



STUDIJŲ KOKYBĖS VERTINIMO CENTRAS

Vilniaus universiteto
STUDIJŲ PROGRAMOS MATEMATIKA IR JOS TAIKYMAS
(valstybinis kodas - 612G10001)
VERTINIMO IŠVADOS

EVALUATION REPORT
OF MATHEMATICS AND APPLICATIONS OF MATHEMATICS
(state code - 612G10001)
STUDY PROGRAMME
at Vilnius University

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Išvados parengtos anglų kalba
Report language – English

DUOMENYS APIE ĮVERTINTĄ PROGRAMĄ

Studijų programos pavadinimas	<i>Matematika ir jos taikymas</i>
Valstybinis kodas	612G10001
Studijų sritis	Fiziniai mokslai
Studijų kryptis	Matematika
Studijų programos rūšis	Universitetinės studijos
Studijų pakopa	Pirmoji
Studijų forma (trukmė metais)	Nuolatinė (4)
Studijų programos apimtis kreditais	240
Suteikiamas laipsnis ir (ar) profesinė kvalifikacija	Matematikos bakalauro
Studijų programos įregistravimo data	2001-05-24 No. 877

INFORMATION ON EVALUATED STUDY PROGRAMME

Title of the study programme	<i>Mathematics and Applications of Mathematics</i>
State code	612G10001
Study area	Physical sciences
Study field	Mathematics
Type of the study programme	University Studies
Study cycle	First
Study mode (length in years)	Full-time (4)
Volume of the study programme in credits	240
Degree and (or) professional qualifications awarded	Bachelor of Mathematics
Date of registration of the study programme	2001-05-24 No. 877

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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.	Action plans
2.	Student publications
3.	Students' practice reports

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

The study programme of “Mathematics and Applications of Mathematics” is implemented by the Department of Differential Equations and Numerical Mathematics and the 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 27 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 aim of "Mathematics and Applications of Mathematics" bachelor study programme is to prepare professionals who acquire different aspects of mathematics and ability of critical thinking. The study programme focuses on pure mathematics, applied mathematics, and computer science, with an emphasis on advanced mathematical techniques, problem solving, computer programming and clear communication of ideas.

The competencies developed and intended learning outcomes of the study programme are given in proper details and presented in Table 1.1 (SER, p.6). Competencies are separated into two sets in a logically consistent way emphasizing their different role in graduate's professions:

- Generic competencies: 1. Abstract and analytic thinking; 2. Communication,

- collaboration skills, and social skills; 3. Lifelong learning skills;
- Subject-specific competencies: 4. Comprehensive knowledge of mathematics; 5. Mathematical modelling; 6. Application of mathematical software.

The review team concludes the study programme was changed to acquire the requirements of the adoption of the 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.

According to SER the formulated intended learning outcomes of the Mathematics and its Application study programme students suppose to acquire knowledge and skills to define and illustrate main concepts of mathematics, to state and prove basic mathematical propositions, including their applications in typical problems solving; knowledge of formulating real-world problems in mathematical language, to construct and analyse corresponding mathematical models, including conclusions made and their justification based on their analysis; knowledge of using some programming language to solve mathematical and non-mathematical problems.

Life-long learning skills cover application of various strategies and methods of learning, finding and analysing of literature, collecting data, processing and analysing of received information. Expected learning outcomes to acquire abstract and analytic thinking are also described and soft skills as well.

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

- the catalogue of study programmes of Vilnius University on its official website [https://klevas.vu.lt/pls/pub/public_ni\\$www_prog_app.show](https://klevas.vu.lt/pls/pub/public_ni$www_prog_app.show)
- the official website of the faculty <http://mif.vu.lt/lt3/index.php/studijos/studiju-programos/ba-studiju-programos/matematika-ir-matematikos-taikymai>
- the official website of the University intended to prospective students <http://www.vu.lt/kviecia/>
- the official website of the “Open System of Providing Information, Tutoring and Vocational Orientation”, or AIKOS (a Lithuanian acronym) <http://www.aikos.smm.lt/andgoo.gl/Ups803>

There exist also some publications available during a variety of promotional events: “Vilnius University invites its students. First study cycle programmes and integrated studies”, etc.

During the meetings with stakeholders the review team learned graduates can easily find a job, because of their abstract, analytical and quick way of thinking, data analysis skills, deep knowledge of mathematics, ability to use specialized software, etc. Senior managers informed the review team graduates can also find a job in data analysis, process analysis, in schools, if they acquire 60 ECTS in minor study field of pedagogical studies.

In the opinion of social partners and Alumni representatives some graduates’ skills and competencies could be further improved introducing some additional courses in the curricula, i.e. writing skills in order to prepare good report, IT knowledge including more sophisticated education in development and applications of proper software as well as practical knowledge to understand some economics models, etc.

The review team learned also that the study programme committee (SPC) organizes the meetings regularly in order to discuss the needs of the study programme, analyze the available feedback from the stakeholders and consider the measures to improve the study programme. A significant revision of study programme took place in 2012, where recommendations from the students, social partners and the previous evaluation report were addressed. The clear need of advanced communication abilities of the students was highlighted by social partners; therefore, study programme committee (SPC) involved the training of communication abilities during several courses of the study programme (Foreign language I,II, History and Philosophy of Mathematics, Graduating Work and Professional Practice)). Oral and written communication in

Lithuanian and in English was specified as one of the graduates' learning outcome.

The previous analysis of students' feedback expressed two main problems of the programme: there were too little available elective courses and too much overlapping in the study content of different courses. Hence, SPC allocated 60 credits that students can freely choose or use them for a minor study in Vilnius University. As a consequence of students' and social partners' recommendations the number of applied and business-oriented courses was increased in order to match the needs of the modern labour market (e.g. Database Management Systems, Visual Programming, Basics of Mathematical Modelling, Encoding and Cryptography, etc.). These developments review team considers as very positive.

Hence the review team concludes Programme objectives and intended learning outcomes are linked to the state, societal and labour market needs. Programme objectives and intended learning outcomes correspond to the mission, operational objectives and strategy of the Vilnius University.

Upon completion the study programme of "Mathematics and Applications of Mathematics" graduates may engage in further studies in mathematics or a related Master study programme. Also, after further work, graduates could enrol in an unrelated second cycle study programme or get employed by science or education institutions, information or social investigation agencies. Graduates can also pursue a career in spheres where their mathematical knowledge, abstract and analytical thinking as well as ability to use specialized software are needed.

Qualification obtained upon completion of this first-cycle study programme is in conformity with qualification VI as specified in the Qualification Framework of the Republic of Lithuania, by putting emphasis on broad theoretical knowledge based on the results of new fundamental and applied research; ability to study and work independently, selecting the methods for task completion, analysing and recording activity results, submitting reports to activity coordinators, ability to adapt to constant and normally unpredictable changes predetermined by the progress of knowledge and technologies in a specific professional field.

All the improvements of the learning outcomes (development of communication skills, more courses of applications of mathematics and business oriented, lifelong learning skills, formulated real-world problems in mathematical language and applications of mathematical software) are well implemented. Qualifications are based on graduates' advanced knowledge and understanding in the field of study, its application, making judgements, communication and lifelong learning skills.

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

The volume of the study programme is 4 years or 240 ECTS credits. 165 credits are allocated for the study field subjects in mathematics, 15 for general university studies, 60 for specialization such as database management systems, number theory, applied statistics, basics of mathematical modelling and reliability theory, etc. 18 credits for internship and 12 for final thesis. For each semester there are 5 or 6 courses thought. Thus the programme structure is in line with the legislative requirements.

The review team found that the description and analysis on the curriculum design in the Self Evaluation Report are well-written and comprehensible and the site visit confirms most parts in the SER. More precisely the courses in the study programme are taught in a consistent way in general with no significant portion of repeated topics among the subjects, and content of subjects reflects the main aim set up for a Bachelor's degree and are adequately designed for this purpose. The implementation of the courses and study methods such as case study, practical computer work in applied subjects, enable students to achieve expected learning outcomes.

Although this is a good study programme from the beginning, there is a considerable

amount of work done since the last evaluation. One example is that the programme now enables students to have an opportunity to choose the minor studies from the list in other study fields, for example, teacher's education. The review team believes that the education of highly qualified school teachers with a solid background in mathematics is a great contribution to the society and country. Another example is that the programme has introduced a new course in History and philosophy of mathematics. This will deliver to students more perspectives in mathematics discipline, abilities to develop critical reasoning and thinking skills. Moreover, the programme has been modernized by offering more contemporary courses mentioned above and by relocating the hours of the already existing courses. The review team recognizes that the balance between the theoretical subjects and applied subjects is good, and informatics and basics of computer science are well represented in the programme. In particular, the review team noticed that data mining is included in the curriculum. This shows that the programme is not only aiming to being up-to-date in active research areas but also aware of high demand of graduates specific skills among future employers. All these indicate that the content of the programme corresponds to the latest academic and technological achievements.

The programme is definitely of international standard at this study level. To make students even better prepared for contemporary challenges, the review team points out the following comments or suggestions for improvement. Firstly the topics from the following disciplines are not represented: bio-chemical network and systems biology, climate science and life science. These very active and dynamical research and application areas that demand very high competences in mathematics may be introduced in the study programme. A reorganization of the course Basics of mathematical modelling is recommended. The course could partially cover up-to-date scientific and application areas, for example, topics in bio-chemical network, systems biology, climate science, life science may be introduced. This would enable students to understand how many seemingly very different mathematics topics are merged. Also this may serve as motivation for students to study more pure mathematical subjects because there is no classical distinction in present-days when applications are concerned.

The review team also believes that faculty may realize the lack of algebra, geometry and topology in both study programmes as well as in research, if such topics are brought to the students. The review team observed that lack of these subjects is not just a problem in VU but rather a nationwide problem. It should be noted that some social partners the review team interviewed showed concern on the need of more and more pure mathematics in order to develop challenging applications. They manifested their satisfaction that this programme and the master's programme in mathematics generate such candidates with solid background in mathematics.

Social partners also showed concern on the need of skills in *writing* mathematical text in English, which may be reinforced in the programme, for example by imbedding writing in the study programme during the whole period of study. Some possible implementations without increasing amount of subjects may be as follows: in writing final thesis it could be required to write an extended abstract – this is also good for students if they apply for a job or a master programme internationally; the “History course” can offer some subjects in English with emphasis on writing a good English text; students may be asked to write an abstract in English after each course.

Some students and graduates during the interview expressed their concern in having computer programs late in their education. The review team finds that it might be improved by introducing some computer programs that do not need significant time to learn in earlier study of the programme. Such computer programs could be Wolfram's Mathematica because its open source Wolframalpha (<https://www.wolframalpha.com/>) is in fact free. The purpose is not only to introduce IT but also to provide students with the possibility to investigate more complex problems and examples than those that are done by hand in order to develop skills in heuristics (formulating and testing their own conjectures, engaging in critical thinking, etc.) in relation to inquiry-based approaches and more creative teaching and learning activities.

2.3. Teaching staff

There are 26 academic staff members engaged in the programme: 6 Professors (Dr Habil. or Prof. Dr.), 8 Associate Professors (Dr), 8 Lecturers (Dr) and 4 lecturers or assistant lecturers without a doctorate degree. The staff is experienced with an average teaching experience of about 18 years. The average teachers-to-students ration during the evaluation period is 0.73 (the number of admitted students varies in the range 41-66), which is favorable to the programme.

The teaching staff meets the legal requirement with 92% of staff having being researchers in mathematics, informatics or physics. 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, computer-aided geometric design) and informatics (Information system design, Image analysis, Neural networks, Complexity 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 in mathematical modeling and informatics. 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. The interviews permitted to confirm that those domains are not currently represented in the research carried out at VU. 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.

Half of the teachers are in the >50 age group. This situation induces a potential staff shortage that should be dealt with. The SER does not mention any specific plan to recruit teachers, apart from the description of the general VU recruitment policy. The SPC should take care of this issue to ensure the viability of the SP. The SER shows that 10 teachers left VU in the 2012-16 period. It was discovered during the interviews that this turnover is due to the retirement of teachers (5) but also to low salaries that led younger doctors to leave to work in an IT company or to postdocs abroad.

The SER mentions that the Faculty of Mathematics and Informatics hired in 2016 three former students of the programme. This raises the issue of inbreeding and the necessity of setting up a more open hiring policy. Mobility within Lithuania is indeed a viable option on the basis of 20 universities in Lithuania. 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. Postdocs should be encouraged for students who obtained a PhD degree from VU before they are locally hired as associate professors.

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. Teachers are involved in 2 international projects, including a Marie Curie training network. These indicators attest the high competence of the main part of the teaching staff, especially senior researchers. In 2012-2016, the SPC has invited 2 academic staff from abroad in 2012-16, what is also a positive sign with regard to the international dimension.

The current teaching load of teachers is 320 hours /year for a professor and 360 hours / year for a lecturer. Although this workload is better and more democratic than in other study programs at VU, it should be pointed out that 360 h doesn't give a lecturer decent conditions for professional development as a researcher on the international scale, which is bound to lead to negative middle-term effects on the programme. The same considerations apply for professors in order to ensure fruitful research outcomes. It was then discovered during the interviews that VU is currently planning a reform of the workloads. 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.

Finally, 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 secondary-tertiary transition in relation to mathematics, the transition from calculus to analysis, the issues of abstract subjects such as linear 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.

2.4. Facilities and learning resources

There are sufficient number of classrooms and laboratories for the implementation of study programme. The lectures of study programme are carried out in the buildings at Naugarduko St. 24 (classrooms and teacher's offices) and Šaltinių St. 1A (computer laboratories). In addition, students have some 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.

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

Teaching materials, such as 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.

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 1st cycle studies at the VU. As stated in SER, the entrance score is based on the results of some school subjects and the Matura examinations. The Matura examinations considered for the entrance score are the following: mathematics, informatics or physics, Lithuanian language, any different from the previous three.

The entrance score has a slightly decreasing trend in the recent years (2014 – 7,767 for state funded (SF) and 6,135 for not state funded (NSF), 2015 – 7.774 for sf and 5,79 for nsf, 2016 – 7,519 for sf and 5,418 for nsf), although we cannot directly compare 2012 and 2013 with other years of enrolment scores since the calculation of the score has changed. Decreasing numbers highlights that new entrants of the programme might be less motivated. Nevertheless, all the mean values in the recent years slightly exceeded the mean value of other programmes in the faculty.

The general trend in Lithuanian HEIs is that the number of students is decreasing. Nevertheless, the programme is not affected with significant changes in the number of the admitted student (2014-41, 2015-49, 2016-50). The stable numbers prove that the programme is considered as popular.

Although the programme admits the significant number of students, the dropout rate is high varying from 27% in 2012-2016, 58% in 2013-2017, 37% in 2014-2018, 47% in 2015-2019 to 14% for 2016-2020. The trend is fluctuating from year to year but the main reason why students are leaving the programme is their own free will. This indicates that the content is not clear for the entrants and there is a mismatch between programme management and students expectations. It is remarkable that the programme management introduced informal methods with the students who face academic debts in order to manage the dropout rate but the attitude

towards the dropout rates should be viewed more systematically.

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 participate in research activities starting from the first years. 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, students are encouraged to take internships in Research Council of Lithuania where their research activities are also funded by the state. These grants were awarded to a couple of students from the programme.

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 (according to SER on average, 3.5 students per year took part in exchange programmes). 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. 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. 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. Although programme management is changing the questionnaire for student's feedback it is also suggested having more face to face conversations with the students during each module.

Similar with general rules for assessment, the evaluation of students' bachelor 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. Nevertheless, the students highlighted that the procedure of writing Bachelor thesis could be improved since the minority of professors introduces the students with their research field, the upcoming Bachelor thesis, consults on how select the topic for 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 75% when graduating. The examples of employers for this programme graduates consist of "Bentley Systems Europe", "Affecto Lietuva", "Barclays Technology Centre Lietuva", "AB SEB bankas", "AB Swedbank", "A/S Danske bank". Taking into account the employees of graduates, the majority of them is working according to the field of Mathematics as financial analysts, finance managers, insurance agents etc. The graduates of this programme are highly valued by the stakeholders who employ the students during their studies for internship and full-time jobs. According to the stakeholders, the only limitation of the graduates to be successful is the average communication in English.

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

Implementation of the study programme is administered by the Department of Studies, which is also responsible for ensuring the quality of studies. All subdivisions of the University involved in the implementation and improvement of the programme keep to the established order, based on 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 responsibility is taken by the Study Programme Committee (SPC). The Committee exerts every effort to promote quality of the programme. In particular, accumulates regularly and analyses data about the programme, processes feedback received from the stakeholders and makes necessary decisions, discusses urgent problems with Faculty Council (at least once a year), Faculty administration and teaching staff of the programme, prepares questionnaires, organizes surveys (twice a year; also, during the semester), etc. But, in students' opinion (experts' team meeting's outcome), the feedback, as well as the internal study quality assurance system, as a whole, does not function sufficiently well (feedback needs to be improved, presentation of some lectures in style "slide-by-slide" is not successful, some teachers are more involved in their research work than in teaching, i.e. they are not much responsible in communicating with students, lack of "software" skills among the students, etc.). One more urgent problem for the SPC is the significant number dropout rate. It would be of use to the programme implementers to know exact reasons of this undesirable process.

What concerns social partners, they are in close and fruitful cooperation with SPC representative of Centre for Analytics Modelling and Innovation at Euromonitor International and representative from Bank of Lithuania are members of the Committee; one or more social partners enter the Bachelor's Thesis defence Commission. For instance, following recommendations of social partners and the previous external evaluation report (2011), a significant revision of the programme has been carried out (e.g. the training of advanced students' communication abilities during several courses of the study programme has been introduced).

The SPC and the teaching staff of the programme benefit from exploring the Vilnius University information system of studies (VUSIS). System makes information management and the implementation of the programme much easier.

The Faculty community (students, teachers) 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 and so on. In other words, availability and transparency of the information is very good.

Summarizing, the programme management and the internal study quality assurance measures, taken by the programme implementers, are adequate, at an average effective and transparent. The teaching staff is high-qualified; minor studies (in other faculties) are available for students involved in the programme; the arsenal of the internal study quality assurance measures is wide enough; access to all the resources of information about the programme and its improvements is easy and without any limitations.

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 scope in view to the graduates' professional development:

- *Generic competences: 1. Abstract and analytic thinking; 2. Communication, collaboration skills, and social skills; 3. Lifelong learning skills;*
- *Subject-specific competences: 4. Comprehensive knowledge of mathematics; 5. Mathematical modelling; 6. Application of mathematical software.*

III. RECOMMENDATIONS*

1. A reorganization of the course Basics of mathematical modelling is recommended.
2. It is recommended that training to write mathematical text in English be imbedded in the study programme during the whole period of study.
3. It is recommended that the programme introduce mathematical computer programs in earlier study years, for example, Wolfram's Mathematica or Wolframalpha (<https://www.wolframalpha.com/>) could be embedded in any basic courses.
4. Competencies in Algebra, Geometry and Topology should be reinforced in order to assert these competencies by the presence of research specialists in these fields. 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.
5. The level of internationalization of the programme should be enhanced by increasing the mobility of students and academic staff as well as introducing some courses held in English. International mobility of the teaching staff should be encouraged through exchange programmes, taking advantage of the possibility of a sabbatical. Initial teacher training of PhD students and young doctors should be systematically encouraged. This training shouldn't restrict to general pedagogical concerns and ICT skills but also include an opportunity for reflective thinking on the teaching and learning of mathematical topics.
6. The feedback from Alumni regarding the study programme should be reviewed on a systematic basis. The graduates' careers should be monitored.
7. Project-based and case study teaching methods, as well as group work, should be developed and applied on a regular basis in the study process. It would "soften" the gap between theory and practice, which is noticeable at the moment.
8. The process of gaining competences and advancing through career should be accelerated for the young generation of teachers.

IV. SUMMARY

The aim of “Mathematics and Applications of Mathematics” bachelor study programme is to prepare professionals who acquire different aspects of mathematics and ability of critical thinking. The study programme focuses on pure mathematics, applied mathematics, and computer science, with an emphasis on advanced mathematical techniques, problem solving, computer programming and clear communication of ideas.

The competencies developed and intended learning outcomes of the study programme are given in proper details. Competencies are separated into two sets in a logically consistent way emphasizing their different role in graduate’s professions:

- Generic competencies: 1. Abstract and analytic thinking; 2. Communication, collaboration skills, and social skills; 3. Lifelong learning skills;
- Subject-specific competencies: 4. Comprehensive knowledge of mathematics; 5. Mathematical modelling; 6. Application of mathematical software.

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. Graduates of this programme with major field in mathematics and applications of mathematics and pedagogical science as minor (or additional 60 ECTS in pedagogy for qualification) are capable to be teachers of mathematics in primary and secondary schools.

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, computer-aided geometric design) and informatics (Information system design, Image analysis, Neural networks, Complexity theory). 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. 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 and Applications of Mathematics* (state code – 612G10001) 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	3
	Total:	19

*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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