STUDIJŲ KOKYBĖS VERTINIMO CENTRAS

Vilniaus universiteto

STUDIJŲ PROGRAMOS *MATEMATIKA (valstybinis kodas - 621G10001)* VERTINIMO IŠVADOS

EVALUATION REPORT OF *MATHEMATICS* (*state code - 621G10001)* STUDY PROGRAMME

at Vilnius University

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Išvados parengtos anglų kalba
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DUOMENYS APIE ĮVERTINTĄ PROGRAMĄ

Studijų programos pavadinimas	***Matematika***
Valstybinis kodas	621G10001
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	1997-05-19, Nr.565

INFORMATION ON EVALUATED STUDY PROGRAMME

Title of the study programme	***Mathematics***
State code	621G10001
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	1997-05-19, No.565

CONTENTS

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.	Action plans
2.	Student publications

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

The study programme of "Mathematics" is implemented by the Department of Differential Equations and Numerical Mathematics and Department of Probability Theory and Number Theory. The Expert Team had possibility to observe various study support services (classrooms, computer services, library), as well as to familiarize with students' final works.

The Expert Team conducted also interviews with students. The Expert Team was familiarized with students' attitude towards the study programme. The meeting was carried out in an active and constructive atmosphere. The students expressed positive as well as critical opinions about the programme.

Expert Team met graduates and potential future employers of the students. At the conclusion of the visit, the Expert Team conducted a meeting with staff of the Faculty and highlighted some strengths and weaknesses of the programme.

In the following, the findings of the Expert Team are outlined. The Self-assessment report submitted by the Faculty, the observations made at the time of the visit, and the supplementary material received during the visit form the basis of these assessments.

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 *28 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

The objective of Mathematics master study programme is to improve students' competencies gained during first cycle study programme Mathematics and Applications of Mathematics BSc, or to some other in compliance to this one, and to train qualified specialists who have advanced knowledge in pure and applied mathematics as well as strong problem solving skills so that they can successfully tackle challenging scientific, industrial, economic problems.

The competencies developed and intended learning outcomes of the study programme are described in proper details and presented in Table (see SER, p.6). Competences are separated into two sets in a logically consistent way emphasizing their different role in graduates' professions:

- Generic competences: 1. Abstract and critical thinking skills; 2. Life-long learning skills;

3. Communication and collaboration skills;
- Subject-specific competences: 4. Advanced theoretical knowledge of mathematics (theory, methods); 5. Ability to apply mathematical knowledge and skills; 6. Ability to perform mathematical research.

The review team concludes that the study programme was changed to meet the requirements of the adopted new description of Mathematics study field approved by the Ministry of Education and Science of the Republic of Lithuania and the objectives correspond with Dublin descriptors and the Lithuanian legal acts. Consequently, the review team concludes that generic and subject-specific competencies and learning outcomes are in compliance with the description of knowledge and abilities necessary for Mathematics according to "Mathematics Study Area Description".

According to SER intended learning outcomes formulation students suppose to acquire advanced and in-depth knowledge and understanding of complex theories, models, methods in areas of pure and/or applied mathematics; usage of modern mathematical methods for problem solving, including understanding of latest results and trends in selected branch of mathematics as well as ability to create mathematical models of the analysis of real-world processes, including analysis of simulation results of the search for optimal solutions, assessing the adequacy and accuracy of the model, if needed to improve models.

Ability to perform mathematical research covers development of students' skills in conducting a primary research of scientific literature in their chosen field of investigation, use pure mathematical or applied methods to understand some aspects of the frontiers of mathematical knowledge, including selection and use specific software for research or practical activity data needed for synthesis, processing and analysis as well as presenting of mathematical results of the research in the appropriate mathematical language. Expected learning outcomes to acquire abstract and critical thinking skills are also described and soft skills as well.

A qualification obtained upon the completion of the second-cycle study programme Mathematics is in conformity with qualification VII as specified in the Qualification Framework of the Republic of Lithuania.

Information on the purpose, learning outcomes, content of the study programme and admission requirements is accessible on the Internet to all prospective students, academic community and the society at large. The information is freely accessible at:

- In the catalogue of study programmes of Vilnius University on the official website https://klevas.vu.lt/pls/pub/public_ni$www_progr_app.show
- On the official website of the Faculty http://mif.vu.lt/lt3/studijos/studiju-programos/ma-studiju-programos/matematika
- On the official website of the University intended to prospective students http://www.vu.lt/kviecia/
- On the official website of the Open System of Providing Information, Tutoring and Vocational Orientation, or AIKOS (a Lithuanian acronym) https://www.aikos.smm.lt/Registrai/Studiju-programos/lavouts/15/Asw.Aikos.RegisterSearch/ObjectFormResult.aspx?o=PROG&f=Prog&key=4378&pt=of&ctx_st=NOAJZ8Kgp7rOy5e34aTmdDoVpOI%3d

There exist also some publications available during a variety of promotional events: "Vilnius University is calling. Second cycle study", etc.

During the meetings with Senior management, social partners and Alumni representatives the review team learned that learning outcomes and subject-specific competencies acquired studying Mathematics are well adopted to the state, societal and labour market needs. The majority of students, before enrolling this study programme have already had a job in data analysis, process analysis and other fields. Since students can easily find a proper job they might be not well motivated for studies of Mathematics study programme. Hence, there exists a certain number of students who do not finish their studies. To reduce this number of students the Vilnius University supports master employed students and offers lectures after 4:00

PM.

To correspond to the state, societal and labour market needs the variety of meetings and activities have been organized. For instance: Each semester the meetings (one or two) of the study programme committee (including social partner) are organized. During such meetings the improvement of study programme implementation, according to recommendations from students, social partners and the previous evaluation report, are discussed. The last year meetings were organized for the first (Mathematics and Applications of Mathematics) and the second (study programme Mathematics) cycles study programme committees.

The last time the learning outcomes were revised in 2016 during the self analysis in order to make the improvements concerning the recommendations from students and social partner as well as to match the requirements specified in "Mathematics study area description". The clear need of advanced communication abilities of the students was highlighted in SER as well as during the meeting with social partners. Review team learned that study programme committee (SPC) is already involved the training of communication abilities during several courses (Mathematical Writing at Higher Level, Integral Equations, Partial Differential Equations, Parallel Computing, Abstract Algebra, etc) of the study programme. A clear communication of mathematical ideas, research ideas in appropriate contexts both orally and in writing to a range of audiences was specified as one of the graduates' learning outcome.

Students have emphasized to the review team that they appreciate strong theoretical mathematical knowledge including the proofs acquired during the study of this Programme very much. Therefore, it encouraged them to develop an intuition important for further career development. They also pointed out the analytical thinking and data analysis skills as well as communication skills acquired in several courses helping to develop presentation and public speaking skills which are in compliance with societal and labour market needs.

Programme objectives and intended learning outcomes correspond to the mission, operational objectives and strategy of the Vilnius University.

After completion of the study programme Mathematics, a graduate may engage in further studies at the doctoral level (PhD) level in mathematics, informatics and related areas of physical sciences. Graduates are able to work in science and education institutions, high-technology industries, agencies of data analysis and social investigations, management institutions. Graduates are also able to pursue a career in any other sphere, where their mathematical knowledge, analytical skills and ability to use specialized software are needed.

The title of the programme, intended learning outcomes, the content of the programme and the qualification to be obtained are well-tuned.

2. Curriculum design

The curriculum design under review comprises 120 ECTS credits (four semesters) and 5 units are thought each semester, 78 credits beyond the course units within the study field, 30 credits optional course units offered by the university are intended for specialized studies and 30 credits for final thesis. A student individual work is more than 43%. The programme structure is in line with the legislative requirements.

The curriculum is designed in accordance with good balance between compulsory and optional courses: 13 courses of 6 credits compulsory and 7 courses of 6 credits can be chosen freely by students. The former are aimed to develop main subject-specific competences of the study programme and the latter is meant for higher specialization in the study field. It is well-designed and courses/subjects are of high quality that educates students to have solid mathematical background. Consequently, the content of subjects corresponds to the second cycle of study programme in mathematics leading to master's degree in mathematics.

Study methods are developed in several ways and consist of in-depth lectures, communication training such as seminars and presentations, tutorial and supervision. Also there

are practical and laboratory work meant for students to use mathematical methods to solve mathematical problems independently and in teams in order to learn how to exchange ideas and skills. Knowledge will be examined by tests and examinations and the thesis are required to be presented. Hence it enables students to achieve the expected learning outcomes.

The review team found, based on the SER and interviews with the students, teachers and graduates during the site visit, that the content of each subject is taught in a consistent manner, topics are not repeated, and if a topic is necessary to repeat it is always done in such a way that makes the subject a level higher or it brings new dimensions to students. It is worthwhile pointing out that master's students are very satisfied with teaching in small groups, direct communications with teachers and immediate discussions on unclear thoughts and a lot of research training.

It is notable that the study programme underwent a major revision according to the recommendations of the 2010 review. Since VU has other study programmes in mathematics related subjects, it is possible to design a more theoretical curriculum in mathematics as it is now. The purpose is to attract talented students and encourage them to continue in a PhD in mathematics. The review team recognized that the social partner appreciate this development since they started understanding that more and more traditionally pure mathematics subjects are useful in applications, not least to say they help students develop their logic and abstract thinking at higher level, learn to communicate mathematics with problem providers. So the scope of 120 credits, with the curriculum design as such in this study programme with high competent mathematicians teaching in classes, is definitely sufficient to achieve the learning outcomes.

The study subjects within the curriculum reflect the faculty research interests. More precisely, they are number theory, probability theory, partial differential equations including some applications in physics and fluid mechanics. It provides an excellent study environment where students can learn mathematics with an expertise view of subjects and experience how the research can be carried out. Thus the up-to-date content of the programme corresponds to the latest academic achievements.

The review team would bring the following observation to the study programme committee and the faculty: some fundamental elements in mathematics such as algebra and geometry at a little more advanced level and algebraic topology are absent in the curriculum. They are not only very important subjects in their own right but also extremely useful in modern and dynamical multidisciplinary research and applications. In particular, in the era of the big data, large and complex systems and bioinformatics where effective algorithms are highly demanded. This is because these subjects help one to recognize data structures, shapes so to develop theory for reducing complexity in computation.

In conclude, to better equip students with knowledge to meet today's research and applications development it is recommended to design one or two courses on algebra, geometry and topology that deal with algebraic structures, computer algebra and topological shapes if possible. For instance, if two courses are considered then they could be alternated every two years in order not to loose the good balance that the programme already has. Teachers from abroad may be recruited in the frame of the Erasmus program before candidates are found to be hired as professors in VU in these fields

One final remark is that the weakness of lack of above-mentioned subjects in algebra and geometry is a nationwide problem.

2.3. Teaching staff

There are 13 academic staff members engaged in the programme: 6 Professors (Dr Habil. or Prof. Dr.), 2 Associate Professors (Dr) and 5 Lecturers (Dr). The staff is stable and experienced with an average teaching experience of about 21 years. It nevertheless includes younger members (4 young doctors) for the rejuvenation of the teaching force. The average

students-to-teachers ration during the evaluation period is 1.77 (the number of admitted students varies in the range 5-13), which is favourable to the programme.

The teaching staff is meeting the legal requirement and even surpassing it with 100% of academic staff having a doctoral degree and doing research in mathematics. Moreover, half of course units is taught by professors. The fields of expertise of the teachers covers mathematical domains ranging from pure mathematics (Number Theory, Probability Theory) to applied mathematics (Differential Equations, Numerical Methods, Mathematical Modelling, Parallel Computing, Risk Theory). 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 advanced theoretical knowledge of mathematics as well as its applications. Nevertheless, competencies in Algebra, Geometry and Topology should be reinforced in order to offer the range of topics that may be expected from HEI having the long-lasting Mathematics School traditions in comparison with the international standards, for the sake of the scientific development of the country. Teachers from abroad may be recruited in the frame of the Erasmus program before candidates are found to be hired as professors in VU in these fields.

The international recognition of the research carried out by the staff members is acknowledged by numerous scientific publications in international journals, the editorial work of several professors who are members of editorial boards of international journals, and the regular participation in international conferences. These indicators attest the high competence of the main part of the teaching staff, especially senior researchers.

The pedagogical professional development of teachers is encouraged by the university policy through the participation in various courses focusing on pedagogy and the use of ICT in teaching, in relation to the creation of the Vilnius University Pedagogy Center. Nevertheless, the interviews permitted to clarify that this training program was currently suspended due to the restructuring of the university. In fact, very few teachers attended these seminars, partly due to their focus on secondary education. A proper plan of professional development for university teachers should include seminars in the didactics of mathematics adequate to transfer to teachers the results of the international research in education at the tertiary level. The training proposed by the Vilnius University Pedagogy Center did not cover content-specific issues in the teaching and learning of mathematics (e.g. the issues of abstract subjects such as abstract algebra, the epistemology of mathematical models, etc.).

It was discovered during the meeting that there might be an opportunity to work hand in hand with the Department of Didactics of Mathematics and Informatics, and set up collaborations between didacticians with a sufficient background in mathematics and mathematicians with some acquaintances with didactics. It may be worth hiring an experienced researcher in University Mathematics Education (UME), or at least give volunteering staff members the opportunity to attend international conferences in this field. These teachers may, after suitable training, contribute to the international research in UME and organize locally, jointly with staff members from the Department of Didactics of Mathematics and Informatics, seminars on university pedagogy and didactics. Initial teacher training of PhD students who are lecturing as well as young doctors should be systematically encouraged.

Although each age group if currently represented in the age distribution of teachers, half the teachers fit in the >50 category. In the evaluation period, 4 teachers left the programme with main reasons the retirement age, but also the current salary and heavy teaching loads which are not motivating, especially for younger teachers. VU is currently planning a salary reform that will hopefully help to improve the situation. This is an important issue for the programme since staff shortage is a major threat for its middle-term viability.

The SER mentions that 3 students who graduated from the programme and recently completed their PhD were recruited as lectures in other study programmes. The efforts to retain the young promising specialists should be balanced by a more open hiring policy in order to prevent the danger of inbreeding. Mobility within Lithuania is indeed a viable option on the basis of 20 university in Lithuania. Postdocs should be encouraged. The SER also mentions that, since

2013 at VU, the teaching and research staff is recruited and promoted on the basis of the result of an open competition. Unfortunately, it was discovered during the interviews that the calls are not open in practice, since a candidate is most of the time in mind when the position is proposed, and the positions are not advertised as broadly as possible through the existing academic networks. Indeed, positions were advertised for the first time in 2017, at the website of Lithuanian Science Council. Communication with SPC confirmed that SPC and VU Faculty are aware of the necessity of setting up a proper plan of recruitment based on more open calls in order to potentially attract the best researchers from Lithuania and other Baltic and neighbouring countries.

Finally, it should be pointed out that the current teaching load of lecturers (360 hours /year) and assistant lectures (420 h /year) do not offer good conditions for professional development as a researcher, which is bound to lead to negative middle-term effects on the programme. Although this teaching load is better than in other programmes, it doesn't encourage the improvement of the research output and suggests the necessity of a global reform of academic workloads, as stated in the SER by the SPC. The planned teaching load (288 contact hours / year for a professor, be it an assistant who prepares for a PhD, an associate or full processor, and 412 hours / year for a lecturer) that was announced during the interviews are approaching international standards of about 200 contact hours / year for a professor. The external expert team strongly calls for the success of this reform.

2.4. Facilities and learning resources

The lectures of study programme take place mainly in two buildings: Naugarduko St. 24 (classrooms and teacher's offices) and Šaltinių St. 1A (computer laboratories). Also students have optional courses at the Didlaukio St. Building, and general university courses (GUS) at the other university facilities, depending on their choice.

There are 17 classrooms (total number of seats 983), 6 computer laboratories (total number of seats 157). The building at Didlaukio St. was renovated, and 8 new computer classes were installed. The three largest rooms in the Didlaukio St. building are equipped with remote control cameras for online broadcasting of lectures for disabled students.

Classrooms for lectures are equipped with blackboards and projectors. Some lecturers have their own laptops to connect to the projector, otherwise they can use laptops kept at the security office. Bigger lecture rooms are all equipped with laptops. During practice classes Lecturers use classrooms with blackboards and projectors at Naugarduko St. 24 or computer laboratories at Šaltinių St. 1A. The larger rooms equipped with microphones. In the laboratories students may work on different operating systems (Linux, Windows, iOS) and use various software, statistical-econometric packages like SAS, Eviews, R, and SPSS.

Wireless internet connection is available in all Faculty buildings. Students and staff can use Eduroam or MIF open wireless connection. Students and academic staff can also use the supercomputer21 located at the Faculty of Mathematics and Informatics for scientific research purposes or educational activities free of charge. Vilnius University Centre of Information Technology Development provides various core IT services for staff and students. VU E-learning and Examination Centre provides Virtual Learning Environment for lecturers and enables examination of large groups of students simultaneously in large computer classes in Saulėtekio St. buildings.

The number of classrooms and computer laboratories are sufficient for successful studies and available software and computer equipment meets teaching and learning needs.

In the Faculty library there are around 70.000 various resources and publications (books, journals, textbooks) on mathematics, statistics, probability theory, economics, informatics, information technologies, and other subjects in different languages (mostly in

English and Lithuanian). The mathematical and statistical literature constitutes the majority of the library holdings. Students can find relevant information in electronic databases (via Vilnius University library, which subscribes more than 60 databases): Springer Link, Science Direct, JSTOR, Annual Reviews, etc. There is a library reading room in Naugarduko St. with 90 seats (8 of them with computers). Students can also use the new modern Vilnius University library (MKIC) located at Saulėtekio St. 5. Students prefer to use MKIC facilities since they are more modern, open on a 24/7 basis and are close to dormitories.

The lecture notes and study material of the subjects on lecturers' are available on WebPages and on Moodle based Vilnius University virtual learning environment.

Teaching materials (textbooks, periodical publications, databases) are sufficient for study programme. Access to electronic databases through is available. The premises meet the safety and hygiene norms requirements. The Faculty buildings are currently being renovated.

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 at the VU and are laid out according to the Senate-prescribed Rules of Admission to the Study Programmes of the Vilnius University. As stated in SER, the entrance score is based on the mean value of the marks enumerated in the Diploma Supplement and a mark for the graduation thesis or marks for the final examinations.

The entrance score has a decreasing trend in the recent years (2012 – 20,03, 2013 – 19,43, 2014 – 19,52, 2015 – 18,66, 2016 – 14,91), Decreasing numbers highlights that new entrants of the programme might be less motivated or weaker in terms preparation for continuing in 2nd cycle studies. Additionally, the mean values in the 2 recent years were lower than the mean value of other 2nd cycle programmes in the faculty.

The general trend in Lithuanian HEIs is that the number of students is decreasing. The programme faces with significant variations in the number of the admitted students (2014-5, 2015-12, 2016-5). It is also highlighted that admitted students (% of planned number) is decreasing because the number of applications to the programme remains stable (2012 - 15, 2013 - 17, 2014 - 16, 2015 - 15, 2016 – 16) but the admitted number of students is varying from 36% to 108% and should monitored the by programme management.

Although the programme had a high dropout rate in the past (58% in 2012 and 38% in 2013) it has now been stabilized to 20% in 2016 while last year there was a 0% drop out rate. The numbers may be within acceptable limits keeping in mind quite difficult curriculum (based on pure mathematics). The main reason why students left the programme is their own free will such as being unable to maintain adequate academic standards. It is remarkable that the programme management introduced informal methods with the students who face academic debts in order to manage the dropout rate.

The students of this programme have the possibility to get variety of support such as career development, job openings, psychological assistance, accommodation, cultural activities etc. Additionally, students are able to receive different types of financial support such as special grants for academic excellence, social grants, single social allowances and single special social allowances.

University encourages students to actively participate in research activities It is remarkable that talented students with exclusive academic excellence and taking part in research may be eligible for special VU grants according to study and research fields. Additionally, the number of students from this programme has already published their works and presented it in the research conferences as well as took part in the research on the international level which is an indicator of a good academic environment for the young researchers.

The faculty has a number of agreements with the universities for students and professors

to temporarily study abroad. Nevertheless, the number of students using this opportunity is low. The reason for this is mainly that majority of the students already have jobs. As the importance of internationalization is increasing in the market, the programme management should define exact means how to increase the student international mobility and promote Erasmus+ and other programs more extensively as well as expand international research activities. Additionally, students expressed the need to introduce more subject taught completely in English in order to be more competitive in the market.

The general rules for the assessment of students' achievements are clearly elaborated in the faculty and VU. Students are well-informed about all requirements they have to follow during the study process as well as appealing procedure. The knowledge assessment system is criteria-proportional as well since it is assessed based on ten-score system. At the beginning of each course, students are introduced to the module description, learning outcomes and the upcoming learning process. The feedback culture is also being established in the programme as students are able to fill in the questionnaire at the end of the semester. Nevertheless, the questionnaire is not actively used by the students due to the large number of questions and lack of feedback after the changes are implemented in the programme.

Similar with general rules for assessment, the evaluation of students' Master theses is also well defined. The members of the Committee take into consideration the graduation thesis, its presentation during the defence, the responses of the author of the thesis to the questions of the reviewer and the members of the Committee, and the reviews and opinions of the reviewer and the supervisor of the thesis.

The faculty is also taking measures to increase academic honesty. It is working according to the Code of Academic Ethics of Vilnius University, which defines general norms of academic, teaching, studies and research ethics. The students are familiarized with this document and have to adhere to the principles stated in it.

According to SER, the employability rate is very high and reached around 85% after 6 months of graduating. Every year several graduates of Mathematics starts PhD studies at Vilnius University or other research institutions as this programme is considered as a gateway to the PhD studies in Vilnius University. Taking into account the employees of graduates, the majority of them are working according to the field of Mathematics as teachers in other higher education institutions, consultants or finance managers, mathematicians, actuaries, analytics etc. Nevertheless, the graduates pointed out that they do not receive any particular communication from the faculty after the graduation and the external evaluation was the first time they were centrally contacted by the faculty. Hence, the faculty could benefit from monitoring the changes in graduates career, gathering their opinion on the changes in the programme as well as their suggestions for master thesis.

2.6. Programme management

The study programme's implementation is administered by the Department of Studies (Vilnius University), which is also responsible for ensuring the quality of studies. All subdivisions of the University and responsible individuals who are involved in the implementation and improvement of the programme keep to the established order, specified by various regular acts (*Regulation of Study Programmes of Vilnius University*, *VU Quality Manual*, *Procedure of Ensuring Feedback to all involved in the Study Process*, *Standards and Guidelines for Quality Assurance in the European Higher Education Area*).

In monitoring the programme, the main role is played by the Study Programme Committee (SPC). The Committee spares neither time nor effort to promote the quality of the programme, i.e. accumulates and analyses data about the programme, processes feedback received from the stakeholders, discusses pressing problems with Faculty Council (at least once

a year), Faculty administration and teaching staff of the programme, propose questionnaires for regular surveys. In review's team opinion, cooperation of the committee with social partners and employers could be more reconciled and productive. Only one social partner from Bank of Lithuania is a member of SPC. In the self-evaluation report, there is no information about the ties of SPC with any potential employers of the programme's graduates.

The SPC and the teaching staff of the programme explore the Vilnius University information system of studies (VUSIS), which evidently makes the information management and implementation of the programme much easier and more convenient.

The Faculty community (students, teachers, etc.) have good access to data recourses and information on the study process and monitoring of the programme. In particular, official websites of the University and Faculty, AIKOS, Discovery Days, Study Fair (Learning, Studies and Career), special annual publications, etc. The availability and transparency of the information is ensured.

Taking into consideration the previous external assessment results and recommendations, a few serious and important changes, associated with the list of study subjects, have appeared in the programme, e.g. two new compulsory study modules have been introduced, namely: "Packages of Statistics" (compulsory, 6 credits, 3rd semester, to develop currently in demand students' software skills) and "Parallel computing" (compulsory, 6 credits, 2nd semester, to match the labour market needs).

Summarizing, the study programme's management and the internal study quality assurance measures, taken by the programme's administration are adequate, transparent and effective. The study programme has very strong theoretical foundation built up on serious advanced mathematical courses; professional experience and competencies of the teaching staff are very high.

2.7. Examples of excellence *

The competences developed and intended learning outcomes of the study programme are given in proper details. Competences are separated into two sets in a logically consistent way emphasising their different role graduates professions:

- *Generic competences: 1. Abstract and critical thinking skills; 2. Life-long learning skills; 3. Communication and collaboration skills;*
- *Subject-specific competences: 4. Advanced theoretical knowledge of mathematics (theory, methods); 5. Ability to apply mathematical knowledge and skills; 6. Ability to perform mathematical research.*

III. RECOMMENDATIONS*

1. To better equip students with knowledge to meet today's research and applications development it is recommended to design one or two courses on algebra, geometry and topology that deal with algebraic structures, computer algebra and topological shapes if possible.
2. International mobility of students and the teaching staff should be encouraged through exchange programmes, taking advantage of the possibility of a sabbatical as well as introducing some courses held in English. Initial teacher training of PhD students and young doctors should be systematically encouraged. This training should not restrict to general pedagogical concerns and ICT skills but also include an opportunity for reflective thinking on the teaching and learning of mathematical topics.
3. It is recommended to review the study programme in a systematic way involving Social partners and Alumni representatives in order to keep it up-to-data and more attractive.
4. Despite active involvement in their own research work, the teaching staff should be more flexible in proposing and developing topics (for students' final thesis) on the boundary of two or more research fields.
5. The process of gaining competences and advancing through career should be accelerated for the young generation of teachers.

IV. SUMMARY

The aim of Mathematics master study programme is to improve students' competencies gained during first cycle study programme Mathematics and Applications of Mathematics BSc, or to some other in compliance to this one, and to train qualified specialists who have advanced knowledge in pure and applied mathematics as well as strong problem solving skills so that they can successfully tackle challenging scientific, industrial, economic problems.

The competencies developed and intended learning outcomes of the study programme are described in proper details. Competences are separated into two sets in a logically consistent way emphasizing their different role in graduates' professions:

- Generic competences: 1. Abstract and critical thinking skills; 2. Life-long learning skills; 3. Communication and collaboration skills;
- Subject-specific competences: 4. Advanced theoretical knowledge of mathematics (theory, methods); 5. Ability to apply mathematical knowledge and skills; 6. Ability to perform mathematical research.

The synergy of demanding students, programme management and teaching staff is exemplary for a good implementation of the study programme. Connections of pure and applied mathematics are in line with labour market needs concerning development of challenging applications.

The international recognition of the research carried out by the staff members is acknowledged, especially in partial differential equations, probability theory and analytic number theory. Nevertheless, competencies in algebra, geometry and topology should be reinforced in order to assert these competencies by the presence of research specialists in these fields. They are not only very important in their own right but also extremely useful in modern and dynamical multidisciplinary research and applications. In particular, in the era of the big data, large and complex systems and bioinformatics where effective algorithms are highly demanded. This is because these specialists help one to recognize data structures, shapes so to develop theory for reducing complexity in computation. The interviews permitted to confirm that those domains are not currently represented in the research carried out at VU. International cooperation is not enough intensive as could be.

V. GENERAL ASSESSMENT

The study programme *Mathematics* (state code – 621G10001) at Vilnius 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	4
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	4
	Total:	**20**

*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.

Grupės vadovas: Team leader:	**Prof. Neda Bokan**
Grupės nariai: Team members:	**Prof. Yishao Zhou**
	Assoc. Prof. Thomas Hausberger
	Prof. Jonas Valantinas
	Mrs. Aldona Savičienė
	Ms. Dalia Miklaševičiūtė

Vertimas iš anglų kalbos

<...>

V. APIBENDRINAMASIS ĮVERTINIMAS

Vilniaus universiteto studijų programa *Matematika* (valstybinis kodas – 621G10001) vertinama **teigiamai**.

Eil. Nr.	Vertinimo sritis	Srities įvertinimas, balais*
1.	Programos tikslai ir numatomi studijų rezultatai	4
2.	Programos sandara	3
3.	Personalas	3
4.	Materialieji ištekliai	3
5.	Studijų eiga ir jos vertinimas	3
6.	Programos vadyba	4
	Iš viso:	**20**

* 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 magistrantūros studijų programos tikslas – gerinti studentų gebėjimus, įgytus pirmosios pakopos matematikos ir matematikos taikymo ar kitoje ją atitinkančioje studijų programoje, rengti kvalifikuotus specialistus, turinčius išplėstinių grynosios ir taikomosios matematikos žinių bei stiprių problemų sprendimo įgūdžių, gebančius sėkmingai spręsti sudėtingas mokslo, pramonės ir ekonomikos problemas.

Studijų programos ugdomi gebėjimai ir numatomi studijų rezultatai smulkiai aprašyti toliau. Gebėjimai logiškai suskirstyti į dvi grupes, pabrėžiant jų skirtingą vaidmenį profesinėje veikloje:

Bendrieji gebėjimai: 1. Abstraktus ir kritinis mąstymas. 2. Mokymosi visą gyvenimą įgūdžiai. 3. Bendravimo ir bendravimo įgūdžiai.

Dalykiniai gebėjimai: 4. Išplėstinės teorinės matematikos žinios (teorija, metodai). 5. Gebėjimas taikyti matematines žinias ir įgūdžius. 6. Gebėjimas atlikti matematinius tyrimus.

Studijų programoje dalyvauja reiklūs studentai, programos vadovai ir dėstytojai, kurie padeda ją sėkmingai įgyvendinti. Grynosios ir taikomosios matematikos derinys patenkina darbo rinkos poreikį specialistams, gebantiems kurti sudėtingas programas.

Dėstytojų atlikti tyrimai matematinės fizikos lygčių, tikimybių teorijos ir analizės skaičių teorijos srityse pripažinti tarptautiniu mastu. Algebros, geometrijos ir topologijos kompetencijos turėtų būti sustiprintos įtraukiant šių sričių tyrimų specialistus. Šie dalykai yra ne tik svarbūs, bet ir naudingi atliekant šiuolaikinius dinamiškus įvairių sričių tyrimus bei taikant jų rezultatus, tuo labiau didžiųjų duomenų, plačių ir sudėtingų sistemų bei bioinformatikos laikais,

kai veiksmingi algoritmai itin reikalingi. Šių sričių specialistai padeda atpažinti duomenų struktūras, diagramas ir sukurti teoriją skaičiavimams supaprastinti. Atliktos apklausos patvirtino, kad šios sritys šiuo metu nėra atstovaujamos VU atliekamuose tyrimuose. Tarptautinis bendradarbiavimas nepakankamas.

<...>

III. REKOMENDACIJOS

1. Siekiant geriau parengti studentus šiuolaikiniams moksliniams tyrimams ir jų taikymui, rekomenduojama paruošti vieną ar du kursus, susijusius su algebra, geometrija ir topologija, kuriuose, jei įmanoma, būtų nagrinėjamos algebrinės struktūros, kompiuterinė algebra ir topologinės figūros.
2. Tarptautinis studentų ir dėstytojų judumas turi būti skatinamas per mainų programas, metines atostogas ir siūlant dalį kursų anglų kalba. Turi būti sistemingai skatinamas doktorantūroje studijuojančių ir ją neseniai baigusių studentų rengimas mokytojauti. Mokymai neturėtų apsiriboti bendrosiomis pedagoginėmis temomis ir IRT įgūdžiais, bet taip pat turėtų apimti refleksyvųjį mąstymą apie mokymą ir matematikos temų mokymąsi.
3. Rekomenduojama sistemingai peržiūrėti studijų programą kartu su socialiniais dalininkais ir absolventų atstovais, kad ji būtų atnaujinta ir pritrauktų daugiau studentų.
4. Dėstytojai turėtų ne tik aktyviai dalyvauti savo mokslinių tyrimų srityse, bet taip pat siūlyti ir plėtoti temas (studentų baigiamiesiems darbams), kurios sietųsi su dviem ar daugiau mokslinių tyrimų sričių.
5. Jaunosios kartos dėstytojams turėtų būti suteikta galimybė sparčiau kelti kvalifikaciją ir kilti karjeros laiptais.