STUDIJŲ KOKYBĖS VERTINIMO CENTRAS

Vilniaus Gedimino technikos universiteto

STUDIJŲ PROGRAMOS TECHNO*MATEMATIKA (valstybinis kodas - 621G16001)* VERTINIMO IŠVADOS

EVALUATION REPORT OF TECHNO*MATHEMATICS* (*state code -621G16001)* STUDY PROGRAMME

at Vilnius Gediminas Technical University

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DUOMENYS APIE ĮVERTINTĄ PROGRAMĄ

Studijų programos pavadinimas	***Technomatematika***
Valstybinis kodas	621G16001
Studijų sritis	Fiziniai mokslai
Studijų kryptis	Matematika
Studijų programos rūšis	Universitetinė 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	2007

INFORMATION ON EVALUATED STUDY PROGRAMME

Title of the study programme	***Technomathematics***
State code	621G16001
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	2007

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The Centre for Quality Assessment in Higher Education

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I. INTRODUCTION

1.1. 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).

1.2. 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.	Study plan for year 2017-09
2.	Faculty staff prepared books and monographs

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

The Departments of Mathematical Modelling, Strength of Materials and Theoretical Mechanics located in the Faculty of Fundamental Sciences of the Vilnius Gediminas Technical University (VGTU) are directly responsible for the programme, overseeing its delivery and

monitoring. VGTU is an institution of higher education whose start is deemed to be September 1, 1956, when Vilnius Evening Division of the Evening of Kaunas Polytechnic Institute (KPI) was established. It consists of 9 faculties and 1 institute of studies: "A. Gustaitis" Aviation Institute, the Faculty of Environmental Engineering, Architecture, Electronics, Fundamental Sciences, Creative Industries, Mechanics, Civil Engineering, Transport Engineering and Business Management. The structure includes 60 departments. Research is conducted in 6 University research subdivisions, 22 faculty research centres and 9 accredited laboratories. Other departments, such as Department of Philosophy and Political Theory, Foreign Languages, etc. are also involved in the Study programme development and implementation. VGTU also consists of library, publishing house, administration and other subdivisions.

1.4. 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 *26 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

Objectives of Technomathematics master study programme are: to improve students' competences gained during the first cycle study programme Technomathematics BSc, including applied mathematics, informatics and engineering to be capable of applying acquired knowledge and modern technology in the field of scientific research and experimental development. The objectives indicated in Self-evaluation report (SER) correspond with Dublin descriptors, the descriptions of the Lithuanian legal acts and cover knowledge and its application, scientific

abilities to conduct research, including special abilities and soft skills of social and personal types.

According to SER the formulated intended learning outcomes of the Technomathematics study programme students suppose to acquire knowledge of information technology project management, information visualization technology, development, testing and support of sophisticated mathematical modelling and analysis packages, knowledge of engineering objects design systems, design technology, automated design systems, the principles of modern algorithms structure and realization, etc. Abilities to conduct research cover scientific research planning; using packets of mathematical modelling and analysis, algorithms of information visualization technology; developing of mathematical models of physical, technical and biological objects and analysis of achieved result by looking for optimal solutions using various methods, and finally analysis the complexity of these algorithms. Special abilities important for describing of physical, technical, biological, economic and other fields in the mathematical language are also described as well.

Hence the review team conclude this master study programme is an interdisciplinary and unique in Lithuania, based on teaching staff experience developed cooperation with colleagues from Kaiserslautern University and other universities in Germany and other European countries.

The evaluation of study programme objectives and intended learning outcomes according the recommendations of the previous external evaluation team have been presented in SER, p.34, and Table 7.2. We emphasize the objective concerning abilities to conduct research. Meetings with the National Cancer Institute researchers are currently taking place to discuss cooperation in the project activities. During the meeting with students of this study programme the review team have learned one of student already prepares his master thesis in the frame of this project.

Strengths, weaknesses and improvement actions of the study programme aims and intended learning outcomes have been also observed (more details one can see in Table 2.3, SER p.11, and Annex 9). Details of the Technomathematics programme aims and anticipated learning outcomes are available on the university's information system "Alma Informatica" on https://medeine.vgtu.lt/programos/, on the website of the Department of Mathematical Modelling http://www.techmat.vgtu.lt, on the website of the open information, consulting and guidance system (AIKOS) http://www.aikos.smm.lt/aikos/ and on the website of Lithuanian Higher Education Association for General Admission (LAMA BPO) http://www.lamabpo.lt/. Also, this information is presented in the annually organized VGTU "Open Doors" events, and on the built-in information monitors in the VGTU lobby.

Consequently, the review team conclude that programme objectives and intended learning outcomes are well-defined, clear and publicly announced.

Programme objectives and intended learning outcomes are linked to the state, societal and labour market needs mainly of the European Union. The conclusion comes from observation during the meetings with teaching staff, and stakeholders representatives. Concerning the needs of labour market redundancy in Lithuania some graduates may find a job in compliance with all of their competencies acquired during the studies and others mainly in informatics companies which use not only their knowledge acquired in informatics, but also some other skills acquired during Technomathematics studies. Social partners have recognized especially knowledge of Technomathematics' graduates in teams of engineers who work in developing of software for engineering purposes and who needs finite element knowledge for civil engineering purposes. Despite the fact that labour market needs of Technomathematics graduates are not very significant all social partners support the sustainability of this study programme because of its uniqueness and interdisciplinary.

Representatives of Alumni organization during the meetings pointed out that due to current contextual labour situation it is important to build a net of mathematics, physics and informatics to develop tools which solves real world problems. Knowledge and other skills

acquired in Technomathematics study programme are linked in professional requirements of individual and team work in order to reflect real world problems concerning technologies based on applications of mathematics and informatics.

It is important to take into account stakeholders and students need for learning outcomes which depend on project-based teaching methods, case study, simulations, etc. These skills would offer better employment opportunities in the fields related to the application of mathematics, computing and engineering knowledge: the high-tech sector (telecommunications, mechatronics, etc.), the sectors of state management, business, trade, services, finances, education, health care and social security.

As it is pointed out during the reorganization of the study programme, following Experts' observations, the continual consultations with social partners: UAB "Telia-Sonera", UAB "Affecto", National Cancer Institute on the issues of the study programme's aims and intended learning outcomes have been organized.

Programme objectives and intended learning outcomes correspond to the mission, operational objectives and strategy of the Vilnius Gediminas Technical University. The second cycle Technomathematics study programme corresponds with the descriptions of the Lithuanian legal acts and normative documents.

Graduates can also continue the doctoral studies of pure and applied mathematics in Lithuania and other countries as they acquire sufficient level of abilities for the research through analytical thinking, critical analyzing information based on interdisciplinary knowledge.

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

The title of the programme, intended learning outcomes, the content of the programme and the qualification to be obtained are balanced. The title of Technomathematics study programme are in compliance with programmes similar to that one in Germany, Sweden and some other countries.

2.2. Curriculum design

The study programme is at advanced level with a master's degree upon qualification. A full time working load is 2 years with 120 ECTS credits distributed in four semesters with 30 credits each. Therefore the curriculum is in line with the legislative requirements.

The SER states that the allocation credits among courses is modified from time to time after the analysis of students results as showed in the evaluation of their knowledge and other abilities. Consequently the expected learning outcomes adjusted accordingly. This is possible because there are a very small number of students. In turn this might indicate that subjects of study are taught with students need in the centre and in a consistent manner.

The study program may well fall in the category of Engineering mathematics as it is in many universities in other European countries. Thus the designed curriculum is much different from study programmes in mathematics at a typical university where students study mathematics without a clear future profession. On the other hand, the review team noticed that the requirements for mathematics are at low degree if the study programme leads to a master's degree in mathematics as the ultimate learning outcomes.

Since the curriculum under review is essentially the same as the one in the previous review the current review team still agrees to most critics and comments from the previous review on the curriculum design, though the review team understands very well difficulties to implement changes according to the previous recommendations, because there are only two years between the two reviews. Nevertheless the situation is not unique. The review team does recognize improvements done by other programmes in a similar situation. Furthermore the explanation of bureaucratic rules from the programme committee is inconsistent with the

statements mentioned in the SER, to repeat "the allocation credits among courses is modified from time to time".

The current review team recognizes that the department and the programme committee have done some work on improving the curriculum. So the rest of analysis will be focused on the new curriculum indicated in the SER. According to the programme committee a new curriculum is formed in accordance with the 2014's review. The following courses are introduced to the curriculum, starting from academic year 2017: Cryptography systems, Object-oriented design, Biotechnical systems and medical diagnostic methods, Markov chains, Operations Research, scientific seminar, Advanced discrete mathematics.

Although it is not possible to judge quality and quantity of these courses without information of contents of each subject, the review team considers this as a development in the right direction. Some courses are reorganized and the order of courses given in the two-year study period is also reorganized. The expected learning outcomes are sounding because there is more freedom to choose courses for deeper specialization. However, the review team could not find action plans in several levels. As for the curriculum design the changes are short of analysis. To be more precise, one can ask why such changes meet the previous review's recommendations and will improve the programme. Questions as follows are arisen after inspecting the SER and the site visit. It is unclear why the subject Cryptography systems is chosen as representative for software engineering. It is unclear why the programme established the course Markov chains (although it is the previous review's recommendation) not a course Stochastic processes (or stochastic analysis) which covers Markov chains. It is unclear why the course Operations research more demanded than possible courses like more specific subjects, for instance, game theory, neural network, network optimization since Operations research has a very large span of subjects.

According to SER, a few changes are already in action. For example, "the academic staff is already working individually with students, meeting the students' individual needs. The current first-year students will start working accordingto the new study plan starting 1 September 2017".

The review team noticed that the graduates from the programme are satisfied with the programme as well as some social partners. Nevertheless, the graduates wished to have had courses like big data science, machine learning and robotics as an improvement. So the review team questions why such a meaningful feedback is not taken into account nor is analyzed in SER. In addition, both the students and the graduates expressed the need of deeper knowledge on computer architecture. Obviously it cannot be considered as deeper specialization in the study field mathematics. Thus the review team also questions whether or not Technomathematics programme is considered as a mathematical programme by students in reality.

The idea of combining mathematics with informatics and engineering science should benefit students on labour market. Some social partners do agree to this statement. So the content of the programme corresponds to the latest technological development. However, a very strong profile in IT in the study programme has some negative effect for the identity of the study programme (mathematics element), observed by the review team. Firstly, the students identify themselves more as a programmer with good mathematics knowledge rather than a mathematician with good knowledge in informatics and engineering science. Secondly, it is hard to claim that the labour market desires such a study programme only by social partner opinion. Thirdly, the graduates, if not working at an IT company, continued as PhD students in IT. Hence, it gives an impression that this is a study programme in informatics. Hence the content of subjects is questionable to achieve the intended learning outcomes dedicated to mathematicians.

The review team believes that the combination of mathematics and engineering science with IT subjects in a mathematical programme is strength of the study programme. However these three parts are currently not integrated optimally. It is also not clear if the programme committee has a strategic action plan to integrate subjects. Since there seem to exist several master's programmes at VGTU that are informatics related, the Technomathematics programme

has to show the solid mathematics to distinguish it from other programme. The review team notice that the social partners also made this observation.

The review team suggests a deep analysis on how three parts of the programme should be better integrated to make the study programme a true mathematics study with strong computer science and engineering science background as original idea aims to. After such an analysis the programme committee should make a strategic action plan on: (i) allocation of credits in mathematics and other subjects with focus on integration of them; (ii) design of each mathematical subject, if already exist improve them in accordance with learning outcomes in the strategy of integration with the two other subjects. It is recommended to have some analysis on why such a design meet the specific needs of the programme, that is, an integral part of the three; (iii) Design of curses in IT and engineering subjects with mathematics in centre; (iv) the curriculum should have a clear identity for students: a mathematical study with strong profiles in engineering and computer science. A concrete suggestion could be some practice, for example, a course on mathematical communication. Students learn how to speak with different target groups with their deep mathematical knowledge and to convince their future employers why they are unique, as a mathematician.

2.3. Teaching staff

There are 12 teachers engaged in the programme: 4 Professors, 7 Associate Professors and 1 Lecturer (the single case who's CV does not mention a PhD degree). The teacher-student ratio 0.93 – 1 – 1.17 – 1.56 – 3 who was already increasing in the preceding evaluation keeps raising with a critical number of 4 students in 2015-16 (9 in 2014-15) and currently 2, despite the quality of the study programme and the dedication of the teaching staff.

The teaching staff is meeting the legal requirement with 100% of teachers having an academic degree in relation to the study subjects. The fields of expertise of the teachers attested by their on-going research activities are coherent with the taught courses and ensure that the qualifications of the teaching staff are adequate to achieve the learning outcomes. 58% of the teaching staff work in the department of Mathematical Modelling; the other 42% come from other departments and provide adequate competencies in Strength of Materials & Engineering Mechanics, Engineering Graphics, Mathematical Statistics, Informatics.

The international cooperation and research activities of the main part of the academic staff are assessed by the publications in international journals and the participation in international scientific conferences, projects and exchange programmes. These well-developed research activities contribute to the quality of the Technomathematics study programme. The academic staff also prepares textbooks for students. Regular research seminars are organised locally. Pedagogical (non-regular) seminars are also organized; the digitalization of courses, the use of ICT in teaching, the teaching of specific courses and related issues are discussed among teachers. English courses have been organised in order to allow teachers to improve their English and thus favor the internationalisation of the technomathematics programme.

Nevertheless, only half of the teaching staff is engaged in international programmes. The interviews confirmed that a limited number of teachers visited foreign universities, for short stays (1-2 weeks) only. This is apparently a consequence of limited capacity of teachers to take a sabbatical due to heavy teaching loads and to low salaries of academics in Lithuania which often induces a necessity for a second job. The main efforts are therefore directed towards local seminars. The programme committee are aware of the importance of promoting academic exchange programmes and are working on the possibility to cover trip costs from faculty resources and thus compensate the unfavorable university policy with regard to professional development. This should be encouraged. The SER also mentions the possibility of sharing courses among faculties in order to decrease the average teaching load and give teachers time for research as required by law. This possibility should be explored and optimized as much as possible. Indeed, the current teaching workload confirmed during the interview (14 hours contact

hours / week, except isolated cases) is too much to insure the development of research to international standards. Remarkable research is achieved by some staff members, but interviews allowed to clarify that these teach little hours or currently do not teach at all, which induces a separation between teaching and research that is not favourable to the teaching programme.

58.4% of teachers are in the age group >50. The necessity of setting up a proper hiring policy and the danger of inbreeding have been pointed out in the last evaluation report by the appointed experts. In response to the recommendation, the improvement actions mentioned in the SER are based on the promotion of 5 local young doctors to Assoc. Prof. and the recruitment of 2 lecturers with a doctorate degree from VU. These facts confirm a lack of mobility within Lithuania, although mobility is possible on the basis of 20 universities in Lithuania. The main efforts are directed towards "retaining the young, promising specialists" under the "unfavourable external conditions" of implementation of the study programme (SER p. 21). Despite the unattractive salaries mentioned in the SER, open calls should be set up and the positions advertised in order to potentially attract the best researchers from Lithuania and other Baltic and neighbouring countries, as recommended in the previous evaluation report.

2.4. Facilities and learning resources

The facilities of VGTU Faculty of Fundamental Sciences are used for the implementation of Technomathematics study programme. The Faculty has 2 training laboratories: one for mechanical tests (Research Laboratory of Strength of Mechanics, 10 test stands and 30 seats); the other for fatigue tests (Teaching Laboratory of Strength of Materials, 4 test stands). Students of Technomathematics may also use the facilities provided by the Laboratory of Parallel Computing, The Laboratory of Parallel Computing runs the personal computer cluster VILKAS with two types nodes, connected into Gigabit Ethernet local network. This cluster provides access to various software development and visualization tools and libraries. The laboratory also runs a cloud computing infrastructure – Open Stack „private cloud".

There are a sufficient number of classrooms for lectures, seminars and laboratory works and sufficient number of seats in the classrooms (taking in mind the number of students in the study programme). According to self assessment report for the implementation of the aims of the study programme the computer classrooms are provided with software such as Microsoft Office, Microsoft Visual Studio, Mathematical software packages Matlab, Maaple, Mathcad, etc.. For virtual experiments and calculations carried out in the course of the study subjects are used software packages as follows: Solid Works(SRL-I-427) and ANSYS (SRL-I-324, SRL-I-325), AutoCad and STAAD-Pro software packages are being used (SRK-II-612).

The university is equipped with optical 1Gbps backbone computer network, thus Wireless internet access is available in the premises of the faculty and dormitories. The wireless computer network EDUROAM is available in all buildings of the university and accessible to all university students who have laptops or smart phones. Students have an access to the lecture notes of study subjects. The lecture notes of all study subjects are available online at Technomathematics study programme web site at http://www.techmat.vgtu.lt/konspektaiM.html and at the virtual studies platform *Moodle.*

Internships are not included in Technomathematics study programme. The topics of master thesis are prepared with social and academic partners what allows students to carry out their research activities using partner's facilities, guidance and expertise. Carrying out research in such way students obtain, gather and process the experimental research data and validate and approve the obtained modelling results.

During the site visit the experts saw facilities, but did not have the opportunity to see the classrooms and laboratories, they were closed. Experts agree that the faculty has premises for studies which are adequate in their size and quality for programme implementation. The

premises meet the labour safety and hygiene norms requirements and are adjusted for disabled students: a special parking lot, premises equipped with special wheelchair ramps and lifts.

Library of University provides 330 working seats, 48 of which are computerized. During the visit the experts did not have the opportunity to visit central Library of University but did visit a faculty library in the Faculty of Fundamental Sciences (17 working seats, 9 of which are computerized). The students have an opportunity to use the online access to 29 subscribed databases. The list of available databases is provided on the university library website: http://biblioteka.vgtu.lt/unit-pages/databases/192735.

Also departments that carry out the programme possess own textbooks and teaching materials on different topics, which are available in Lithuanian and foreign languages. Publications of VGTU publishing house "Technica" are accessible on a specialized web site from the local university network: http://www.ebooks.vgtu.lt. The access to the university local network for remote users is available.

Teaching materials (textbooks, books, periodical publications, databases) and technical equipment as observer in modern faculty library are in line with the programme and up to date and accessible.

2.5. Study process and students' performance assessment

There are no entrance examinations for the candidates of studying in Technomathematics Master study programme which motivates students from different study programmes to apply for Technomathematics. Additionally, if the candidate has graduated from other study programme than mathematics, statistics, physics, chemistry or informatics, he/she should prove passing required amount (18 ECTS for mathematics subjects and 12 ECTS for Information Technology subject) of ECTS in mathematics and informatics which is sufficient as an admission criteria.

The dynamics of entrants has a decreasing trend: 2012 – 9, 2013 – 6, 2014 – 3, 2015 – 1, 2016 – 2, which shows that study programme does not attract enough students to make the programme sustainable. Moreover, the dynamics of admitted to graduated students' ratio is also decreasing during the recent years: 2012 – 0,36, 2013 – 0,57, 2014 – 0,78, 2015 – 0,43, 2016 – 0,33. This means that attracted students face some problems to graduate. This problem is also signalized by the average admission points. They are considered being relatively low varying from 10,64 to 12,06 out of 20 with no additional points.

In order to increase the motivation of students and attraction of these studies, the study programme feasibility study was prepared together with foreign universities and the plans were to get involved in the activities of the ECMI (European Consortium of Mathematics in Industry). Nevertheless, these plans were already prepared in the previous assessment of the programme but the percentage of students graduating has decreased since then. The measures to increase student's motivation should be reviewed by the programme management.

The students of this programme have the possibility to get support such as career development, job openings, accommodation, cultural activities etc. Additionally, students are able to receive different types of financial support such as motivating scholarships (nominal and other scholarships for good study results), one-time scholarships and benefits. Although, students are aware of various opportunities to strengthen their knowledge abroad, the students from the programme does not use this opportunity frequently due to the fact that the majority of second-cycle students are working. There were no incoming students to this programme as well.

Additionally, students and graduates highlighted the need of better English communication skills in order to be more competitive in the labour market.

The programme management encourages students to participate in scientific conferences such as "Science – the future of Lithuania". Unfortunately, there is no proof of this programme students participating in such conferences or publishing papers in scientific Journals. There is 1 student from this study programme continuing learning for PhD diploma in Vilnius university.

The assessment system of students is clearly stated and students are familiar with it while the system is stated in module card. This was confirmed during the site visit. The knowledge assessment system is criteria-proportional. The learning material is published on the website of the university which is accessible only to the academic society of VGTU. The students are also introduced to the module description, learning outcomes and the upcoming learning process. Additionally, there is a feedback giving culture among the students and the professors – students evaluate study modules every semester, have personal meetings with the professors as the number of students is very low this makes it possible to receive constant feedback on their examination results. Additionally, students are able to file a motivated appeal in writing to the head of the Department of Mathematical Modelling due to infringements of knowledge assessment or/and knowledge assessment procedures.

According to SER, the employability rate is very high as students enrolling in this programme already have jobs and want to deepen their knowledge in the field. The examples of employers for this programme graduates consist of Bentley Systems Ltd., Informacinė raida Ltd., the public enterprise "GIS-Centras", Barclays TCL, AB "FL Technics", the public institution Project Management Centre, JSC ProboNova Medical Innovations, AB Swedbank. Nevertheless, both the graduates and the stakeholders of this programme stressed out that the graduates of this particular programme needs more IT skills related to programming languages, machine learning, artificial intelligence. Only one stakeholder confirmed that his company needs in particular a combination of engineering and mathematics students – programme management should reconsider the competitive advantage of Technomathematics comparing to other applied mathematics and IT programmes in Lithuania.

2.6. Programme management

In the study programme the main role of management process is played by the Study Programme Committee (SPC). The allocated members of the committee perform the very first steps in approving all proposals and updates to the programme, verifying their compliance with legal acts and presenting them to the Faculty Council. To promote an update the programme, a hierarchic chain of actions, carried out by various subdivisions of the University (SPC, Department, Faculty Council, University SC), is applied.

Data and information about the implementation of the study programme is accumulated in the University Information System "Alma Informatika", University Academic Affairs office, at the Department, Dean's office, etc. As stated in SER in case of necessity, the stored data and/or associated records are analysed and put into action.

The University has implemented the Quality Management System which serves all University processes. The quality of the study process is coordinated by the Centre of strategic planning, quality control and analysis. In the study quality assurance process, the feedback (students, graduates, social partners, etc.) plays an important role. What concerns students, three surveys are organized (each year). The survey results are analysed in the meetings of the

Department, Faculty SC and, sometimes, in the Rector's office. The SPC organizes annual meetings with students (on changes in the programme, motivation questions, pressing discussions). However, students during the visit were not aware of changes made in the study programme based on their feedback.

The self-evaluation report insufficiently identifies how the social partners are involved in common seminars, open discussions (on the website) and meetings, organized by the programme implementers. The Alumni's organization formally exists, but is not active enough. Some of the alumni the review team met were not aware of Alumni organisation. The programme's administrators were unable to elaborate on strategic plans and ways for the future. Despite the fact that majority of employers show interest and appreciate knowledge, as well as competencies of the programme's graduates, the internal study quality assurance system needs to be updated and made more effective and efficient.

Taking into consideration the previous external assessment results and recommendations, some serious and indispensable changes have been made, mainly, in the programme's curriculum. Other recommended and urgent amendments associated with the number of students, teaching load hours, visiting teachers, sabbatical leaves for the teaching staff, etc., are not highlighted in the self-evaluation report. The review team did not find evidence that actions were taken to implement mentioned previous recommendation.

Publicizing of many-sided facts about the programme and its improvements is maintained at a proper level and includes the University websites (links are presented), Facebook, Society of mathematicians, conferences for young researchers and many other events. The internal quality assurance system suffers from existing shortcomings; the programme's promotion system, despite all the efforts and intentions of the programme's implementers, does not function sufficiently well.

III. RECOMMENDATIONS*

1. It is recommended to the study programme committee to improve learning outcomes which depend on project-based, case study teaching/learning methods, as well as simulations having in mind stakeholders needs and students opinion.
2. The main recommendation to the programme curriculum design is to have a deep analysis on how to integrate three parts to make the programme a true mathematics study with strong computer science and engineering science background as original idea aims to.
3. Researchers need to be more involved into the teaching of the study programme, in particular to improve the development of research skills.
4. The number of contact hours should be limited to approach the international standard of 200 contact hours / year and therefore guarantee research conditions of staff members for the viability of the study programme. As a lever, the possibility of sharing courses among faculties should be explored and optimized as much as possible.
5. 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. Open calls should be set up and the positions advertised in order to potentially attract the best researchers from Lithuania and other Baltic and neighboring countries. The programme's administrators should spare no efforts to improve conditions for visiting teachers.
6. It is recommended to prepare the action plan for increasing the number of students in the programme while aligning the demand of subject-based skills and competences with the social partners.
7. The study programme's implementers should identify ways and measures to improve the internal quality assurance system.
8. To achieve better results in managing the programme, more tight cooperation with external organizations, such as Lithuanian Mathematicians' Association, Alumni, etc., is desirable.
9. The project-based and case study teaching (learning) methods, as well as group work, are preferable and should be applied in the study process. It would "soften" the gap between theory and practice, which is visible at the moment. Also, it would stimulate gaining of student's presentation skills.
10. It should be expedient to introduce, into the syllabus of the programme, some modern study modules (subjects), associated with computer-based knowledge, machine learning techniques, big data analysis methods, programming, etc.
11. For students, further development of their "responsibility skills" (through fair study process, adequate assessment schemes, high-level communication "student-teacher", etc.) is desirable.

IV. SUMMARY

Objectives of Technomathematics master study programme are: to improve students' competences gained during the first cycle study programme Technomathematics BSc, including applied mathematics, informatics and engineering to be capable of applying acquired knowledge and modern technology in the field of scientific research and experimental development. This programme is recognized by its interdisciplinarity and uniqueness (in Lithuania). Some social partners emphasize the quality of this programme in developing of skills important for team work in companies where is necessary to solve engineering problems by using mathematics. Social partners have good relations with VGTU and provide an influence in curriculum design. Teaching staff includes very good researchers who have well developed cooperation with colleagues around Europe and references published in prestige scientific international journals. They are also concerned with pedagogical issues.

However, the review team would like to point out that different meetings at the on-site visit showed that the programme management including programme curriculum design could be improved significantly. It is important to integrate the three parts to make the study programme a true mathematics study with strong computer science and engineering science background as original idea aims to. The teaching and administrative staffs need to consider reasons why number of students is a concern for the variability of programme. Teaching methods in compliance with social partners as well as labour market needs are not sufficiently used, e.g. project-based teaching method and others, important for developing soft skill of students. The workload of teaching staff in education and research activities are not enough balanced.

V. GENERAL ASSESSMENT

The study programme *Technomathematics* (state code – 621G16001) at Vilnius Gediminas Technical University is given **positive** evaluation.

Study programme assessment in points by evaluation areas.

No.	Evaluation Area	Evaluation of an area in points*
1.	Programme aims and learning outcomes	3
2.	Curriculum design	2
3.	Teaching staff	3
4.	Facilities and learning resources	3
5.	Study process and students' performance assessment	3
6.	Programme management	2
	Total:	**16**

*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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V. APIBENDRINAMASIS ĮVERTINIMAS

Vilniaus Gedimino technikos universiteto studijų programa *Technomatematika* (valstybinis kodas – 621G16001) vertinama **teigiamai**.

Eil. Nr.	Vertinimo sritis	Srities įvertinimas, balais*
1.	Programos tikslai ir numatomi studijų rezultatai	3
2.	Programos sandara	2
3.	Personalas	3
4.	Materialieji ištekliai	3
5.	Studijų eiga ir jos vertinimas	3
6.	Programos vadyba	2
	Iš viso:	**16**

* 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

Technomatematikos magistrantūros studijų programos tikslai yra gerinti studentų gebėjimus, įgytus pirmosios pakopos Technomatematikos studijų programoje taikomosios matematikos, informatikos ir inžinerijos srityse, mokyti pritaikyti įgytas žinias ir šiuolaikines technologijas mokslinių tyrimų ir plėtros srityje. Programa pripažinta dėl savo tarptautiškumo ir unikalumo (Lietuvoje). Kai kurie socialiniai dalininkai pabrėžia šios programos ugdomus įgūdžius, reikalingus komandiniam darbui įmonėse, kuriose inžinerinės problemos sprendžiamos naudojant matematiką. Socialiniai dalininkai palaiko gerus santykius su VGTU ir turi įtakos programos sandarai. Tarp dėstytojų yra labai gerų mokslininkų, kurie turi gerai išvystytą kolegų tinklą visoje Europoje ir kurių darbai minimi prestižiniuose tarptautiniuose mokslo leidiniuose. Jie taip pat rūpinasi pedagoginių problemų sprendimu.

Tačiau ekspertų grupė norėtų atkreipti dėmesį į tai, kad įvairūs susitikimai vizito metu atskleidė, kad programos valdymą ir programos sandarą galima būtų gerokai patobulinti. Svarbu integruoti visas tris dalis, kad programa taptų tikra matematikos studijų programa su kompiuterių mokslo ir inžinerijos mokslo dalykais – to buvo siekiama nuo pat pradžių. Dėstytojai ir administratoriai turėtų apsvarstyti priežastis, dėl kurių studentų skaičius yra nedidelis nepaisant programos įvairovės. Nepakankamai taikomi socialinių dalininkų bei darbo rinkos poreikius atitinkantys mokymo metodai, pavyzdžiui, projektinis ir kiti studentų socialiniams įgūdžiams ugdyti reikalingi mokymo metodai. Nėra pusiausvyros tarp mokymo ir mokslinių tyrimų veiklos.

<...>

III. REKOMENDACIJOS

1. Studijų programos komitetui rekomenduojama tobulinti tuos studijų rezultatus, kuriems pasiekti reikalingi projektinis ir atvejų tyrimo mokymo metodai, taip pat simuliacijos, kuriose atsižvelgiama į studentų ir darbuotojų poreikius, studentų nuomonę.
2. Pagrindinė rekomendacija dėl programos sandaros yra nuodugniai išanalizuoti, kaip integruoti visas tris dalis, kad programa taptų tikra matematikos studijų programa su kompiuterių mokslo ir inžinerijos mokslo dalykais – to buvo siekiama nuo pat pradžių.
3. Tyrėjai turi aktyviau dalyvauti dėstant studijų programos dalykus, ypač tam, kad būtų tobulinami mokslinių tyrimų įgūdžiai.
4. Kontaktinių valandų skaičius turėtų būti ribojamas iki tarptautiniu mastu pripažįstamų 200 kontaktinių valandų per metus, studentams užtikrinančių sąlygas atlikti mokslinius tyrimus, kurie yra būtini, kad studijų programa egzistuotų. Turėtų būti apsvarstyta ir kuo geriau išnaudota galimybė kursus vesti skirtinguose fakultetuose.
5. Tarptautinis dėstytojų judumas turi būti skatinamas per mainų programas, suteikiant galimybę pasiimti metų atostogas. Turi būti sistemingai skatinamas doktorantūroje studijuojančių ir jas neseniai baigusių studentų rengimas mokytojauti. Turi būti rengiami vieši kvietimai teikti paraiškas bei skelbiamos siūlomos pozicijos, kad būtų pritraukti geriausi Lietuvos ir kitų Baltijos bei kaimyninių šalių tyrėjai. Programos administratoriai turėtų dėti visas pastangas ir gerinti sąlygas atvykstantiems dėstytojams.
6. Rekomenduojama parengti veiksmų planą pagal šią programą studijuojančių studentų skaičiui didinti, dalykinius įgūdžius ir gebėjimus suderinti su socialinių dalininkų reikalavimais.
7. Studijų programos vykdytojai turėtų nustatyti būdus ir priemones vidaus kokybės užtikrinimo sistemai tobulinti.
8. Norint geriau valdyti programą, rekomenduojama glaudžiau bendradarbiauti su išorinėmis organizacijomis, pavyzdžiui, Lietuvos matematikų draugija, absolventais ir kt.
9. Turėtų būti parengti ir studijoms taikomi projektinis ir atvejo tyrimais grindžiamas mokymo metodai, taip pat darbas grupėse. Tai „sušvelnintų“ atotrūkį tarp teorijos ir praktikos, kuris šiuo metu yra pastebimas. Taip pat būtų skatinamas studentų prezentacinių įgūdžių ugdymas.
10. Būtų tikslinga į programos sandarą įtraukti naujausias sritis atspindinčius studijų modulius (dalykus), pavyzdžiui, tai galėtų būti „kompiuterinės žinios“, „mašininio mokymosi metodai“, „didelių duomenų analizės metodai“, „programavimas“ ir kt.
11. Rekomenduojama toliau ugdyti studentų „atsakomybės įgūdžius“ (per sąžiningas studijas, tinkamas vertinimo sistemas, studentų ir dėstytojų produktyvų bendravimą ir t. t.).