STUDIJŲ KOKYBĖS VERTINIMO CENTRAS

Šiaulių universiteto

STUDIJŲ PROGRAMOS *MATEMATIKA (valstybinis kodas - 621G10006)* VERTINIMO IŠVADOS

EVALUATION REPORT OF *MATHEMATICS* (*state code -621G10006)* STUDY PROGRAMME

at Šiauliai University

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Išvados parengtos anglų kalba
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DUOMENYS APIE ĮVERTINTĄ PROGRAMĄ

Studijų programos pavadinimas	***Matematika***
Valstybinis kodas	621G10006
Studijų sritis	Fiziniai mokslai
Studijų kryptis	Matematika
Studijų programos rūšis	Universitetinės studijos
Studijų pakopa	Antroji
Studijų forma (trukmė metais)	Nuolatinė (2)
Studijų programos apimtis kreditais	120
Suteikiamas laipsnis ir (ar) profesinė kvalifikacija	Matematikos magistras
Studijų programos įregistravimo data	2010-05-03

INFORMATION ON EVALUATED STUDY PROGRAMME

Title of the study programme	***Mathematics***
State code	621G10006
Study area	Physical sciences
Study field	Mathematics
Type of the study programme	University Studies
Study cycle	Second
Study mode (length in years)	Full-time (2)
Volume of the study programme in credits	120
Degree and (or) professional qualifications awarded	Master of Mathematics
Date of registration of the study programme	2010-05-03

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I. INTRODUCTION

Background of the evaluation process

The evaluation of on-going study programmes is based on the **Methodology for evaluation of Higher Education study programmes,** approved by Order No 1-01-162 of 20 December 2010 of the Director of the Centre for Quality Assessment in Higher Education (hereafter – SKVC).

The evaluation is intended to help higher education institutions to constantly improve their study programmes and to inform the public about the quality of studies.

The evaluation process consists of the main following stages: *1) self-evaluation and self-evaluation report prepared by Higher Education Institution (hereafter – HEI); 2) visit of the review team at the higher education institution; 3) production of the evaluation report by the review team and its publication; 4) follow-up activities.*

On the basis of external evaluation report of the study programme SKVC takes a decision to accredit study programme either for 6 years or for 3 years. If the programme evaluation is negative such a programme is not accredited.

The programme is **accredited for 6 years** if all evaluation areas are evaluated as "very good" (4 points) or "good" (3 points).

The programme is **accredited for 3 years** if none of the areas was evaluated as "unsatisfactory" (1 point) and at least one evaluation area was evaluated as "satisfactory" (2 points).

The programme **is not accredited** if at least one of evaluation areas was evaluated as "unsatisfactory" (1 point).

General

The Application documentation submitted by the HEI follows the outline recommended by the SKVC. Along with the self-evaluation report and annexes, the following additional documents have been provided by the HEI before, during and/or after the site-visit:

No.	Name of the document
1.	Feedback forms
2.	Examination material

Background of the HEI/Faculty/Study field/ Additional information

This report summarizes the observations of the expert team based on the analysis of documents prepared by the self-assessment group consisting of experts of Šiauliai university (SU) and the information obtained from the interviews during the visit at the SU. The

members of the Team acquainted themselves with and assessed the documentation and annexes provided by the Lithuanian Centre for Quality Assessment in Higher Education (CQAHE) in Vilnius.

The Team would like to thank the authorities of SU for their friendly welcome and hospitality. We also want to express our appreciation to the various representatives of SU who actively participated in the meetings and considerably contributed by their open discussions to a good overview of the institution.

The Review Team

The review team was completed according *Description of experts' recruitment*, approved by order No. V-41 of Acting Director of the Centre for Quality Assessment in Higher Education. The Review Visit to HEI was conducted by the team on 25 April, *2017.*

1. **Prof. Neda Bokan (team leader),** *Former Professor of the University of Belgrade, Serbia, Serbia;*
2. **Prof. Yishao Zhou,** *Professor of Mathematics, Department of Mathematics, Stockholm University, Sweden;*
3. **Assoc. Prof. Thomas Hausberger,** *Associate Professor, Department of Mathematics , University of Montpellier, France;*
4. **Prof. Jonas Valantinas,** *Professor at Kaunas University of Technology, Applied mathematics department (Lithuania);*
5. **Mrs. Aldona Savičienė,** *CEO of insurance mediation company UADBB "AM sprendimai" (Lithuania)*
6. **Ms. Dalia Miklaševičiūtė,** *student of Kaunas University of Technology study programme Big Data Analytics (Lithuania).*

II. PROGRAMME ANALYSIS

2.1. Programme aims and learning outcomes

Objective Mathematics master study programme is to: *improve competencies of students who graduated the first cycle study programmes Finance Mathematics BSc, and Mathematics BSc at the Šiauliai University as well as the graduates of the field in mathematics of other higher education institutions, such that to acquire relevant knowledge of mathematics substantiated with the results of scientific research, as well as being able to integrate and responsibly apply it in the new situation, while conducting scientific research of chosen area and/or in the work of a high qualification analytics professional, a modelling and data scientists.* The aim do correspond with Dublin descriptors, the descriptions of the Lithuanian legal acts and covers knowledge and its application, scientific ability to conduct research, including special abilities and soft skills of social and personal types.

According to SER the formulated learning outcomes of the Mathematics study programme students suppose to acquire knowledge of pure mathematics emphasized on analysis of number theory, function theory, theory of differential equations to be capable to apply them creatively solving practical tasks; knowledge of modern methods of multidimensional statistical

analysis, reliability analysis, optimization, graph theory to be capable of applying them in modelling real processes and in analysing the results; deeper knowledge of mathematical modelling to be capable in studies of interdisciplinary subjects or in professional activity while implementing the innovations, and finally knowledge of usage specialized software in solving the tasks of data analysis, optimization and the tasks of implementation of mathematical models.

Abilities to conduct research covers identifying and substantiating of the issues to understand the need of scientific research by using analysis and synthesis of subject-based literature and evaluating research field; initiating and conducting independent scientific research to process research data, being capable to process research data in order to provide innovative recommendations and forecasts, and finally preparing of determinant, stochastic, differential equations mathematical models, to the proceeding of physical and social processes, as well as their characteristics.

Special abilities important for conducting research contain perceiving mathematical statements and their proofs by substantiating them theoretically and practically so that a student will be able to formulate new statements analogous to already known statements or more complex statements and to prove them successfully. Some other abilities important for development of logical and analytical way of thinking, generalization of some results, study of mathematical problem of fundamental and/or applied nature in order to make innovative decisions and some soft skills as well.

To achieve each of these learning outcomes teaching/learning methods and assessment methods are defined. For example: the learning outcome: "the ability to present the obtained results clearly and understandably" the corresponding teaching/learning methods and assessment methods are: literature analyze, one-to-one tutorials, scientific paper analyze and non-traditional task; peer assessment, self-assessment respectively. To develop ability to work individually and in a team one use library/information retrieval tasks, one-to-one tutorials, scientific paper analysis and peer assessment, case study, control work respectively, etc.

The correspondence between subjects, learning outcomes is submitted in Annex 7 of SER. Programme objectives and concise description are published in AIKOS. The information is available on the website www.studijos.lt, on the University website http://www.su.lt, the faculty website. Consequently, the review team conclude that programme objectives and intended learning outcomes are well-defined, clear and publicly announced.

According to SER Programme objectives and intended learning outcomes are monitored by the Study Programme Committee and other committees on University, Faculty, Department levels, as well as by experts and social partners. In accordance with remarks provided by previous external evaluation team and social partners more subjects of applied nature were included, all elective subjects were moved to the third semester, a subject of *Group Theory* was introduced and Discrete Mathematics were involved to achieve better link to the state, societal and labour market needs.

During the meeting with employers and social partners the review team has recognized their well developed cooperation with Šiauliai University. Two events every year are organized to exchange experience in using of IT and mathematics in sustainable development of region. Among the aims of this cooperation is also consideration of necessary competences acquired in study programme and their improvement as well as corresponding learning outcomes. By the opinion of employers and social partners graduates achieve well chosen subject specific competences for the work in high qualification analytics profession, modelling and data analysis. Moreover, graduates acquire problem solving skills, logical way of thinking and hence they know how to find information quickly by using optimized procedures.

The representatives of Alumni organization have emphasized a proper feedback of their recommendation to improve the study programme. Consequently, graduates acquire: creative way of thinking, abstract way of thinking developed through good examples and motivation to generalize some results in a formal way, subject specific skills in line with labour market needs. An involvement of students in the Šiauliai University's Senate, Study Programme Committee,

Faculty Council, etc. help them to develop project leader, team leader skills as well as teaching/learning methods help to achieve presentation skills.

Consequently, the review team concludes that the Programme objectives and intended learning outcomes are linked to the state, societal and labour market needs. Many activities have been organized to acquire these aims.

The programme aims comply with the University's mission – by means of the activity of innovations of arts, science and studies of international level to promote the national and regional advancement (see the Šiauliai University Strategy for 2015-2020) as well as with one of Šiauliai City Strategic Tasks – to develop public awareness, citizenship, to promote collaboration of business, education and culture. The Programme learning outcomes are the proof of aiming to prepare the employees of high quality for Šiauliai and other regions, who are able to professionally act in different situations of life.

Programme objectives and intended learning outcomes are linked with academic and professional requirements. Programme objectives and intended learning outcomes allow graduates to continue PhD studies and work as data scientists, statisticians, researches, teachers (after getting teachers qualification).

The relevance of other learning outcomes is confirmed by the forecasts for 2020 conducted by Cedefop, the requirements of Šiauliai Industrialists Association, etc. Detailed description one can find in SER, pp. 7-8.

Elective sets of study subjects offered by 4 options may offer the qualifications to all graduates in the frame of analyst, data scientist, teacher in higher education institutions and research in several branches of pure and applied mathematics (number theory, differential equation, statistics in economy, etc).

The interface between profession activity field and expected learning outcomes of the Programme is presented in Table 2 (SER, p.8). For example, researcher and analyst are prepared for planning and organization of scientific research aiming to detect mathematical problems and the ways of their solution, creation, preparation and improvement of theories and methods of mathematics; preparation of research articles and reports (corresponding learning outcomes A1, B1, B2, B3, C1, C2, C3, D1, D2, D3, E2). In a similar way is described analyst, modelling specialist, teacher, data scientist (assessment, handling explanation and analysis of statistical data, their preparation and publishing) (A2, A4, B3, C2, C3, D1, D2, D3, E3).

Programme objectives and intended learning outcomes correspond to the type and cycle of studies and the VII level the Lithuanian qualification framework. The compliance of Programme learning outcomes with Descriptor of Study Cycles in Higher Education of Lithuania regulating second cycle studies and Descriptor of Study Field of Mathematics is presented properly in Annex 8 of SER.

Every two years on average one graduate of this Programme continues doctoral studies. The title of the programme, intended learning outcomes, the content of the programme and the qualification to be obtained are well-tuned.

2.2. Curriculum design

This is a master's programme in Mathematics. A full time working load is 2 years, or four semesters, with 120 credits (ECTS). This is in line with the Lithuanian legal acts regulating the structure of study programmes.

The Programme is designed in accordance with the learning outcomes, aiming at having students prepared for doing research and solving problems in other scientific applications. There are 6 credits for each subject, 30 credits for Master's Degree Work, and 18 credits for the *Research Work in Science,* which is distributed in the first three semesters before the master's thesis. This construction enables students to broaden their learning perspective and increase their chance to succeed in independent research during their thesis work. This can be thought of

as the strength of the programme. The content of each educational component corresponds to the intended learning outcomes of that component. Size and content of all educational components are appropriate; for example, a six-credit course includes 160 hours work with 64 hours classroom teaching and 96 hours tutorial and individual work. The curriculum design meets the legal requirements.

The review team found that the programme has been improved since the previous evaluation. In the previous review it was pointed out that the programme was short of courses in *algebraic structures and algorithms*, and *applied mathematics*. Currently the programme provides a course *Group theory*, integrated with the open source software, Groups, Algorithms, Programming, a system for computational discrete algebra. Moreover, it includes now courses in Financial mathematics, modelling hydrodynamics.

The review team also found that the subjects offered within the programme are sufficient to achieve the learning outcomes and contents required for mathematical education at an advanced level. The programme has a strong focus in subjects such as analytics number theory, probability theory and (nonlinear) differential equations. The curriculum of these blocks is carefully prepared and modern in a sense. The review team does believe that it is a great improvement for the programme by development of topics in applied mathematics on the one hand. On the other hand some courses seem unnecessary to be restricted in application areas. For example, it is possible to have Optimization, together with convex analysis and optimal control theory, as a common elective course for more general interests. Mathematical modelling could include some more applicable areas such as, but not limited to, bioinformatics and systems biology – a few modern and dynamical research areas, and applications within mathematics. The purpose is not just to apply mathematics but also to train students' critical view and gain insights of the on-going research in science and engineering. In particular, the programme has already provided such a background for students. This could be made more transparent for students.

The content of the programme reflects the latest achievements in science and technology to certain extent. For example, the Group Theory course uses the modern open source GAP. In general the review team found that the curriculum of the master's programme is of a high quality with regard to international standard, and it meets expected requirements both in mathematics, application of mathematics in science and technology, especially for students pursuing a PhD program.

After the interviews at site visit, the review team found that both students including graduates, faculty members and social partners are satisfied with the curriculum design and programme learning outcomes. The students and the teaching staff are able to manage the balance of working load so to keep the quality of learning outcome although the study programme is intensive and some courses are heavy.

The qualification of the faculty research in pure mathematics could be merged smoothly with applied subjects. Here are a few observations from the site visit. Analytic number theory is a strong subject chosen by students in the majority of their master's theses. Although it is a pure mathematics subject, the interactions with dynamical systems have been explored during the last decade. And hence it is a possible improvement in a long run. So it is necessary for students to learn some computational aspects of algebraic geometry and algebraic topology to understand the data structures and shapes. Note that it puts the subject in a rather new perspective or higher level than the traditional treatments. The review team believes that the faculty is able to make such an effort for this kind of improvement in the future. From the social partners' discussion it seems like a good idea to have a course such as machine learning with emphasises on the fields of mathematics, mathematical statistics together with complexity theory (to distinguish it from a subject in computer science/informatics).

The review team recommends a further investment in the study programme to prepare students for recent dynamic academic and technological developments. More precisely, the faculty could extend the strong tradition in analytic number theory, probability theory and partial

differential equations to the areas of dynamical systems and the theoretical treatment of topics in machine learning. The programme designers are also recommended to make an effort to establish study subjects such as commutative algebra, algebraic geometry and algebraic topology, and to merge analytic number theory with dynamical systems to maintain the mathematical strength. However, the review team considers this as a big challenge for the faculty since the lack of such topics seems to be a common problem in the country. We suggest to put an effort to establish relationship with Scandinavian Countries universities because they can share their experience with Lithuania; they are small nations as it is Lithuania and are dedicated to development in the Baltic countries.

2.3. Teaching staff

There are 14 academic staff members engaged in the programme: 7 Professors, 4 Associate Professors, 3 Lecturers. The staff is stable and experienced with an average working experience of about 22 years. The number of accepted students per year varied from 4 to 6 in the evaluation period, with a total number of 11 students enrolled in the study programme in 2016-17 and 6 students allocated per teacher's post (1.85 post in total). The last evaluation pointed out a small number of students (7) but also a dedicated staff and the opportunity that was worth giving to talented and ambitious students of north Lithuania to obtain a master's degree in mathematics. Currently, SU is co-financing the study programme in consideration of the need of developing abilities in mathematics to address contemporary societal and economic challenges, which should indeed be encouraged. The number of students therefore appears to be increasing, which is a positive sign, although this number is still a bit low to promote well-developed classroom dynamics (currently about 2-3 students in a classroom, according to data collected during the interviews).

The teaching staff is meeting the legal requirement with 100% of staff having a doctorate title in sciences and 50% of course units being taught by professors. The fields of expertise of the teachers covers various mathematical domains ranging from pure mathematics (Algebra, Number Theory, Probability Theory) to applied mathematics (Statistics, Differential equations, Computational modelling), Mechanics, Physics and Informatics (Programming and Data Mining). This expertise is coherent with the content of the taught courses, on the individual level, and it globally ensures qualifications adequate to achieve the learning outcomes regarding mathematics and its applications. Nevertheless, it should be pointed out that crucial competences with regard to contemporary mathematics (e.g. Group Theory) are provided by visiting teachers and that local competencies in mathematical domains are concentrated in Analytic Number Theory. The latter is clearly reflected in the subjects chosen by students for their graduate thesis.

50% of the teachers are in the >50 age group. This situation induces a potential threat of staff shortage in the middle-term that should be considered for the viability of the programme. Although the recruitment procedure of teachers is not detailed in the SER, it should be noted for future reference that the external expert team recommends that open calls be set up and the positions advertised in order to potentially attract the best researchers from Lithuania and other Baltic and neighbouring countries. The domain of expertise of the teachers should be considered in relation to the action plan for future development of the study programme.

The international recognition of the research carried out by the staff members is acknowledged by scientific publications in international journals (35 article papers published in the 2012-16 period belong in the Clarivate Analytics Web of Science database), the editorial work of several professors who are members of editorial boards of international journals, and the regular participation in international conferences. International conferences are also organized locally, such as the second International Teachers on Number Theory. Teachers are involved in international projects and several teachers leave for short term internships on exchange programmes. The number of internships has increased since the last evaluation of the programme who recommended academic or sabbatical leaves to foreign universities. A few incoming

teachers are also mentioned in the SER document. Moreover, all teachers in SU are provided with equal conditions for professional development and the funding seems sufficient to allow the required international mobility. Teachers have a right to take a sabbatical every 5 years, which is favourable to the development of research and the international mobility.

The current teaching load of teachers stated in the SER is 657 hours /year (contact work with students). During the interviews, it was clarified that the number of contact hours in class rooms was about 500 hours/year. The SER does not make any comment on this huge working load, by comparison with international standards. It should be pointed out that, in the view of the external expert team, such a teaching load doesn't offer decent conditions for professional development as a researcher on the international scale, which is bound to lead to negative effects on the programme. Moreover, the opportunity to take a sabbatical has never been taken by any teacher involved in the program. It was clarified during the interviews that low salaries of academics in Lithuania often induce a necessity for a second job and therefore hinders the capacity of a teacher to take a sabbatical. It was also elucidated that the number of contact hours is determined every year by the Senate of the University, as well as the ratio between teaching and research activities. The review team would like to raise the attention of the University authorities on the importance of ensuring good conditions for research since university studies are based on their relationship with fundamental and applied research, especially in the case of a graduate programme. Measures should be taken to reduce the number of contact hours in order to guarantee research conditions of staff members for the viability of the graduate study programme whose anchoring on contemporary research and up to international standards is still feasible.

Finally, the teachers develop their pedagogical competencies through courses on pedagogical and didactic innovation as well as e-learning. The annex 9 of the SER document describes the courses and seminars that teachers may take. These initiatives are much appreciated. Nevertheless, in the light of annex 9, it appears that these courses deal with general pedagogical issues but do not give enough attention to the didactic of mathematical domains. Issues related to the teaching and learning of given mathematical topics should be also discussed by the teaching staff. A proper plan of professional development for university teachers should include seminars in the didactics of the scientific disciplines adequate to transfer to teachers the results of the international research in mathematical education at the tertiary level. Moreover, the external expert team stresses that initial teacher training of PhD students and young doctors should be systematically encouraged.

2.4. Facilities and learning resources

In the Faculty 1100 m2 area is devoted for the premises for the Programme implementation. 20 classrooms are distributed as follows: theoretical lectures are delivered in 15 classrooms for general use (14 - 70 seats) and 5 computer classrooms with various numbers of seats. Classrooms are equipped with multimedia systems, in computerized classrooms are interactive whiteboards and printers.

Assistance for the students studying according to individual study schedule is combined/distance studies. E-Studies Centre provides teachers and students with technical and methodical aid in implementing a synchronic e-studies (virtual learning environment – Moodle with Tex support). In *E-Studies Centre* is created to use video conferencing classroom and hall, LieDM distance learning/teaching classroom. What allows up to 35 persons or auditoriums participating in video conferences can be connected into one or several interactive synchronous events that are held in parallel. Wireless internet access (EduROAM) is available in all faculty premises.

The library is equipped with modern software and Internet access (there is Eduroam wireless Internet in the library). The computeried work stations are devoted for information

retrieval for science and studies or writing of research works, work with graphics files, self-service scanning. The library employees provides consultations to Master students, teachers and administrative staff, organizes different trainings on search in databases, rules of citing and referencing, consults students who write Final Works.

The premises for studies are adequate both in their size and quality. Quantity, quality and media/IT facilities of the teaching rooms are in line for the programme implementation and the student's needs. The premises meet labour safety requirements and hygiene norms, are adapted for the disabled students.

The students and the academic staff have access to the SU Library, one of the most modern libraries in Lithuania, which is 400 meters from the *Faculty*. There are sufficient library workstations available to students with sufficient technical equipment and rooms for group work, seminars as well for individual work with computerized work stations. There are two modern conference halls: a 180-seat hall with stationary multimedia and the system of simultaneous translation and a video conference hall with 120 seats, which are used for the conferences, seminars for school students, teachers. Wireless Internet access EduROAM is available in the *Library*. There are General Reading Room and Periodicals Reading Room with open funds, and it is possible to copy, scan or take photo of a necessary publication.

In the Library funds there are available and accessible books, textbooks, periodical publications. Available periodical mathematic journals, which allows Master students familiarize with the most recent results of scientific research. Also the access to different multidisciplinary databases in the area of Mathematics and Finances are available. The library at certain intervals subscribes free access to databases necessary for mathematicians. Though, during the site visit the actual data how effectively is used databases was not presented. Such monitoring is important in order to see the most used and relevant databases, especially when focus is shifted from physical books to databases.

The experts agree that the teaching materials, technical equipment - books, textbooks, periodical publications, and databases - are adequate and up to date for the implementation of the programme and accessible to the students.

2.5. Study process and students' performance assessment

The admission requirements in the Mathematics programme are clearly elaborated and they follow all requirements applied for the 2nd cycle studies. The candidates can apply in this programme if they have acquired Bachelor's degree of university studies in the field of Informatics, Engineering, Life Sciences or Social Sciences and completed additional studies (in mathematics) up to 30 credits as well as have Professional Bachelor's degree – up to 60 credits, during which the necessary subjects are completed. The entrance point is composed of the sum of weighted coefficient of evaluations indicated in diploma supplement and additional points which can be gained for research activities or participation in the conferences.

Although the number of admitted students has increased from 4 to 6 in the recent years, the overall number of students in the programme is extremely low. Keeping in mind that the general trend in Lithuania is that the number of students is decreasing especially in the regions, it might raise the question of further development of this programme. Therefore, the dropout rate (1 or 2 students per year) should be considered as an important KPI since every student leaving the programme might hinder the implementation of the programme.

It is worth mentioning that this programme attracts talented and motivated students from Šiauliai region since the average entrance scores are relatively high for state funded places even with the changed system of calculating the entrance score. Nevertheless, the programme management should keep in mind the significant difference between the highest and lowest scores in the programme (for instance in 2015 the highest score – 18,1, the lowest- 5.8). This raises the risk that the learning outcomes might not be reached by all the students in the

programme.

The general rules for the assessment of students' achievements are clearly elaborated in the faculty and SU Study Regulations. Students are well-informed about all requirements they have to follow during the study process, study programme, its aims, developed abilities, evaluation system, elective alternatives, requirements for Master Thesis preparation, mobility possibilities, career possibilities, as well as appealing procedure. The on-site visit confirmed that all regulations are clear to students. At the beginning of each course, students are introduced to the module description, learning outcomes and the upcoming learning process. Additionally, there is a feedback giving culture among the students and the professors – students evaluate study modules every semester, receive constant feedback on their examination results and are able to personally provide the feedback to the professors as well as fill in the questionnaires.

It is remarkable that SU introduced personal direct consultations for students which are planned in advance and published in a separate timetable. It is a valuable practise in order to align every student needs.

The students of this programme have the possibility to get variety of support such as career development, job openings, library, accommodation, cultural activities etc. Additionally, students are able to receive different types of financial support such as incentive, one-time, targeted and social. One-time scholarships are allocated for the publicizing of the University: for exceptional results of studies and research activity; for representing the University in international projects, conferences; for high achievements in the skills of arts, sport, cultural activities; for active social activities. In 2016, one student due to deteriorated material situation was allocated with one-time social scholarship. Additionally, the students are encouraged to participate in the research activities while preparing joint articles with their supervisors but there is no evidence of students being involved in the international research community or presenting their work in research conferences.

The faculty has a number of agreement with the universities for students and professors to temporarily study abroad. Nevertheless, the number of students using this opportunity is very low due to the high employment rates and the fact that students already have families. SU provided additional means how to increase mobility: 2 students each year go to international Olympiad of Mathematics for students, 1-3 students go to the conferences organized by Latvia University of Agriculture. There were also 4 students from abroad coming to this study programme and the material was prepared in English. Additionally, during expert's visit, the university held an International week highlighting the importance of internationalization. Nevertheless, as the importance of internationalization is increasing in the market, students stressed out that more subjects could be lectured completely in English.

The faculty is also taking measures to increase academic honesty. The requirements for academic honesty are defined in a range of the University documents: Šiauliai University Students' Ethics Code85, sanctions for academic dishonesty are foreseen in ŠU Study Regulations. Additional means are organized by student representatives in order to discourage students from cheating. All Master Theses are placed in eLABa for the verification of originality.

According to SER, the employability rate is very high and reached around 80% 1 year after graduation. The examples of employers for this programme graduates consist of UAB "Siauliu bankas", AB "SEB Bank", public schools and higher education institutions. It is worth mentioning that 2 graduates is continuing their research and seeking for PhD in Vilnius University. Taking into account the employees of graduates, the majority of them is working according to the field of Mathematics as consultants, teachers, specialists etc. During the expert's visit, the stakeholders highlighted the need of such specialists and appreciated student's ability to solve complex tasks quickly and in a qualitative manner.

2.6. Programme management

Programme management activities are efficient and sufficiently effective. It is a

consequence of properly chosen and multi-level allocation of responsibilities for decision-making and monitoring of the programme at all levels (University, Faculty, Department, teacher, student). Responsibilities are clearly defined, well-founded and fairly dynamic.

During the programme's implementation process, the assessment of achievements is conducted regularly and systematically. In this context, various events (meetings, round-table discussions, surveys of students' opinion, etc.) take place regularly. Later, the students and teachers receive feedback about their impact on the programme's development. The study process elements requiring task-oriented analysis and improvement, as well as methods of monitoring the whole study programme, are planned ahead, and give exceptionally good results. According to the self-evaluation report, truly active role is played by the social partners (graduates, employers, etc.). Communication with them is conducted on social websites, by e-mail, through numerous meetings and occasional days.

The information about the programme and its amendments is provided by the Department, Dean's office, the study quality programme committee and the academic staff, and appears in the Academic information system (AIS). The collection of data on the employer's opinion is standardized and formalized at the Institution level (publicly available on the University website).

The internal study quality management system was established in 2011-2012 (Project UNI-Q-MAS), and operates irreproachably. The outcomes of the external evaluation (2012) of the programme have been seriously discussed, and appropriate measures implemented. In particular, some new study modules (Group Theory, Graph Theory and its Applications, elective courses on Economics and Finance, Optimization methods in Economics, etc.) have been introduces. Also, to induce students to higher research activities, the study schedule has been corrected. On the other hand, even though previous experts' recommendations have been taken into account, further steps (based on results of different evaluations) in developing systematic procedures to improve teaching and research have to be further refined.

The main shortcomings in the programme's management model are associated with not fully spread out internationalization of the programme and manifestation of glaring publicity (press, TV, etc.) about the prospects and long-term future of the University. The latter circumstance exerts negative influence on the enlisting process of applicants to the programme. Exceptionally clear description and reasonable multi-level allocation of responsibilities for decision-making and monitoring of the programme is given.

In the self-evaluation report, the labour-market needs, for the graduates of the programme, could be highlighted better.

2.7. Examples of excellence *

The course Group theory is very well designed in all aspects, including chosen examples in a proper way. One of these examples is symmetry groups of Platon's bodies which connect two different fields of mathematics (algebra and geometry), help students to acquire some knowledge in geometry of Platon's bodies motivate them to search other geometrical properties of these bodies and develop students spatial abilities important for achievement of problem solving skills.

III. RECOMMENDATIONS*

1. Competences and learning outcomes are defined formally in a correct way in line with all legal requirements. This study programme has been changed taking into account lot of recommendations of the previous external evaluation team. However, in accordance with the analysis of the study programme presented above and the actions of study programme improvement, the follow-up activities plan need to be prepared.
2. The mathematical domains of expertise in pure mathematics of the teaching staff should be expanded in order to include in the study programme a wider offer of mathematical subjects that include substantial contemporary developments in mathematics (e.g. in Algebra, Geometry, Topology and their interactions). Therefore, the review team suggests to continue the internalization, inviting visiting professors, usage of sabbatical, increasing of the subjects lectured completely in English.
3. The number of contact hours should be limited as much as possible to approach the international standard of 200 contact hours / year and therefore guarantee research conditions of staff members for the viability of the graduate study programme.
4. The spectrum of study methods needs to be enriched by introducing more project-based with oral presentations, group work and modelling-based learning schemes

IV. SUMMARY

The aim of Mathematics master study programme is to: *improve students' competencies gained during the first cycle study programme Finance Mathematics BSc, such that to acquire relevant knowledge of mathematics substantiated with the results of scientific research, as well as being able to integrate and responsibly apply it in the new situation, while conducting scientific research of chosen area and/or in the work of a high qualification analytics professional, a modelling and data scientists.* In the Curriculum design new subjects have included according to recommendations of previous external evaluation team. The new course Group theory is very well designed in all aspects, including chosen examples in a proper way. One of these examples is symmetry groups of Platon's bodies which connect two different fields of mathematics (algebra and geometry), help students to acquire some knowledge in geometry of Platon's bodies motivate them to search other geometrical properties of these bodies and develop students spatial abilities important for achievement of problem solving skills. The programme implementation shows the good cooperation between Šiauliai University and stakeholders. Teaching methods, such as Moodle platform, project-based method, etc. are developed in compliance with the challenges of new academic development, IT technologies and labour market needs. Internationalization of this study programme is recognized through mobility of teaching staff, mobility of students, visiting professors to teach some courses, organization of internationalization week, etc.

The review team would like also to emphasize the teaching and administrative staff need to recognize the main weaknesses of the study programme such as the low number of enrolled students, lack of specialists in several areas among which algebra, geometry, topology, statistical analysis and consequently lack of corresponding contents in curriculum, important for applications in big data analysis, complexity systems, developing of problem solving skills, etc. The capability to recognize weaknesses is essential for improvements. The shortage of competitive actions from pure mathematicians to make seemingly pure and abstract mathematics more interesting to students implies insufficient ability to attract the master students to do a PhD programme in mathematics. The heterogeneous background of students need to be considered not as a weakness but as a potential problem for the educational quality in mathematics core subjects. The workload of teaching staff in education and research activities are not enough balanced.

V. GENERAL ASSESSMENT

The study programme Mathematics (state code – 621G10006) at Šiauliai University is given **positive** evaluation.

Study programme assessment in points by evaluation areas.

No.	Evaluation Area	Evaluation of an area in points*
1.	Programme aims and learning outcomes	3
2.	Curriculum design	3
3.	Teaching staff	3
4.	Facilities and learning resources	3
5.	Study process and students' performance assessment	3
6.	Programme management	3
	Total:	**18**

*1 (unsatisfactory) - there are essential shortcomings that must be eliminated;
2 (satisfactory) - meets the established minimum requirements, needs improvement;
3 (good) - the field develops systematically, has distinctive features;
4 (very good) - the field is exceptionally good.

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Vertimas iš anglų kalbos

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V. APIBENDRINAMASIS ĮVERTINIMAS

Šiaulių universiteto studijų programa *Matematika* (valstybinis kodas – 621G10006) vertinama **teigiamai**.

Eil. Nr.	Vertinimo sritis	Srities įvertinimas, balais*
1.	Programos tikslai ir numatomi studijų rezultatai	3
2.	Programos sandara	3
3.	Personalas	3
4.	Materialieji ištekliai	3
5.	Studijų eiga ir jos vertinimas	3
6.	Programos vadyba	3
	Iš viso:	**18**

* 1 - Nepatenkinamai (yra esminių trūkumų, kuriuos būtina pašalinti)
2 - Patenkinamai (tenkina minimalius reikalavimus, reikia tobulinti)
3 - Gerai (sistemiškai plėtojama sritis, turi savitų bruožų)
4 - Labai gerai (sritis yra išskirtinė)

<...>

IV. SANTRAUKA

Matematikos magistro studijų programos tikslas yra *gerinti studentų gebėjimus, įgytus pirmosios pakopos finansų matematikos studijų programoje, gilinant atitinkamas matematikos žinias, pagrįstas mokslinių tyrimų rezultatais, siekiant, kad studentai gebėtų jas integruoti ir atsakingai taikyti naujose situacijose, tuo pat metu jas plėsdami atliekamais pasirinktos srities moksliniais tyrimais arba dirbdami aukšto lygio analitikos specialisto, modeliavimo mokslininko ar duomenų mokslininko darbą.* Remiantis ankstesnės išorinės vertinimo grupės rekomendacijomis, į programos sandarą buvo įtraukta naujų dalykų. Naujas grupių teorijos kursas yra labai gerai suplanuotas visais aspektais, įskaitant tinkamai pasirinktus pavyzdžius. Kaip pavyzdį pateikiame Platono kūnų simetrijos grupes, kurios jungia dvi skirtingas matematikos sritis (algebrą ir geometriją), padeda studentams įgyti žinių apie Platono kūno geometriją, skatina ieškoti kitų šių kūnų geometrinių savybių ir lavina studentų erdvinius gebėjimus, reikalingus problemų sprendimo įgūdžiams ugdyti. Programa įgyvendinama bendromis Šiaulių universiteto ir jo darbuotojų bei studentų pastangomis. Atsižvelgiant į naujus akademinius pokyčius, informacinių technologijų ir darbo rinkos poreikius, parengti tokie mokymo metodai kaip naudojimasis „Moodle“ sistema, projektinis mokymų metodas ir kt. Programos tarptautiškumas didinamas per dėstytojų ir studentų judumą, kviečiant profesorius dėstyti kursus, organizuojant tarptautiškumo savaitę ir kt.

Ekspertų grupė taip pat norėtų pabrėžti, kad programos dėstytojai ir administratoriai turėtų pripažinti pagrindinius studijų programos trūkumus, t. y. mažą užsiregistravusių studentų skaičių, algebros, geometrijos, topologijos ir statistinės analizės specialistų bei šių dalykų, kurie

yra reikalingi dideliems duomenims analizuoti, sudėtingumo sistemoms, problemų sprendimo įgūdžių ugdymui ir kt., trūkumą mokymo programoje. Gebėjimas pripažinti trūkumus yra būtinas norint juos ištaisyti. Grynųjų matematikų iniciatyvos trūkumas siekiant labiau sudominti studentus abstrakčiąja matematika lemia tai, kad nepakankamai studentų, baigusių magistro studijas, renkasi matematikos doktorantūrą. Studentų nevienalytiškumas yra ne trūkumas, o potenciali pagrindinių dėstomų matematikos dalykų kokybės problema. Nėra pusiausvyros tarp mokymo ir mokslinių tyrimų veiklos.

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III. REKOMENDACIJOS

1. Gebėjimai ir studijų rezultatai yra apibrėžti teisingai, laikantis visų teisinių reikalavimų. Ši studijų programa buvo keičiama atsižvelgiant į ankstesnės išorinio vertinimo grupės rekomendacijas. Nepaisant to, turi būti parengtas tolesnių veiksmų planas, paremtas pirmiau pateikta studijų programos analize ir rekomenduojamais studijų programos gerinimo veiksmais.
2. Turi būti išplėsta grynos matematikos dėstytojų ekspertizė, siekiant į studijų programą įtraukti daugiau matematikos studijų dalykų, apimančių naujausius matematikos pokyčius (pvz., algebros, geometrijos, topologijos dalykus ir jų sąveiką). Ekspertų grupė rekomenduoja tęsti tarptautiškumo stiprinimą kviečiant profesorius, siūlant kūrybines atostogas ir didinant anglų kalba dėstomų dalykų skaičių.
3. Kontaktinių valandų skaičius turėtų būti ribojamas iki tarptautiniu mastu pripažįstamų 200 kontaktinių valandų per metus, drauge užtikrinant sąlygas studentų moksliniams tyrimams, kurie yra būtini, kad studijų programa egzistuotų.
4. Studijų metodai turi būti išplėsti, sudarant daugiau galimybių projektiniam mokymuisi, pristatymams, grupiniam darbui ir modeliavimu grindžiamam mokymuisi.

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