciplinary, with courses and professional activities undertaken abroad taken fully into account.

Since 2015–16 students have been required to provide feedback on their studies each semester through the TTÜ information system ÖIS. The SER says that feedback on supervision and the management of doctoral study as a whole is collected at department level through the annual process of attestation (progress review) and in doctoral seminars. Overall the Engineering Physics students have been more positive in their evaluations than the Earth Sciences students.

Appointment of academic staff

The University has started to introduce a tenure-track system for staff appointments. Currently there are plans for some 60 such positions across the University, of which 40 are available for existing staff to transfer into and 20 are for new appointments, who will be given start-up support. About half of these 20 are now in the process of being filled, and include a number of good appointments from abroad. The more favourable conditions for the tenure-track appointments are naturally giving rise to some turbulence among existing staff. Nevertheless, the team believes that the tenure-track system is essential to renew and grow the staff available to supervise PhD study and hence that these appointments should be pursued vigorously.

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

2.2.1. Engineering Physics

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

The Engineering Physics programme has run since 1997, and now has four specializations: applied physics, applied mathematics, applied mechanics, and biomedical engineering & medical physics. Doctoral courses make up 18% of the programme and research makes up the other 82%. In relevant areas, there is collaboration with and access to the research infrastructure and supervision at the National Institute of Chemical Physics and Biophysics (NICPB).

The courses include general studies to develop transferable skills; teaching skills are developed through supervising and giving lectures, supported by an elective course; and teamwork is developed through day-to-day working in the research group plus a professional training course that includes a group project. In particular, doctoral students may supervise BSc and MSc students, albeit not regularly. Students are allowed to take courses from other doctoral study programmes for credit.

Most courses are in English, and English is the working language in several research groups. There are also doctoral seminars, mostly but not entirely in English; clearly those in Estonian are not accessible to international students. Students who met the team indicated that colloquia and seminars were not well publicized.

At the start of each year students set out their study plans, and at the end of the year they must pass their attestation, which involves a discussion of progress against the plan. Study plans are flexible in order to meet the individual needs of students.

Students usually take part in one or two international conferences a year, for which funding is readily available. Some research groups have international collaborations that give their doctoral students more international experience, and students can readily spend a semester abroad.

Industrial PhDs are possible, and students who met the team were interested in setting up their own companies. An orientation towards commercial applications seems appropriate for an Engineering Physics programme, but there is a need to explain more widely the value of a PhD for work outside academia.

Feedback from students is generally positive, although views on the volume of general courses in the doctoral programme diverge. Feedback from a range of stakeholders is used to develop the programme, though the SER says more active feedback from students through an annual questionnaire is desirable.

A major concern is the low and falling number of PhD students, and the very low number of those in actual full-time researcher training in TTÜ. With four research areas in Engineering Physics, the number of students working in TTÜ (4 in 2017) is sub-critical to sustain a healthy research group structure with professors, senior scientists, post-doctoral fellows and PhD students, and students who met the team felt isolated. This raises fundamental questions concerning the research environment for PhD study and the strategic goals and aims of the PhD programme.

Strengths

- The programme contains a high proportion of research; the courses provide good coverage of different areas of knowledge and offer systematic development of general and transferable skills.
- Students are encouraged to participate in international conferences

Areas of improvement and recommendations

- The number of students should be increased to sustain a suitable research environment for the PhD programme.
- The fraction of students participating in teaching activities should be higher.
- As the SER suggests, there should be systematic annual gathering of feedback from students and other stakeholders.
- More vigorous interactions with industry should be developed, including industrial placements, say for a semester; an entrepreneurial mind-set should be fostered among students, enhanced by outreach activities to raise general awareness of the value of the PhD programme.

Resources

Standards

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|---|---|
| ✓ | In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme. |
| ✓ | Universities shall ensure that sufficient funds are available to conduct doctoral |

<p>studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.</p> <ul style="list-style-type: none">✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.
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Comments

The university provides a good standard of accommodation and other facilities for teaching and research, including laboratories, computing infrastructure and the main library. A number of doctoral students carry out their research projects at NICPB, which has an excellent research infrastructure.

Resources to support PhD projects must be shown to be available at the start of the programme. Adequate funding depends on continued funding of the research projects to which students are attached in order to supplement their state stipend; this appears to be sustainable for now but the general decline in research funding is a concern for the School.

In practice TTÜ now employs all doctoral students as early career researchers, a practice which the team finds commendable. Although external projects could help support students, the team was told that company practice normally precludes publishing the necessary papers. In other countries this obstacle can be overcome through suitable agreements on intellectual property rights (IPR), and so the team would encourage TTÜ to explore what can be done under Estonian law. Students have access to various sources of funds for international mobility.

Overall, students appear satisfied with the adequacy of the available resources. Maintaining and replacing the necessary equipment will require continuing investment. In particular, access to cutting-edge equipment and computing resources has to be guaranteed. EU structural funding ends soon, with no guarantee that it will be replaced, and there appear to be no plans about how to manage after that. Staff who met the team were generally pessimistic about the low success rate in grant applications.

The number of PhD students per supervisor is low, which could imply close supervision and mentoring by senior researchers. However, as noted earlier, a good research environment also requires a functioning research-group structure.

Strengths

- The university employs doctoral students as early career researchers.
- The infrastructure is good, with modernized lecture and seminar rooms.
- Feedback from students regarding resources is good.
- The low number of students permits good interactions with academics.

Areas of improvement and recommendations

- Some research groups appear sub-critical in size and structure and are scattered, which calls for strategic decisions about future research directions.
- External research grants, including those from the European Research Council, should be vigorously pursued.
- Plans should be developed about how to sustain and renew the research infrastructure, which looks vulnerable once European structural funds run out.
- Resourcing for industrial collaboration is at a relatively low level and should be strengthened, but mechanisms are required to ensure that this does not prevent students from completing their PhDs in a timely manner.
- Means should be established to encourage the development and protection of IP (subject to local laws), including financial incentives for student inventors.

Teaching, learning, research and/or creative activity

Standards

- ✓ Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses).
- ✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.
- ✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.
- ✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.
- ✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.
- ✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.

Comments

Students take courses tailored to their specific needs, which may come from other doctoral programmes; the courses are taught by research-active scientists. Students have to pass the courses in sufficient volume and at the right level to achieve the intended outcomes and hence to progress.

Students may develop teaching skills by giving lectures and laboratory classes and by supervising bachelor's and master's student exercises; their load is not controlled. They also receive feedback from the students on their teaching, via the study information system.

Student progress is reviewed annually, working from the student's self-evaluation, which also proposes goals for the following year. This is combined with the supervisor's assessment including the student's performance in seminars, research

and publishing to yield an overall evaluation and plan for the coming year. Feedback on progress is provided through a variety of channels.

Doctoral theses are scanned by specialist software to indicate plagiarism, and there are formal procedures to handle suspected cases, including suitable penalties.

Procedures are established for the recognition of prior learning, but most doctoral students are MSc graduates from TTÜ, so RPL is little used.

Strengths

- A central teaching-related information system is used
- Doctoral studies are embedded in a versatile research environment (but with the weakness of small student numbers).

Areas of improvement and recommendations

- Enhancements to the academic environment are needed, such as regular group seminars, departmental colloquia and related activities.
- Measures are needed to further increase student recruitment, mobility and diversity.
- Alumni networks and career advice mechanisms should be developed.

Teaching staff

Standards

- ✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.
- ✓ Teaching staff develop their supervisory competences and share best practices with one other.
- ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).
- ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.
- ✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.
- ✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility.

Comments

Staff who supervise doctoral students are all recognized active researchers, visible at conferences and through their publications. As already noted, they have to compete for the privilege of supervising doctoral students on the basis of their publications and supervision record. New staff start by supervising bachelor's and master's students and acquire doctoral supervision skills by co-supervising with experienced staff.

Students report that supervisors are often busy with a wide range of duties, but nevertheless weekly meetings are common. When students drop-out (which is not common), problems with the supervisor are not usually the cause. Several courses are provided for staff and students to develop supervising and teaching skills. Staff may also apply for study leave to support their professional development.

Thesis evaluation typically involves an international scholar, and visiting academics sometimes give lectures to doctoral students. Students also benefit from the doctoral schools mentioned earlier.

Feedback is obtained online for teaching and during the annual review for supervision. The results are analysed by the programme director and discussed with the parties involved.

An ample number of staff are available for teaching and doctoral training and they are well trained pedagogically. The number of supervisors for doctoral studies also appears to be more than enough.

Strengths

- The tenure-track system for faculty recruitment provides opportunities for strategic decisions and a necessary renewal of the staffing base.
- New staff can develop their supervision skills through co-supervision or mentoring.
- International opponents are involved in thesis examination panels.

Areas of improvement and recommendations

- Students should be assured of sufficient regular access to their supervisors, whose overall load should take account of their supervision duties.
- Students should have more influence in selecting their supervisor and project: the present system is too heavily weighted towards the supervisor's publication record and other indicators.
- International cooperation should be increased to broaden the spectrum of topics available.
- Teaching staff development should be made systematic.

Doctoral students

Standards

- ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria.
- ✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.
- ✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses.
- ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.
- ✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.

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| <ul style="list-style-type: none">✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁷.✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates. |
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Comments

Doctoral students prepare a plan for their study and research with their supervisor. On average, around 10% of students drop out each year, which the SER calls “low”, arguing that engagement in research and joint activities keeps them motivated. Permission to submit the thesis is recommended by an independent internal assessor. A handful of students graduate from the programme each year.

Feedback from alumni is too sparse to be comprehensive. More than half of graduates end up working at TTÜ, having typically spent a post-doctoral period elsewhere. Most other graduates work in research and development; as noted earlier, current students are also interested in starting their own companies, and some have done so while studying.

Strengths

- The feedback of students on their experience is generally positive.
- Alumni are in general successful in the labour market.

Areas of improvement and recommendations

- The dropout rate of around 10% is rather high for doctoral students, and the reasons for it should be investigated.
- More systematic feedback from alumni and employers should be collected to improve the programme and inform students of job opportunities.

⁷ In the context of this document, ‘research and development institutions’ denotes both research institutions and research-intensive companies.

2.3.2. Earth Sciences

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

The Earth Sciences doctoral study programme at TTÜ started in 2006, in close collaboration between two independent research institutes, the Institute of Geology and the Institute of Marine Systems (now departments under the School of Science). The programme was launched in order to fill gaps in the professional training of experts in the fields of meteorology, oceanography, mining engineering and geology. It also has strong components to transfer the knowledge of senior researchers or professors in both departments to PhD students and early-career scientists. It aims to provide high-quality education for persons who want to stay in academia as well as for those who seek a position in the public sector, state institutions and industry. The doctoral training programme is relevant for the rejuvenation of both departments, for carrying out research and applied projects, and for providing a route to continue studies after BSc and MSc level education in applied Earth Sciences.

The number of PhD students in Geology, Meteorology and Marine science is rather small, but seems to be reasonable given the size of Estonia and the need in the different sectors. A new promising institution recruiting PhDs is the recently established Estonian Geological Survey, which according to its Director General has a long-term aim to have about 75% of its staff at PhD level. The Earth Sciences programme has run since 2006. It was last revised in 2009, but a new study programme including earth sciences is under development for launch in 2018–19. The team did not obtain any information about the progress of this development.

There are two specializations, physical geology and oceanography, which are largely the responsibility of the respective departments. To graduate, students must have published at least three papers in high-ranking journals, with at least one as first

author. In reality, the publication output is higher. The choice of courses is tailored to the needs of individual students. Textbooks and other materials for special studies courses are usually in English and language skills are also developed through presentations, workshops and conferences. A number of courses are offered in English (both teaching and associated material), though the quality and suitability for the PhD progress of the individual PhD students varies. The self-assessment report states that "international mobility of students could be higher, and this is taken into account" in the new programme under development.

Strengths

- The recently established tenure-track system is promising and will strengthen Earth Sciences through two new positions already filled in Meteorology and Mining Engineering.
- The strong and active research background of the supervisory staff is an important positive factor for the success of the PhD students, most of whom can get access to their supervisors on a daily basis in an informal and friendly atmosphere.
- Admission to the PhD-programme has clear regulations and seems to be working well in allowing all senior researchers and professors to offer PhD projects and provide good supervision.
- The financial situation of the students has improved owing to a higher level of state stipend plus top-up funds from the University to match the national average salary. This important achievement will allow the students to concentrate more on actual research and finish on time.

Areas of improvement and recommendations

- Progress has been made in the recruitment of foreign students, although the proportion of foreign students is still considerably smaller than in most European PhD programmes. The university announces PhD positions internationally in English, allowing more students from abroad to enter TTÜ. More visibility and promotion at conferences and through the internet could further increase internationalization.
- Interaction between the alumni and employers outside the University, the programme committee and the PhD students could be improved: actions could include opportunities for practice outside the University, adjunct professorships, invited seminar presentations from potential employers and collaboration in PhD projects.
- The requirement to publish a minimum of three peer reviewed papers (with at least one as first author) within a four-year period should be made more flexible, with higher priority given to the quality of publications rather than the quantity. Important and highly-cited papers are not only needed for academic career paths but are also relevant for the public sector.
- Alumni and employers pointed out the importance of transferable skills in areas such as business administration and management, project management, communication, law, teamwork, coaching, and IT. The programme should make efforts to increase the availability of these subjects to PhD students.

- Alumni and employers indicated that more courses should be offered in applied geology including raw materials exploration and mining, given the importance of this field to society. The new tenure track position in mining engineering will greatly enhance this sector.

Resources

Standards

- ✓ In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme.
- ✓ Universities shall ensure that sufficient funds are available to conduct doctoral studies, to provide development activities associated with doctoral studies and research, and to support the professional development of teaching staff and researchers.
- ✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.
- ✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.

Comments

Doctoral studies in Earth Sciences are based on the resources of the Department of Marine Systems and the Department of Geology, both located in modern buildings. As doctoral students are considered part of the academic staff, they have access to the same infrastructure as the senior staff and professors, library resources and equipment, though one student reported difficulties in accessing the research infrastructure. PhD students share offices with their research group or with other students. The new buildings and infrastructure seem to provide a research environment that functions very well.

The students have access to a broad base of generic infrastructure as well as specialized laboratories, to the largest geological collections in Estonia, and in the oceanography specialization to the only research vessel in Estonia (with a new one currently under construction). Research is to a large extent project-based, i.e. researchers and laboratories are generally supported by personal research grants, which largely finance the laboratory activities.

The main concern is the long-term maintenance of equipment following the recent cut in national research funding and the expected reductions in EU funding, where in both cases the future trends are not yet clear. Mitigation should be possible by cooperation with groups inside and outside TTÜ.

Strengths

- The excellent research infrastructure funded by development projects of the Estonian Research Council, the Archimedes Foundation, the Environmental Investments Centre, the Ministry of Education and Research and the EU.

- The access to unique and important facilities in Geology, Meteorology and Marine Sciences, including
 - (i) the newly renovated field station at Särghaua (used jointly with the University of Tartu), which serves as a drill core repository and offers students a place for seminars and field courses;
 - (ii) the research vessel, with its costs managed by the research centre through direct research funding, external partnerships (e.g. the Maritime Museum) and commercial services.
- The new uniformly high stipends that will reduce study times and should allow students to finish their studies within four years.
- Graduates have good prospects of finding a job outside academia.

Areas of improvement and recommendations

- Services offered to the public, industry and governmental bodies, including the Estonian Geological Survey, should be further investigated as a possible additional source of funding to cover the running costs of the laboratories.

Teaching, learning, research and/or creative activity

Standards

- ✓ Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses).
- ✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.
- ✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the objectives and learning outcomes of doctoral studies.
- ✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.
- ✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.
- ✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.

Comments

The PhD study process is comparable to that in most other European universities and is based on individual study plans, which are followed up with detailed annual plans. Most information related to teaching and learning is managed by the Study Information System ÕIS. This system keeps track of study programmes, courses, students, teaching staff, grades and credit points etc., and also different types of feedback to lecturers and programmes. Doctoral students manage their study plan in ÕIS and annual reports and evaluations are also stored in the same system. This

makes it possible to analyse different aspects of study programmes, including the present one.

As well as core and specific modules in oceanography and geology the programme offers courses in general subjects including an obligatory course to develop teaching, supervising, communication and planning skills. Students who met the team wanted more structured and regular courses on pedagogy in order to be better qualified for teaching activities. Students regularly take courses from other departments and also from the University of Tartu, in each case for credit. Teaching methods are often innovative because of the high academic quality of the supervisors and knowledge-sharing via international mobility, such as participating in conferences, visiting foreign research laboratories, and doing joint fieldwork. Students receive regular feedback from their supervisors. During doctoral seminars and working group meetings, their research topics and scientific progress are discussed and advice is provided by the supervisors.

The programme has wide-ranging ambitions for its graduates, and it values research quality as the main aspect to be assessed. Because of this, quality control is largely based on the number and quality of peer-reviewed papers. This can cause conflicts between supervisors and students, and the team believes that the number required for thesis submission should be justified by their quality and the requirements of the thesis. The high rate of academic and state employment among the graduates is an additional measure of the success of the programme, although students would value more career advice and support.

Annual reports to the progress review committee are of variable quality and level of detail, which the SER says needs addressing by better advice. The SER also mentions that communication between supervisors and students could be more active, and collection of student feedback should also be improved.

Strengths

- The research and learning environment for PhD students is very good and the feedback from students is generally positive; if problems arise, these are solved directly at the level of the supervisor, research group or department.
- More than 80% of graduates in recent years are employed by academic or state institutions in field related to Earth Sciences.

Areas of improvement and recommendations

- Courses on pedagogy should be more structured and regular.
- Careers advice for students should be enhanced.
- The number of publications required for thesis submission should be justified in terms of their quality and relevance to the thesis.

Teaching staff

Standards

- | | |
|---|---|
| ✓ | Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses. |
| ✓ | Teaching staff develop their supervisory competences and share best practices with one other. |
| ✓ | Teaching staff collaborate in fields of teaching, research and creative work within |

<p>the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions).</p> <ul style="list-style-type: none">✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences.✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses.✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility.

Comments

The qualification requirements for academic staff are set out in various University documents: TTÜ employees should be professional, internationally active in their fields of work and able to work in an international environment. Requirements for supervisors of doctoral theses are further specified in the document "Good Practice of Doctoral Study at Tallinn University of Technology". The recently established tenure-track system with two new young faculty members will strengthen the departments and increase the opportunities to attract new research funding, but current staff working under less favourable conditions will need to feel they are being treated fairly.

New rules for supervisors of doctoral thesis were set in 2016 with the aim to increase the quality of supervision. According to the rules, doctoral thesis topics need to be approved based on the results of the competition among supervisors. The supervisor's ranking is calculated taking into account its number of publications and citations over the last ten years, as well as the number of supervised and defended doctoral theses. Supervisors may not take new PhD students if several students have not defended their thesis yet. All new applications for doctoral projects in Earth Sciences proposed under these new rules in 2016 and 2017 were approved, showing that the scientific quality of supervisors meets the higher standards set by the university. Support for supervisors in developing their supervising skills is provided by the university through various training courses for improving the level of pedagogical, didactic, language and other skills.

It is important to ensure that these new rules do not keep junior staff (including those who might be recruited through the new tenure-track system) from getting early experience of supervision. Experience can be gained through co-supervision, mentoring is available, and the university provides some skills training. In other countries new staff may get preferential treatment in the allocation of studentships, but must then have a senior mentor or co-supervisor.

The self-assessment report argues that the few failures of PhD students were attributable to "unsatisfactory scientific level of the supervisor", though a new supervisor and a revised research topic can rescue the project. However, students clearly stated that the supervisors are good teachers who they take supervision seriously and spend much time in supporting their PhD students.

As already noted, students were keen to teach and to improve their teaching skills. The team did not fully understand how the teaching load is distributed between the

staff and students, and who is responsible for the process, and it was also difficult to understand how teaching is financed. It would help students if the system of allocating and financing teaching was made more transparent.

Strengths

- Staff are highly productive and scientifically very active, and are successful in attracting competitive funding.
- Supervisors are good teachers and take their supervision seriously.
- The appointment of two new young faculty members under the tenure-track system will strengthen the programme.

Areas of improvement and recommendations

- The rules defining the transition to the new system with lecturers and tenure-track professors should be made clear to show that it is being applied fairly.
- The system of allocating teaching should be clarified so that students feel they are being given a fair load.

Doctoral students

Standards

- ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria.
- ✓ Doctoral students plan their studies as well as research and development activities in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.
- ✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses.
- ✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.
- ✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.
- ✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁸.
- ✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates.

Comments

The University strategic plans set doctoral studies among its main priorities. TTÜ aims to increase the quality and efficiency of doctoral studies by supporting long-term mobility of doctoral students, increasing the quality of supervision and improving the evaluation procedure of doctoral students. The University development programme for 2016–2022 aims to increase the graduation efficiency of doctoral students within nominal time to 35% by 2018 and to 50% by 2022.

⁸ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

The number of new doctoral students in the programme has remained stable for some years, with 3 or 4 admissions each year. Admission is based on a candidate's previous education, skills and experience, including an interview. In recent years admission has become noticeably more selective for students from Estonia and from abroad in order to reduce the number of dropouts. International admissions make up 12% of the student body, below the university average, but there is scope for the number to grow.

As noted earlier, students develop their own study plans, in consultation with their supervisors. The students are generally motivated and enjoy working with their supervisors; they appreciate the working environment and the facilities they have. They are largely positive about their supervision and the opportunities to develop their skills and to conduct successful research, with nearly all doctoral projects directly linked to national or international research projects. The team was impressed by the strong informal links between students and supervisors, but noticed rather few opportunities for students to interact and communicate with each other as a group; this could happen through seminars, symposia, regular lunchtime meetings, and so on. Students have good opportunities to travel and present their results in conferences and summer schools. As noted earlier, they have good pathways into careers in both academic and public sector organizations.

Strengths

- The positive overall working environment is appreciated by the students.
- More selective admission processes have reduced student dropout.

Areas of improvement and recommendations

- More efforts should be made to increase the proportion of foreign students, for example by advertising PhD positions internationally.
- Opportunities should be developed for students to meet as a group, formally and informally.

3. Assessment report of SPG at Tallinn University

3.1. Introduction

Tallinn University (TU) is the third largest public university in Estonia, focusing primarily on the fields of humanities, social and natural sciences, and having a particular emphasis on pedagogy. TU was last accredited in 2014.

In 2015, a significant structural and management reform took place which merged 26 existing units into nine: six academic schools (Baltic Film, Media, Arts and Communication; Digital Technologies; Educational Sciences; Governance, Law and Society; School of Humanities; and Natural Sciences and Health); two regional colleges (in Haapsalu and Rakvere) and the library. In addition, five centres of excellence (research clusters), nine research centres and 15 support units were formed. The objective of TU for 2015–2020 is to consolidate activities into five main focus fields: educational innovation; digital and media culture; cultural competences; healthy and sustainable lifestyle; and society and open governance.

Currently within the Physical Sciences Study Programme Group only the Physics programme (80094) admits students at doctoral level. This programme was launched in 2007. Until September 2015, these studies were conducted in the Institute of Natural Sciences and Mathematics, but as a result of the structural reform, the programme was moved to the School of Natural Sciences and Health (SNSH) in 2015. Since then, the SNSH and the School of Digital Technologies (SDT) have taught courses on the programme. There is also some collaboration with other academic units within TU. Students can choose general courses from a list that also includes courses from other Schools. A collaboration agreement between TU and the National Institute of Chemical Physics and Biophysics (NICPB) enables NICPB researchers to be involved in teaching and supervising PhD students.

Overview of programme

Numerical data for students on the programme are given below.

Year	2013	2014	2015	2016	2017
Number of doctoral students	6	6	5	6	6
Admissions	0	0	1	1	1
Number of dropouts	0	0	0	1	1
Number of doctoral theses defended within the standard period + two years	1	0	1	0	0
Number of students going abroad	1	0	0	0	0
Number of international students	0	0	1	1	1

The University appears to have appropriate aims and procedures for doctoral study, setting the minimum proportion of research at 70% as required by the national standards; for Physics it is actually 75%. By 2022 the University aims to have 50% of doctoral students graduating within nominal time plus two years, i.e. six years.

3.2. Strengths and areas for improvement of study programme

3.2.1. Physics

Study programme

Standards

- ✓ The launch and development of the study programme are based on the Standard of Higher Education and other legislation, national strategies, university development plans, the effectiveness of research and development, various analyses (including labour market and feasibility analyses); striving for the best overall programme quality.
- ✓ Doctoral programmes contain at least 70% research, development or other creative work by doctoral students, making the results thereof public in international peer-reviewed research journals or in other ways that have international dimensions.
- ✓ Study programmes incorporate doctoral student participation in conferences and/or other professional activities, and are counted towards completion of the study programme.
- ✓ Doctoral programmes enable doctoral students to acquire leadership and teamwork skills, develop coaching and teaching skills as well as a proficiency in foreign languages at the level needed for successful participation in international working environments.
- ✓ Different components of a doctoral programme form a coherent whole supporting the personal development of each doctoral student.
- ✓ Study programme development takes into account feedback from doctoral students, supervisors, employers, alumni and other stakeholders.

Comments

The doctoral programme in Physics has run since 2007 and since 2015 has been one of four offered in the School of Natural Sciences and Health (SNSH), which has about 80 academic staff, with teaching also provided by the School of Digital Technologies (SDT). There is further input from the National Institute of Chemical Physics and Biophysics (NICPB). The programme was last evaluated in 2014.

The specializations of the programme (statistical physics, mathematical physics, and experimental physics, which turns out to mean experimental plasma physics) are chosen to be different from those of the physics-related doctoral programmes at the University of Tartu and Tallinn University of Technology, but the three programmes do co-operate. It was not clear to the team how the programme fits the main objectives and actions of SNSH mentioned in the SER, which refer to physics only in the context of sustainable material science and teaching sciences. None of the staff who met the team gave a clear view of how physics research fits any strategic aims of SNSH or the University. In its meetings the team was not persuaded by the argument that physics research is essential to the University in training school teachers of physics, nor by the suggestion that physics would flourish more in a Natural Sciences PhD programme.

Currently there are six students on the programme, less than 2% of the total in the university. This is typical for recent years, and in the last ten years only seven PhD students have graduated. In five years there have been three international students,

two drop-outs, one student going abroad and two thesis defences. With such small numbers, analysis is more anecdotal than statistical, and students are encouraged to join activities with other doctoral students where possible. Furthermore, the MSc programme in physics was discontinued in 2016 because of the lack of incoming students, so removing a major channel for students to enter the PhD programme.

Formation of programme councils is voluntary, and the Physics programme does not have one, though SNSH has an overarching Council of Studies. There is a programme administrator of professorial status, programme matters are discussed with staff, and the programme administrator reports annually.

The curriculum is flexible in order to allow choice among the three specializations. There are general courses that develop transferable skills, two courses directed at skills students need in teaching and learning, and then subject-specific courses to support the student's chosen specialization, with both compulsory and elective components. Students get credit not only for all courses within TLÜ but also for courses at other universities. The doctoral courses add up to 25% of the total credits, leaving 75% for the research component.

Students are broadly content with the supervision of their projects and with the support they get from the programme in terms of lecture courses and conference and summer school attendance. The most common problem is insufficient financial support that means they have to work to support themselves and so have restricted time to work on their research. Feedback has led to the introduction of a course on R&D, and there are moves to introduce more programming.

The organizational procedures put in place for the doctoral programme in physics are in line with the standards of the university, with standard requirements for students to graduate. The infrastructure appears to be reasonably well developed for the research undertaken. New opportunities to practice oral presentation skills have been organized at summer and winter schools and the national doctoral schools.

The main problems of the PhD programme arise from the physics research programme which is a major factor that accounts for the very small number of graduates. The research programme is rather small and fractured, and spread over three small areas that span only a small fraction of the discipline of physics. No overall coherence can be identified and thus the visibility of the physics research at TLÜ is rather limited. Moreover, no clear identity exists for this programme that could enable it to be seen as a special strength of physics at TLÜ and that would attract students within this topical area as a consequence. A clear warning sign is the closure of the MSc programme in 2016 because of the lack of interested students. Since a sustainable doctoral programme requires a coherent and well balanced research programme, which creates visibility and is attractive for both prospective students and potential new faculty, all measures for improvement have to start with that.

Obviously, there are different ways to move forward. The easiest fix would be to end the physics PhD programme altogether, as has been done with the physics MSc. That would be easy and perhaps obvious, but it is not the best possible solution, because it would not fix the problems within physics research but instead would further weaken it.

A much better solution would be to redirect the physics research over a period of time to create a vibrant, coherent and well-connected programme within SNSH. That would be very beneficial for physics but could also strengthen the whole research area in SNSH. The new tenure-track programme which is in development could be used as a good mechanism to start such a process. At this point, however, what is

needed is a frank and thorough discussion about the long-term strategy for physics research and its connections within the School of Science and Health. Our impression is that no such discussion has taken place in recent years.

While we do not feel that we have the necessary insight to give a clear recommendation what the focus area should be, we would like to discuss a potential scenario to illustrate how it could work and what elements are needed. Given the research fields in SNSH, it seems that large synergies may exist in terms of complex systems. The physics of complex systems with a clear emphasize on computational physics could be a strong and overarching element in such a research direction. Naturally neuroscience, ecology, and applied mathematics as well as some parts of chemistry could benefit from such a programme. Such a modern interdisciplinary research topic could achieve high visibility over time and would result in a sustainable PhD programme clearly different from the two other physics PhD programmes in Estonia assessed by the team.

Although parts of the existing physics programme could contribute to this area, it would be strongly recommended to make new appointments within the tenure-track system to get this started. To implement such a scenario, strategic discussions are clearly needed at the university level and within SNSH, and a clear long-term plan would need to be established.

In principle, there are other ways go forward, such as to form a joint physics PhD programme with Tallinn University of Technology (TTÜ) or to transfer the existing activities in part to the NICPB and in part to TTÜ. Both options have the disadvantage that TLÜ would not gain in visibility and would miss out synergies within the university.

Compared with the question of the future of the research programme in physics, all other aspects of the physics PhD programme are completely minor and the team felt that it makes little sense to discuss them in great detail. A few aspects are briefly mentioned in the following sections.

Strengths

- The range of courses available is very broad despite the low student numbers, helped by access to courses not only elsewhere in TLÜ but also in other universities.
- Students are mostly satisfied with the programme.

Areas of improvement and recommendations

- Redirect the physics research programme as a matter of urgency using new tenure-track positions to create a vibrant, coherent and well-connected physics programme within SNSH that supports a distinctive and sustainable PhD programme.

Resources

Standards

- | | |
|---|---|
| ✓ | In conducting doctoral study programmes, an adequate number of teaching staff and researchers participate, who hold the appropriate qualifications required to carry out doctoral studies and supervise doctoral theses in a given study programme. |
| ✓ | Universities shall ensure that sufficient funds are available to conduct doctoral studies, to provide development activities associated with doctoral studies and |

<p>research, and to support the professional development of teaching staff and researchers.</p> <ul style="list-style-type: none">✓ Resources (teaching, learning and research environments; libraries; resources required for teaching, learning and research) support the achievement of objectives set out in study programmes as well as the actual teaching, learning and research at the level of doctoral studies. Resource development is sustainable.✓ Trends in the numbers of current learners, admitted learners and graduates (by study programme) in doctoral studies under the study programme group during the last five years indicate sustainability.
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Comments

In talking about programme resources the SER first refers back to a general account of resources within the Physical Sciences Group, which is mostly about extensive learning resources and pervasive IT facilities. Physics is so small that the team was shown mostly chemistry laboratories on the laboratory tour. However, the existing infrastructure of the two physics labs that the team saw is reasonably good. The research grant income obtained in recent years appears rather small and the number of international projects is small.

Students can work with other scientists through doctoral schools, international study and conferences, and collaborative projects. Finding suitable projects for students is challenging. University researchers typically stay only when they are awarded large state-funded projects, but these change frequently and so are unreliable as a source of support for students. The need for students to be in part-time employment also restricts their ability to take up opportunities to work abroad. Students who met the team pointed out that the effort of earning supplementary income was a distraction from their research.

Strengths

- Good infrastructure is available, obtained mainly through European structural funds.
- A collaborative agreement with NICPB fosters collaboration.

Areas of improvement and recommendations

- If the overall research programme is redirected and strengthened as suggested above, it will require investment in resources.

Teaching, learning, research and/or creative activity

<h3><u>Standards</u></h3> <ul style="list-style-type: none">✓ Uniform principles, based on best international practices and agreed upon at the university level, shall be followed while implementing doctoral programmes and assuring the quality of the doctoral studies (including supervision of doctoral theses).✓ Doctoral studies support students' personal and social development, including creating an environment which will prepare them to successfully participate in international working environments at research and development institutions, as well as in the business and public sectors.✓ Supervision of doctoral theses; modern methodology used in teaching and research; organisation of studies; and doctoral students' professional research, development and/or other creative activities all support achievement of the
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<p>objectives and learning outcomes of doctoral studies.</p> <ul style="list-style-type: none">✓ Assessment of outcomes of the learning, research and creative work done by doctoral students is relevant, transparent and objective, and supports the development of doctoral students.✓ Doctoral students are asked for feedback regarding supervision on a regular basis and the results of these surveys are taken into account for quality improvement activities.✓ Effectiveness of the doctoral studies is analysed and such analyses serve as a basis for planning quality improvement activities.
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Comments

Teachers on the doctoral programme must be active researchers with good publications and conference participation. Supervisory practice is monitored by the programme director and SNSH, and supervisors are allocated research students only if they have a good record of supervision, although it is not clear how meaningful this is with so few students. Student feedback is sought and responded to. Teachers on the programme collaborate to improve their teaching and supervisory skills, and use a wide variety of teaching methods including flipped classrooms and group work, and there are weekly research seminars. Students have regular formal and informal feedback on their progress.

Students suggest that the number of credits awarded for experimental research should be increased. The thesis must be defended in English, for which additional training is available. Student work and progress are reviewed annually and discussed by an internal panel. Students have access to an official adviser as well as their supervisor, but as already noted the principal problem is finance. If a student has problems with the supervisor, an additional or new supervisor can be appointed.

Strengths

- All students participate in weekly research seminars and twice a year have to give a presentation on their project.
- Students have the opportunity to go to international conferences as well as to summer/winter schools.

Areas of improvement and recommendations

- The research programme needs to be improved as discussed above.
- The proportion of credits in the programme for practical work should be reviewed, especially for students with experimental projects.
- The SER notes that students are not sufficiently prepared for employment in business or the public sector.

Teaching staff

<h3><u>Standards</u></h3> <ul style="list-style-type: none">✓ Teaching staff participate in research, development and/or creative activity at the level of and to the extent sufficient to conduct doctoral studies in the curriculum group and to supervise doctoral theses.✓ Teaching staff develop their supervisory competences and share best practices with one other.

<ul style="list-style-type: none"> ✓ Teaching staff collaborate in fields of teaching, research and creative work within the university and also with stakeholders outside the university (public sector organisations, enterprises, other research and development institutions). ✓ Teaching staff further their skills at foreign universities or other research institutions, participate in international research and creative projects, and present papers at high-level conferences. ✓ Qualified international and visiting teaching staff are involved in conducting doctoral studies, participating in doctoral thesis defence panels and/or reviewing doctoral theses. ✓ When assessing the work of teaching staff (including their evaluations), the effectiveness of their teaching as well as of their research, development and creative works is taken into account; including the effectiveness of their student supervision, development of their teaching and supervisory skills, and their international mobility.

Comments

All lecturing staff (ten from the participating schools SNSH and SDT and others from NICPB) have a PhD; they are active researchers with a good publication record and regularly attend conferences. A regular seminar series 'From supervisor to supervisor' helps new supervisors to develop their skills, and there are other courses to develop teaching skills. Professional development is fostered by attending conferences and doctoral conferences. External experts also lecture at doctoral schools at different times of year, some abroad.

The teaching staff who met the team did not seem very enthusiastic about their programme. They clearly see its shortcomings, but seem to have no longer-term strategy to move forward. The only idea presented in the discussion was possibly implementing the physics programme in the wider scope of a natural science programme. As pointed out above this does not solve the underlying problem of the weakness of the physics research programme.

Supervisors of successful PhD students are paid a monetary reward.

Strengths

- The teaching staff are free to choose teaching and assessment methods.
- The teaching and research staff are pretty much the same people, which ensures up-to-date lectures in the relevant fields of research.

Areas of improvement and recommendations

- The small number of teaching staff means that teaching tends to limit the time supervisors have available for research.
- The monetary bonus for supervisors of successfully defended PhD thesis in nominal time could bias the judgement and should be eliminated.

Doctoral students

<u>Standards</u>	
<ul style="list-style-type: none"> ✓ When admitting students to doctoral study, their suitability for successful completion of their studies is assessed on the basis of transparent criteria. ✓ Doctoral students plan their studies as well as research and development activities 	

<p>in collaboration with their supervisor(s), setting out specific objectives for each year and taking responsibility for achieving these objectives.</p> <ul style="list-style-type: none">✓ Evaluation of doctoral students is transparent and impartial. Its purpose is to support development of the doctoral students, provide an opinion regarding the effectiveness of their work to date, and assess their capabilities to complete their studies on time and successfully defend their doctoral theses.✓ Universities offer doctoral students counselling on completing their studies and planning their further careers.✓ Doctoral students' extracurricular teaching, research and/or creative activities or other work-related activities at the university support successful completion of their doctoral studies.✓ Doctoral students participate in international mobility programmes or take advantage of other opportunities for learning or research at foreign universities and/or research and development institutions⁹.✓ Alumni are regularly asked for feedback on the quality of the doctoral study, and employers are asked for feedback on the preparation of the graduates.

Comments

For admission, students with a suitable background in physics and mathematics must defend a draft of their doctoral project that the supervisor has previously defended in front of a committee. The supervisor is normally a TU employee, and in special cases can also be external, e.g. from the NICPB, while co-supervisors can routinely be external to TU. A student who does not have a broad enough knowledge of physics has a year to pass a supplementary examination.

Once admitted, students submit a study plan at the beginning of each year, helped by a specialist staff member. They mostly join a research project that gives them extra personal funding. If not, they may have to interrupt or extend their studies, or typically take a job. Students say they would like more opportunity to work in groups, and to discuss their research in some detail with other researchers; this is obviously restricted by the small size of the research programme. Among teaching opportunities, students can co-supervise interdisciplinary projects for BSc and MSc students, which use problem-based learning in groups. However, the SER notes that extracurricular teaching and research done by students is not counted in their assessments.

Academic and personal assistance is available from the TU Career and Counselling Centre. With so few students, there are few alumni or employers to give feedback on the value of their PhD.

The three students who met the team (one of them international) all seemed very happy with their situation. They liked their research topics, had regular meetings and seminars, were actively supervised, and had no complaints about any features of the programme, although inadequate personal funding meant they had to work to support themselves during the programme, which therefore took longer to complete. Despite that, the programme is apparently not very visible or attractive from outside, as shown by the very small number of students within the programme.

Strengths

- The low student:staff ratio is seen as an advantage by students, who are very satisfied with their supervisors.

⁹ In the context of this document, 'research and development institutions' denote both research institutions and research-intensive companies.

Areas of improvement and recommendations

- The very small number of doctoral students reflects the fact that the programme is not sufficiently attractive in its current form, so it should be strengthened to make it more sustainable.
- A uniform system for topping up the student stipend should be introduced to treat all students on an equal footing; if set high enough it would save students from having to work alongside conducting their research projects, which delays the completion of their PhD.