

## **Assessment Report**

# Mathematics and Statistics

Tallinn University

University of Tartu

2017

## Contents

INTRODUCTION .....	3
GENERAL FINDINGS AND RECOMMENDATIONS .....	4
1. ASSESSMENT REPORT OF THE STUDY PROGRAMME AT TALLINN UNIVERSITY .....	6
1.1. INTRODUCTION .....	6
1.2. STRENGTHS AND AREAS FOR IMPROVEMENT OF THE STUDY PROGRAMME BY ASSESSMENT AREAS .....	7
1.2.1. MATHEMATICS (BACHELOR'S STUDIES) .....	7
2. ASSESSMENT REPORT OF SPG AT UNIVERSITY OF TARTU .....	15
2.1. INTRODUCTION .....	15
2.2. GENERAL FINDINGS AND RECOMMENDATIONS AT STUDY PROGRAMME GROUP LEVEL .....	17
2.3. STRENGTHS AND AREAS FOR IMPROVEMENT OF STUDY PROGRAMMES BY ASSESSMENT AREAS .....	18
2.3.1 MATHEMATICS; MATHEMATICAL STATISTICS (BACHELOR'S STUDIES); MATHEMATICS; MATHEMATICAL STATISTICS (MASTER'S STUDIES); FINANCIAL AND ACTUARIAL MATHEMATICS; FINANCIAL MATHEMATICS (MASTER'S STUDIES).....	18

## 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 approved by EKKA Quality Assessment Council for Higher Education [\*Quality Assessment of Study Programme Groups in the First and Second Cycles of Higher Education\*](#).

The aim of the assessment team was the evaluation of the Study Programme Group (SPG) of Mathematics and Statistics in two higher education institutions: Tallinn University and University of Tartu.

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:

<b>Ernst W. Mayr</b>	Professor, Technical University of Munich, Germany
<b>Juha Kinnunen</b>	Professor, Aalto University, Finland
<b>Mats Boij</b>	Professor, KTH Royal Institute of Technology, Sweden
<b>Piret Raukas</b>	Actuary, SEB Bank/Insurance, Estonia
<b>Philipp Schulz</b>	Student, RWTH Aachen University, Germany

The assessment process was coordinated by Karin Laansoo (EKKA).

After the preparation phase, the work of the assessment team in Estonia started on Monday, 20 March 2017, with an introduction to the Higher Education System as well as the assessment procedure by EKKA, the Estonian Quality assurance

organization for higher and vocational education. The members of the team agreed on the overall questions and areas to discuss with each group at the two institutions, who were part of the assessment process. The distribution of tasks between the members of the assessment team was organised and the detailed schedule of the site visits agreed.

During the following days, meetings were held with the representatives of Tallinn University (Tuesday, March 21) and of the University of Tartu (Wednesday, March 22 and Thursday, March 23). In all cases, the schedule for discussions on site for each of the various study programmes only allowed for short time slots to be available for team members to exchange information, discuss conclusions and implications for further questions.

On Friday, March 24, the team held an all-day meeting during which the structure of the final report was agreed upon. Findings of team meetings were compiled in a first draft of the assessment report on this date and, via email exchanges, during the weeks thereafter. 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 two sections, the assessment team summarises their general findings, conclusions and recommendations which are relevant across the whole SPG. In so doing, the team provides an external and objective perspective on the 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 study programmes may be achieved. In formulating its recommendations, however, the assessment team did not evaluate the financial feasibility associated with their implementation.

## **General findings and recommendations**

The level of education in mathematics and statistics in Estonia is high and the resources both in terms of teaching staff and infrastructure give a very good study environment for the students.

Several structural changes on the university level are affecting the development of the study programmes. Moreover, a decreasing number of students forces the institutions to adjust the study programmes they are offering.

The number of students competing for admission in the several study programmes as well as the number of admitted students has been decreasing for several years. The main competitors for programmes in the mathematics and statistics study programme group are computer science programmes which are strongly supported by government. A further decrease in the number of students in mathematics and statistics programmes is a threat that needs to be handled on a national level.

The decreasing number of students is especially a problem regarding the fact that graduates of all programmes in the mathematics and statistics study programme group are in very high demand in the labour market. Employers are generally very satisfied with graduates of all programmes and particularly appreciate their logical thinking skills.

A general threat regarding the teaching staff is that the level of salaries for teaching staff in the universities makes it hard to recruit internationally. As a general finding, the competition for university positions is fairly low.

The international collaboration could be enhanced. All parties would benefit from this in research and teaching. More mobility both for the faculty and the students would be advantageous. As of today, only a small number of students is willing to go abroad during their Bachelor's studies; opportunities should be enhanced and promoted among the students.

E-learning and other modern teaching methods are used at both universities but could be used even more extensively.

# 1. Assessment report of the study programme at Tallinn University

## 1.1. Introduction

Tallinn University (hereafter also referred to as the University or TU) is the third largest public university in Estonia, focusing primarily on the fields of humanities and the social and natural sciences. TU is a result of the merger of several higher education institutions (HEI) (Tallinn Pedagogical University, Academy Nord, Estonian Institute of Humanities, Institute of History of Estonian Academy of Sciences, Academic Library of Estonia) of Tallinn into a single institution, which resulted in the founding of TU as a public university on March 18, 2005.

In 2015, structural and management reform resulted in the merger of 26 existing units into nine units: six schools (Baltic Film, Media, Arts and Communication School; School of Digital Technologies; School of Educational Sciences; School of Governance, Law and Society; School of Humanities and School of Natural Sciences and Health), two regional colleges (in Rakvere and in Haapsalu) and the library.

Tallinn University has about 8,000 students (with about 7% of them international), and over 850 employees, including 420 researchers and lecturers (with 9% of them international).

The study programme group of mathematics and statistics consists currently of one study programme – bachelor of mathematics. This belongs to the academic direction Mathematics and Didactics of Mathematics of the School of Digital Technologies (DT). On September 8th, 2016, there were 33 bachelor students studying the bachelor programme.

The numbers of admitted students, terminating studies and who graduated from the bachelor study programme are presented in the following table 1.

Table 1. Bachelor studies in mathematics

<b>Academic year</b>	<b>Admitted</b>	<b>Students terminating their studies without graduation</b>	<b>Graduates</b>
<b>2011/2012</b>		31	24
<b>2012/2013</b>	27	16	14
<b>2013/2014</b>	23	14	13
<b>2014/2015</b>	19	18	13
<b>2015/2016</b>	11	13	14
<b>2016/2017</b>	10		9 <sup>1</sup>

<sup>1</sup> Figure added by the university in June 2017

## 1.2. Strengths and areas for improvement of the study programme by assessment areas

### 1.2.1. Mathematics (Bachelor's studies)

#### **Study programme and study programme development**

##### Comments

The education in mathematics and statistics is in a transition phase where the Bachelor's study programmes recently have undergone a university-wide restructuring, the Master's study programme in mathematics has been cancelled and there are discussions of starting a new Master's study programme in applied mathematics together with Tallinn University of Technology (TTU). These developments have been forced by the university decision to launch a new Statute of Study Programme and by outer circumstances such as a decreasing number of students. In particular, the university wants to decrease the number of study programmes in order to consolidate its resources to a more focused area.

##### Strengths

- As a result of restructuring the study programme, the number of mathematics courses needed for graduation has increased as mentioned in the self-evaluation.
- New innovative course in Enhanced Learning Unlimited (ELU) provides the opportunity to support the development of generic skills like teamwork.
- Recruitment of a professor in data analysis gives the opportunity to develop courses in a new direction with a strong connection to current trends.
- Low student per teacher ratio gives an opportunity to have high student involvement in study programme development.
- Good reputation for mathematics teacher education.

##### Areas of improvement and recommendations

- The feedback from the students could be treated in a more systematic way. It was mentioned in the interviews that the feedback was collected centrally but not distributed to the study programme directors until it was asked for. A system where the feedback from previous students is visible to future students was mentioned as a better system from the perspective of students.

- The strategies for the future development of the study programme from the university's and from the institute's perspective need to be more coherent.
- The committee encourages the teachers in the programme to actively take part in the development of the new ELU courses.
- Consider development of the study programme that can improve the recruitment of more students in general and, in particular, of underrepresented groups, for example male students. From the interviews with the students we got the information that the study programme has almost no male students.
- The courses in the first semester require less work than reflected by the number of ECTS credits given to them. On the other hand, courses later on require more. Consider revising the study programme so that the workload is distributed more evenly. In particular, the course *Studying at a university* was considered useless by the interviewed mathematics students.

## Resources

### Comments

The study programme has very good, modern infrastructure and study premises. Lecture rooms and computer classes appear to be adequately equipped and the quality of the wider study environment is appropriate. There are comfortable areas for students to socialize and to undertake individual learning and group work. Mostly the study programme is using contemporary software, but there are a few exceptions where more advanced and widely used replacements are available. However, students cannot access computer systems outside of the campus area.

The library has a study centre in the university building. Although the library is not very big, there seems to be a sufficient supply of textbooks and e-books. Access to international journal articles and books is very good. Staff and students can use an extensive list of digital libraries which can be accessed anywhere.

The study programme in Tallinn University uses mainly Moodle as its e-course environment. Study materials are also widely available through the Study Information System (SIS). Staff and students generally find Moodle and SIS satisfactory. Students have access to sufficient resources that support the achievement of objectives in the study programme.

There have been governmental and university reforms that have had effects on the budget of the institute. Study programmes in mathematics and statistics are competing with study programmes in computer science, which is a priority field set by government and therefore has received more support. At the moment, the finances of the institute do not depend on the credit points the institute is going

to assign to the students. For the nearest future, the number of admitted students does not affect the finances thus the resource development is sustainable.

### Strengths

- The premises of the institute, learning and teaching environment as a whole are very good.
- Solid availability of e-libraries, study materials.
- Good use of digital resources, like the Study Information System (SIS).

### Areas of improvement and recommendations

- Consider modernizing the list of software used.
- E-courses could be used more widely.
- Raise student awareness of the possibilities for, and responsibilities in connection with, remote access to university computer systems from off-campus.

## **Teaching and learning**

### Comments

The course descriptions are in the Study Information System (SIS) on the Internet. The description includes the learning objectives of the course, a summary of topics, course material, learning methods, evaluation criteria, examination methods and feedback. The learning objectives are clear both for students and teachers. The achievement of the objectives is monitored after a course by collecting student feedback. The learning outcomes meet the requirements of the stakeholders and the reputation of the study programme is good.

Analysis of student feedback is conducted after the end of every term. The data is summarized for each course and also for each lecturer. The results are made available to all teaching staff and serve as a basis for teachers to improve the course content, methods and presentation. The student feedback is positive, but it is not completely clear for the students how the feedback is taken into account and implemented in practice.

Most of the course material is prepared by the teachers. The material is in Estonian and textbooks in English are not widely used. The students seem to be satisfied with the material. Modern teaching methods such as flipped classrooms, e-learning and ICT tools are emerging, but there is room for improvement here.

According to the site visit very few courses use, for example, the Moodle learning environment. Most of the teaching is rather traditional. A good feature is that the electronic library is accessible also from outside the campus.

The classes are small which makes it possible for the teachers to discuss individually with the students. The students receive support and constructive feedback on their performance and progress also during their courses. Continuous and independent learning is encouraged. The balance of the contact teaching and independent work by the students is half and half, which is a relatively good ratio. The students could be encouraged to do a bit more independent work. First year students with different levels of knowledge have the possibility to choose support courses as electives, for example, language and computer skills. In this sense the learning process is flexible and takes into account individual needs and supports the achievement of the learning objectives.

The grading is based on different components, including homework assignments, tests, overall performance during the course as work in pairs and in groups. The grading is increasingly based on continuous evaluation during courses, which is a very positive trend. The assessment of learning outcomes seems to be objective and supports the individual development of the students.

The development of general skills and competences is supported by group work, seminar presentations, project work and the use of ICT tools. Some of the available software is outdated, and in a number of cases the students do not seem to have remote access to it. Very few students consider going abroad through exchange programmes, and mobility does not seem to be encouraged by the teaching and learning practices. Based on interviews with the students, the pool of partner universities in exchange programmes is very limited and not attractive for them. There are new possibilities to include internships and practical training as part of the studies, which is a very good opportunity to combine theory and practice in the learning process.

The student workload is relatively low in international comparison and the balance between the actual workload of a course and the obtained credit points varies between courses. The workload also varies between semesters. In particular, the first year is probably not challenging enough. It would be good to have a more even workload distribution over the semesters.

### Strengths

- Teaching and learning practices work fine, in general. The students and faculty seem to be satisfied and enthusiastic.
- The learning objectives are stated clearly in the study information system and the students are aware of them.
- Modern teaching methods such as *flipped classroom* are emerging.

- Students have a relatively wide freedom of choice and possibility to focus on topics that are of interest for them.

#### Areas of improvement and recommendations

- Access to up-to-date ICT tools and software should be guaranteed for all students, for example, by having suitable campus licenses. E-learning opportunities could be used more systematically and effectively in teaching and learning.
- The student feedback does not seem to be taken into account systematically in teaching and learning.
- Modern teaching methods could be used more efficiently to reduce the relatively high dropout rate and to attract more students.
- More international comparison, collaboration and mobility should be encouraged. For example, more active and closer connections to universities in other Baltic and Nordic countries could be established.

### **Teaching staff**

#### Comments

All relevant information concerning the teaching staff has been provided in adequate detail (and nonetheless succinctly) in the SER (section 13 and appendix 3). Accordingly, the teaching staff for the study programme comprises nine persons. Six of these have a Ph.D. (resp., Cand. Sci.) degree, one is a Ph.D. candidate, and two have a Master's Degree (M.Sc.). All these teachers hold permanent positions, they have been recruited by public contest, and their scientific qualifications meet the corresponding legal requirements.

As a general remark, the evaluation team considers positively the fact that the budget (for the institute and thus indirectly for the teaching staff) does not depend on the number of students, that it is smoothed over several years, and that 15% are indicator based. This certainly helps the efforts of the department to maintain and/or improve standards even in the view of declining student numbers.

It is often said that teachers' salaries (here: at the university) are not competitive with industry and (some) other organizations. In view of this, it still has to be remarked on the positive side that, over the last four years, salaries have risen about 25%, and that, of course, they could/should be even higher.

#### Strengths

- The teachers possess the necessary qualifications.

- Employers are generally very satisfied with graduates of the programme and particularly appreciate their logical thinking skills (obviously, this judgement also reflects on the teachers!)

#### Areas of improvement and recommendations

- The lack of a Master's programme (building on this BSc programme) is perceived as a problem by the staff, both with regard to attracting students to the BSc level programme, but also to the attractiveness of the teaching.
- Research plays no significant role, funds from the department or the university, even though available, are not used substantially.
- The teaching methods of some of the teaching staff are still rather traditional.
- The Institute should improve on the use of e-learning/digital systems available to support teaching and learning, also the number of staff/teachers employing these systems.
- More teaching material should be made available in some cases.

## **Students**

### Comments

Regarding the number of students, a continuous decrease in recent years can be pointed out. In the last two years however, the number of admitted students remained constant. The rather low number of students is a central reason for several strengths and challenges mentioned in this report. Of course, the institute is trying and working hard on increasing the number of applicants for the study programme. The chances for this should be quite good since it is observed that high school pupils in general are quite computer literate.

On the other hand, the Ministry of Education (of Estonia) does not provide any forecasts about the number of graduates needed (from this programme) in the country. This is significant, in particular, with respect to the fact that the department/institute has a strong orientation (for obvious historical reasons) towards teacher education.

In general, the measures that have been taken to increase the number of applicants can be seen as an improvement area. The visibility of the study programme especially in comparison to the study programmes in Tartu is limited; contacts to schools and other ways to attract more students should be intensified.

The dropout rate is on an average level; around half of the students leave the institution without graduation. Two main reasons can be figured out: On the one hand the transition to pure mathematics is challenging for students, especially as mathematics at the university level differs from high school mathematics, on the other hand many students work in parallel which causes time constraints for the students. In this context it has to be stressed that the support students can get from the university is very good. Teachers and support staff are available when needed, even though students are sometimes hesitant to contact them.

The overall satisfaction of students, alumni and employers is high. Especially job market opportunities for graduates are good and employment rates are high. For employers and alumni, the acquired ability of logical thinking is the decisive factor for employers to hire graduates of the study programme

Though the level of satisfaction is generally high, the collection of feedback and improvement ideas appears to be rather unsystematic. Students give feedback to every course but are not aware of what happens with it afterwards, there is no transparent procedure within the faculty for dealing with this information. Also feedback from alumni is acquired through personal contacts, but a systematic approach to keep track of alumni occupation is missing.

Another major improvement area is the opportunities for students to spend time at other higher education institutions. Only very few students go abroad during their studies. Besides personal issues the main reasons are the very low number of cooperation partners and the lack of awareness of existing opportunities. International affiliations of the department and the study programme in particular should be improved; students should be encouraged to use available opportunities to study abroad.

### Strengths

- High level of satisfaction among students, alumni and employers.
- Good labour market chances for graduates, high employment rate.
- Close contact between students and members of the faculty, direct and individual support available for students.

### Areas of improvement and recommendations

- Limited visibility and attractiveness of the study programme for future students (especially in comparison to the study programmes at Tartu University).
- International mobility of students is very limited, low number of cooperation partners and insufficient awareness of exchange opportunities for the students.

## Assessment Report on Mathematics and Statistics

- Based on interviews, feedback of students and alumni is analysed unsystematically, students do not get responses to comments and reviews they address towards the faculty.
- Dropout rate is on an average level even though support from the faculty exists if needed. Students are hesitant to ask for support and should be encouraged to do so.

## 2. Assessment report of SPG at University of Tartu

### 2.1. Introduction

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

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

Since the beginning of 2016, the academic structure of the university consists of institutes and colleges of four faculties (valdkond) and university's institutions not affiliated to any faculty.

The four faculties are: the Faculty of Arts and Humanities, the Faculty of Social Sciences, the Faculty of Medicine and the Faculty of Science and Technology.

There are approximately 13,400 students (as of 01.02.2016) studying at the university's four faculties. The number of visiting and international students is about 800. The number of doctoral students is 1,300, with around 100 doctoral defences taking place each year.

The Institute of Mathematics and Statistics is the only structural unit in the university responsible for the programmes in the group of Mathematics and Statistics.

Study programmes within the study programme group of Mathematics and Statistics in the University of Tartu are the Bachelor's programmes of Mathematics and Mathematical Statistics; as well as the Master's programmes of Financial and Actuarial Mathematics; Financial Mathematics; Mathematics; Mathematics and Statistics and Mathematical Statistics.

The Master's programme of Mathematics and Statistics was launched only in 2016 by merging the programmes of Mathematics and Mathematical Statistics. Correspondingly, the latter two programmes will be closed in 2019.

In 2017, the Institute plans to merge the Master's programmes of Financial and Actuarial Mathematics and Financial Mathematics into the programme of Actuarial and Financial Engineering, and, correspondingly, the former two programmes will be closed in due time.

General data related to students in the programme group is presented in the following table.

Assessment Report on Mathematics and Statistics

Level of study	Code	Curricula	Number of admissions						General number of students					
			2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
Bachelor's studies	2472	Mathematics	34	29	21	18	16	24	93	89	67	61	56	51
Bachelor's studies	2474	Mathematical statistics	15	21	25	21	26	26	74	77	66	62	66	71
Master's studies (3+2)	2577	Financial and Actuarial Mathematics	9	6	12	7	4	4	28	25	26	25	14	9
Master's studies (3+2)	2608	Mathematics	7	3	5	4	2		17	14	16	15	12	4
Master's studies (3+2)	2611	Mathematical statistics	9	6	10	3	6		21	20	20	20	15	10
Master's studies (3+2)	119157	Financial Mathematics			6	3	7	8			6	4	9	11
Master's studies (3+2)	144957	Mathematics and statistics						13						13
			<b>74</b>	<b>65</b>	<b>79</b>	<b>56</b>	<b>61</b>	<b>75</b>	<b>233</b>	<b>225</b>	<b>201</b>	<b>187</b>	<b>172</b>	<b>169</b>
			<b>Total number of graduates</b>						<b>Graduated in standard period of study</b>					
Level of study	Code	Curricula	2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
Bachelor's studies	2472	Mathematics	17	16	23	10	10	17	9	8	16	5	7	9
Bachelor's studies	2474	Mathematical statistics	11	12	29	13	11	14	10	9	21	8	11	8
Master's studies (3+2)	2577	Financial and Actuarial Mathematics	9	9	8	6	11	9	3	3	2	2	9	6
Master's studies (3+2)	2608	Mathematics	2	5	3	2	6	4	1	2	3	2	2	3
Master's studies (3+2)	2611	Mathematical statistics	4	8	6	4	8	4	2	4	6	2	7	2
Master's studies (3+2)	119157	Financial Mathematics				5		3				5		2
Master's studies (3+2)	144957	Mathematics and statistics												
			<b>43</b>	<b>50</b>	<b>69</b>	<b>40</b>	<b>46</b>	<b>51</b>	<b>25</b>	<b>26</b>	<b>48</b>	<b>24</b>	<b>36</b>	<b>30</b>

## 2.2. General findings and recommendations at study programme group level

The Mathematics and Mathematical Statistics education at the University of Tartu has a good reputation in Estonia. The university offers three levels of education in Mathematics and Mathematical Statistics. The overall satisfaction of the stakeholders with the programme seems to be very high. Alumni/ae of this study programme group are highly valued in the labour market. Connections to business, industry and public institutions are very good.

The Institute of Mathematics and Statistics has good infrastructure and study premises. Students have access to sufficient resources which support the achievement of objectives in the study programme. Lecture rooms and computer classes appear to be adequately equipped; however students cannot access computers from off-campus. Staff and students can use an extensive list of digital libraries which can be accessed from anywhere.

Based on the interviews, students were aware of the learning objectives, which are stated in the study information system. Many courses use the Moodle e-learning environment to share digital course material, submit and assess homework. The ECTS credits students receive for courses, when compared to their workload, seem to be higher than assumed. Students could be encouraged to do more independent work with textbooks. The seminars "From Teacher to Teacher" are a sign of good practice and offer opportunity to discuss modern teaching methods. These seminars could benefit from student participation.

The university values student feedback. The university has developed a good system to gather feedback from students and is developing a new improved feedback system. As a result, students feel that their feedback has been and is being taken into account.

The number of admitted students has been decreasing for several years. The main competitors for programmes in the mathematics and statistics study programme group are computer science programmes which are strongly supported by government. The institute has taken several actions to increase the number of admissions and, according to last year's results, the measures seem to be effective.

The institute could benefit from tighter international cooperation with other universities. This includes both students' and teachers' collaboration and mobility. Even though the institute supports studies abroad, the students' willingness to go abroad during their Bachelor studies is very low and should be supported even more.

## 2.3. Strengths and areas for improvement of study programmes by assessment areas

2.3.1 Mathematics; Mathematical Statistics (Bachelor's studies); Mathematics; Mathematical Statistics (Master's studies); Financial and Actuarial Mathematics; Financial Mathematics (Master's studies).

### Study programme and study programme development

The mathematics and mathematical statistics education at the University of Tartu has a very good reputation in Estonia. The study programmes are in line with standards in higher education and other legislation. The overall structures of the programmes appear to be suitable to achieve the desired outcomes. Graduates of the programmes are in very high demand in the labour market, especially as having a Master's degree is seen as a real benefit and increases the graduates' competitiveness in the job market.

In general, study programme developments and improvement processes work very well. All stakeholders, including teaching staff, students, graduates and employers are to some extent involved in the processes. Especially the students' opinion is adequately considered in this process, the students get the feeling that their feedback and ideas are taken into account.

**The BSc programmes in Mathematics and Mathematical Statistics** are under pressure from the university and faculty to become more general and possibly even to merge. Other programmes in the natural sciences have been merged. Such changes can undermine the possibility to support the students in developing important mathematical skills such as logical thinking, highly valued by alumni and employers according to the interviews.

**The Master's programmes in Mathematics and Mathematical statistics** have been merged, but the new programme is not assessed. However, the recommendations are relevant for it. The MSc programme in mathematics is small and mostly focused on preparing students for PhD studies in mathematics. Programme councils with representatives from employers are leading the development of the programmes. The programmes are unique in Estonia since there are no other MSc programmes in mathematics or mathematical statistics in the country.

The international one-year **Financial Mathematics Master's programme** will merge with the two-year **Financial and Actuarial Mathematics** Master's programme to become one two-year Actuarial and Financial Engineering programme taught in English and accessible for both Estonian and international Bachelor graduates from mathematics and related disciplines. This decision is

seen as very reasonable regarding the situation of the existing two study programmes and creates good opportunities for the future. With this change a balancing module is introduced in order to be able to accept students with different backgrounds. This new programme is not assessed but the recommendations are relevant for it. The two study programmes are considered to be a more applied option on the Master's level besides the study programme of Mathematics and Mathematical Statistics also offered at the University of Tartu. The programmes also include short internships at companies to foster practical skills of the students.

### Strengths

- High standards and very good reputation for the Mathematics and Mathematical Statistics education at the BSc and MSc level.
- The presence of all three levels of education in Mathematics and Mathematical Statistics at the University of Tartu.
- Special support for first-year students to ease the transition from high school to university
- Well-functioning system to handle feedback from students on the course level according to the interviews with the students. (A new improved system will also be launched soon.)
- The programmes support the students' development in how to think about data.
- The Bachelor's programmes contain practical training of at least four weeks.
- Practical training through internships is an important part of the Financial Mathematics and Financial and Actuarial Mathematics programmes.
- Good contacts with industry, for example through the partnership with Swedbank.

### Areas of improvement and recommendations

- The overall picture of the education starting from the BSc level through the MSc level could be made clearer to the students, for example in what way the different courses fit together in the programmes. There is also a risk that courses live their own life independent of changes in the neighbouring courses.
- On the Bachelor's level it is important to monitor the development of the students' mathematical skills such as logical thinking as the changes in the first year mathematics courses Calculus I and II settle.

- Consider including more case studies in the MSc programme in mathematical statistics. (Interview with master students and alumni)
- Consider introducing more courses relevant for biostatistics and big data in the MSc programme in mathematical statistics. (Interview with master students and alumni)
- In the Financial Mathematics and Financial and Actuarial Mathematics programmes possibilities for teachers to do shorter internships at companies in the area would help making sure that the education is up to date in terms of terminology and methods used. Introduction of such internships has already been discussed according to the interviews.
- Go over the relation between ECTS credits and workload for the students, who, according to the interviews, saw this as somewhat uncorrelated for different courses in the programmes.
- Make benchmarking comparisons with well-regarded universities in Europe in order to see that the standards and content of the programmes are comparable. According to the interviews the comparisons had been made, but with respect to not so well-regarded or not so comparable universities.

## Resources

### Comments

The Institute of Mathematics and Statistics has good infrastructure and study premises. Lecture rooms and computer classes appear to be adequately equipped, and the quality of the wider study environment is appropriate. There are comfortable areas for students to socialize, to undertake individual learning and group work. The computers in classes are equipped with the necessary software. However students cannot access computer systems outside of the campus area.

The library of the Institute is situated in the Institute premises. Although the library is not big, there seems to be a sufficient supply of textbooks and e-books. Access to international journal articles and books is very good. Staff and students can use an extensive list of digital libraries which can be accessed from anywhere. Students also brought out the possibility to buy some textbooks in Estonian for a reasonable amount of money. The institute has a budget for textbooks which is not always entirely used.

The University of Tartu uses Moodle as its e-course environment. Study materials are also widely available through its Study Information System (SIS). Staff and students generally find Moodle and SIS satisfactory. The lecturers compose their own lecture notes which are also often available for students online. Students have access to sufficient resources which support the achievement of objectives in the study programme.

There have been governmental and university reforms which have had effects on the budget of the Institute. Mathematics and Statistics programmes are competing with computer science study programmes which are a priority field set by government and therefore have received more support. The budget is also influenced by the low number of admitted students. However there are some hopeful signs for the future such as good admission numbers in the year 2016 and the launch of new basic modules in Mathematics in the faculty which has increased the teaching volume of the Institute.

The Institute has some collaboration with private sector industry which might provide some financial resources in the future regarding, for example, scholarships or recruiting lecturers. This kind of collaboration is reasonable and there seems to be potential for partnerships with more companies.

### Strengths

- The premises of the institute, learning and teaching environment as a whole are very good
- Solid availability of e-libraries, study materials
- Good use of digital resources, like e-courses, Study Information System

### Areas of improvement and recommendations

- Provide students access to university computer systems from outside campus.

## **Teaching and learning**

### Comments

The course descriptions are clearly represented in the study information system on the internet. The description includes the learning objectives of the course, a summary of topics, course material, learning methods, evaluation criteria, examination methods and feedback. The learning objectives are clear both for students and teachers. The achievement of the objectives is monitored after a course by collecting mandatory and voluntary student feedback. The feedback scores have been high, which indicates that the students are satisfied. The learning outcomes meet the requirements of the stakeholders and the reputation of the study programme is very good. "From teacher to teacher" seminars seem to be an excellent forum to discuss modern teaching methods.

Most of the courses use e-learning environments, including ICT tools, course materials and submission of the homework assignments. Most of the courses have electronic material prepared by the teachers. In the Bachelor's programmes

the material is predominantly in Estonian and textbooks in English are not widely used. In the Financial and Actuarial Mathematics and Financial Mathematics programmes considerable amount of courses are carried out in English and in the future the whole merged programme will be taught in English. The students seem to be satisfied with the material provided, but very few of them have used material other than given by the teacher. The students could be encouraged to find more material themselves, for example, by reading standard textbooks in English.

The curriculum in actuarial mathematics uses the international IAA standards and international comparisons are also made in financial mathematics. Some of the programmes used as benchmark programmes, for example Mälardalen in Sweden, could be of higher standards.

The development of general skills and competences is supported by teamwork, presentations by students and use of ICT tools. Elective practical training and internships are available. Students feel that the teaching methods are somewhat traditional. Some of the students would like to have more training in written and oral presentation.

Some of the courses have lectures and problem sessions separately, some courses use mixed lessons. Classes are small and the teacher per student ratio is high. Thus it is possible for the teachers to discuss individually with the students. The students receive support and constructive feedback on their performance and progress also during their courses. Continuous and independent learning is encouraged. The balance of the contact teaching and independent work by the students is about half and half, which is a relatively good ratio. The learning process is flexible, takes into account individual needs and supports the achievement of the learning objectives.

A number of courses use, for example, the Moodle learning environment for digital course material, assessment, homework submission, and/or discussion forums. Mathematical and statistical software is integrated into several courses. Separate programming courses and internships are appreciated by the students and the employers. In the case of Financial and Actuarial Mathematics and Financial Mathematics employers are involved in the programme committee, seminars and lectures, which gives the students a good view of how theory is used in practice. Several thesis topics are proposed by national institutions and industry. This is a very good opportunity to combine theory and practice in the learning process. Both students and employers would like to have more real life data and case studies in the courses.

The grading is based on different components, including exams, homework assignments, tests, and overall performance during the course, which is a very positive trend. Several courses offer more challenging problems with extra points and additional material for students who are interested in delving deeper into a topic. Some courses include projects and presentations by students. Most examinations are written, but oral examination is also possible in some courses. The assessment of learning outcomes seems to be objective and supports the individual development of the students.

The quality of Master's theses is high, in accordance with the goal of the programme to train experts and prepare students for doctoral studies.

The student workload is relatively low in international comparison and the balance between the actual workload of a course and the number of credit points assigned to it varies between courses. Some of the courses are very challenging, but the students do not see this as a big problem. However, it would be good to have a more even workload distribution among the courses and the semesters.

### Strengths

- Teaching and learning practices work fine in general. The students and faculty seem to be satisfied and enthusiastic.
- The learning objectives are stated clearly in the study information system and the students are aware of them. The achievement of the objectives is monitored by student feedback, which has been positive. The students also feel that the feedback is taken into account.
- E-learning and modern teaching methods are implemented in many courses. The students get support and feedback on their performance during courses. Continuous learning and assessment methods are used extensively.
- The programs have high standards. Mathematical thinking and ICT skills are obtained in teaching and learning. More challenging problems are offered for students who want to go deeper and support is offered for students who have difficulties. Connections to business, industry and public institutions are very good.
- Clear labour market oriented learning outcomes. The actuarial programme uses the international IAA standards.
- Good practices in teaching and learning are shared in regular "From teacher to teacher" meetings. Teachers are interested in further developing their skills in teaching and learning.

### Areas of improvement and recommendations

- Off-campus access to ICT tools and software should be guaranteed for all students, for example, by having campus licenses. E-learning opportunities could be used more systematically and effectively in teaching and learning.
- Modern teaching methods could be used more extensively to reduce the relatively high dropout rate and to attract more students.
- Fewer contact hours and more independent student work could give better general skills and competences. The students could be encouraged to find

information by themselves, for example, by reading international textbooks in English.

- International benchmark programmes in financial mathematics should be chosen among the best and most comparable institutions internationally.
- At the moment, the International one-year programme is too short, but this is not a problem after merging the programs together in the future.
- It would be important to have student representatives in "From teacher to teacher" meetings as well.
- More international comparison, collaboration and mobility would be encouraged. For example, more active and closer connections to universities in other Baltic and Nordic countries could be established.

## Teaching staff

The relevant information concerning the teaching staff has been provided in adequate detail (and nonetheless more or less succinctly) in the SER (in the five "Teaching Staff" subsections as well as appendix D4).

The teaching staff for the Mathematics Bachelor study programme comprises 50 persons (among them 5 professors, 11 associate professors, 16 lecturers, 8 (senior) research fellows, and 4 assistants; there are also four with a different status, and two belong to two groups each). 34 of these have a Ph.D. degree, 9 hold a Cand. Sci. degree, and 8 have a Master's Degree (M.Sc.) or similar. For the Mathematical Statistics Bachelor study programme, the teaching staff consists of 60 persons (the subdivision, as above, being 6, 15, 18, 4, 7, and 7, and three belonging to two groups each). Again, 34 of these hold a Ph.D. degree, 9 are Candidates of Sciences, and 17 have a Master's degree or similar.

The teaching staff for the Mathematics Master's study programme comprises 15 persons (among them 5 professors, 5 associate professors, 2 lecturers, and a research fellow; there is also one with a different status (emeritus), and one belongs to two groups). 8 of these have a Ph.D. degree, and 7 hold a Cand. Sci. degree. For the Mathematical Statistics Master's study programme, the teaching staff consists of 16 persons (the subdivision, as above, being 2, 5, 5, 2, 2). Again, 8 of these hold a Ph.D. degree, 5 are Candidates of Sciences, and 3 have a Master's degree or similar.

The teaching staff for the Financial and Actuarial Mathematics and the Financial Mathematics Master's study programmes comprises 25 persons (among them 3 professors, 11 associate professors, 6 lecturers, and a senior research fellow; there are also two with a different status, and two belong to two groups each). 14 of these have a Ph.D. degree, 8 hold a Cand. Sci. degree, and 3 have a Master's Degree (M.Sc.) or similar.

Almost all members of the teaching staff hold permanent positions (which was not the case in the past), they have been recruited by public contest, and their scientific qualifications meet the corresponding legal requirements. Also, almost all members of the teaching staff are full-time, very few have a fractional teaching load, and some also have other duties, like management.

For quite some time, government funding for teaching increased every year, and the funding is basically independent of the size of the teaching staff (which recently has gone down slightly). It was stated that the salaries in the department are generally lower than in certain other faculties (and, of course, also lower than for comparable jobs outside the university). Therefore, the faculty would very much like to achieve a more equal playing field compared to other areas (like IT), which are specially supported, for instance, by the government. While there are, of course, good reasons for the latter, the teachers also stress the fundamental and central role of mathematics as well as statistics for modern science and engineering.

The evaluation team has found that the faculty has a very positive attitude towards quality assessment and maintenance, including the further development of the study programmes in the future. This is also very significant in view of the upcoming retirements. The hiring of new faculty has to be seen as a good opportunity to adapt to new powerful and significant developments in the field(s) and in technology, the importance of which cannot be underestimated.

In spite of the widely recognized high standards of the study programmes (and the corresponding recognition of the teachers and scientists), it is very hard for the department/faculty to extend this to the international level. Internationalization efforts (with regard to faculty) are mainly based on individual contacts with colleagues in other EU countries (and some others). It has been observed that, for instance, it is very hard to attract international faculty (except for short visits), mainly for financial reasons.

#### Strengths.

- The study programmes exhibit very good standards.
- The attitude towards study programme development is very positive.
- The inclusion of practical aspects has improved over the years.
- The combination of practical and theoretical teaching is considered as usually very good.

#### Areas of improvement and recommendations

- The tool of "collegial feedback" is generally considered useful, staff participate, however, it should probably be strengthened even more; this is also quite relevant in view of the fact that many courses have been/are being taught by the same teacher for a long time, say five years or more.

- This very same issue could also be one of the reasons for the observation of the evaluation team that, in some cases, teaching methods could be reconsidered and adapted and should be improved.
- Internationalization efforts (here regarding faculty and teaching staff) are important and should be strengthened.

## Students

### Comments

On the Bachelor level, the number of admissions has stopped decreasing in recent years, in Mathematics it has even increased in the last year. The university is taking several actions such as teachers visiting schools and school groups visiting the university in return to increase the popularity of the Mathematics and Mathematical Statistics study programmes among high school students and to promote studies at the University of Tartu. Moreover, the university offers competitions especially for the very talented high school students. The expert panel explicitly encourages the university to continue in this direction as one of the main challenges for the study programmes can be seen in the popularity of the related field of computer science, therefore it has to be assured that the quality of applicants and admitted students remains high in the future as well.

The merger of the two Master's programmes of Mathematics and Mathematical Statistics appears to be reasonable regarding the very low number of applicants in recent years in the old separate programmes. The new programme started with more students than in the old programmes together in their last years, this is a first success. The university is encouraged to continue advertising the merged programme among students in Bachelor's programmes, especially as graduates with a Master's degree are in very high demand.

Regarding the two old programmes of Financial and Actuarial Mathematics (two-year programme, 120 ECTS) and Financial Mathematics (one-year programme, 60 ECTS), it can be seen that especially for the two-year programme the number of admitted students was very low in the last years. From this point of view and also considering the similarities and overlaps in the curricula, merging the two programmes into a new two-year programme fully taught in English language and accessible for both Estonian and foreign applicants appears to be very sensible. As more students are eligible to take part in the joint programme, the merger can be seen as a chance to again achieve higher numbers of students. Resulting from the merger of the two study programmes, the admission requirements are also to be adjusted and the new programme is to be open for applicants with Bachelor's degrees in related disciplines. In his context it has to be assured that their capabilities meet the prerequisites of the new study programme and the drop-out rate does not increase.

The drop-out rate within the Bachelor's programmes appears to be on an acceptable level. Main reasons for dropping out are the differences regarding

content and methods between high school and university mathematics on the one hand and the fact that a considerable number of students work while they are students and therefore cannot handle their overall workload any longer on the other hand. To simplify the transition from school to university mathematics, several actions have recently been taken leading to a decrease of the number of students dropping out in their first semesters. This mostly includes a mentoring system for first-year students getting individual peer support from students in upper years. In addition, the teaching staff is willing to assist all students in an adequate way if requested.

The drop-out rate on the Master's level is at an acceptable level. The main reason for dropping out is the fact that a considerable number of students work while they are students and the overall workload becomes unmanageable.

Regarding all study programmes, it can be seen that the number of students graduating in the standard period of study is at an acceptable level as well.

The overall satisfaction of students, alumni and employers is very high. Only very few suggestions for improvement were mentioned by the students, they appreciate their learning environment and career opportunities.

It has to be pointed out that the system of collecting and analysing feedback from the students appears to work very well in all study programmes. Students give feedback to several courses every semester, this feedback is discussed in the faculty under participation of student representatives. Students get to know about changes made due to their feedback; moreover aggregated feedback results are publicly available to all students. The students notice that their opinion is taken into account and they feel properly informed, this contributes a lot to the overall satisfaction and motivation.

On the Bachelor's level, the number of students studying at other higher education institutions, especially abroad, is rather low. In comparison to the Bachelor's programmes there are more Master's students taking the opportunity to study abroad for a semester. However this number could be increased even more. The mobility of students is very low in the one-year Financial Mathematics programme which is already limited to one year and designed mostly for foreign students, which complicates studying at other higher education institutions. After the merger of the 2-year Financial and Actuarial Mathematics and 1-year Financial Mathematics study programmes into the Actuarial and Financial Engineering programme, all students in the new programmes will have the opportunity to study abroad.

Cooperation partners for outward mobility exist, however the panel encourages the university to provide as many exchange opportunities as possible to their students and motivate them to use them. It has to be pointed out as highly positive that the university acts very supportive when a student wants to study abroad, both regarding organisational issues and the recognition of achievements at the partner university. Consequently, the reason for students not to go abroad can rather be found in their personal environment (e.g. work, raising children) than in the lack of support by the university.

Regarding the labour market opportunities, differences can be pointed out between the Bachelor's and Master's programmes as well as between the "pure" Mathematics and the rather applied Mathematical Statistics or Financial and Actuarial Mathematics programmes. While outside-university career opportunities for graduates of "pure" Mathematics are not always clear and the percentage of students pursuing a research career (including PhD studies after graduation from Master's programmes) is higher, graduates from the more applied programmes are in very high demand and don't have problems to find employment. Though also graduates with a Bachelor's degree already easily find a job, having a Master's degree is seen as a real advantage in the labour market, in some fields even as a prerequisite for getting certain jobs. In general, employers are very satisfied with the graduates' ability of logical thinking; moreover they appreciate their software utilization and programming skills.

An area of improvement can be found regarding communication and project-based working skills of students and graduates, leading to the suggestion to include more complex (and real-life data based) problem sets as well as communication-oriented examinations (e.g. presentations or oral exams where students have to explain and defend their ideas) into all of the curricula.

### Strengths

- Very high overall satisfaction of students, alumni and employers.
- Labour market opportunities with Bachelor's degrees already good. However Master's degree is seen by both employers and students as real advantage as those graduating with a Master's degree are in very high demand on the labour market.
- Number of admitted Bachelor's students no longer decreasing in the last years, commendable actions taken by the university to promote the study programmes among high school students.
- Special support for first-year Bachelor's students to ease the transition from high school to university.
- Merger of the two study programmes Financial Mathematics and Financial and Actuarial Mathematics appears to be a very sensible decision.
- There is close contact between students and members of the faculty, direct and individual support available for students.
- There exists a well-functioning system of feedback collection and analysis, students have the feeling that their opinions and suggestions matter.
- Strong support is available for students willing to study abroad both regarding organisational issues and the recognition of academic achievements from abroad. More students are willing to go abroad on Master's level compared to the Bachelor's programmes.

Areas of improvement and recommendations

- Number of admitted Bachelor's students still not very high, as the Institute is facing stiff competition by related fields in computer science. The same applies for the Master's level – the number of admitted students is still not very high, promotion of Master's studies, including of the new Actuarial and Financial Engineering Master's programme, among students in the Bachelor's programmes could be improved.
- Communication and project-based working skills of graduates could be improved, as indicated by the employers, therefore more complex problem sets and communication-oriented examination methods should be applied.
- Only a small number of students is willing to go abroad during their Bachelor's studies; opportunities should be enlarged and promoted among the students. There is no opportunity to study abroad in the one-year Financial Mathematics programme.