



STUDIJŲ KOKYBĖS VERTINIMO CENTRAS

Kauno technologijos universiteto
STUDIJŲ PROGRAMOS *BIOMEDICININĖ INŽINERIJA*
(621H16001)
VERTINIMO IŠVADOS

EVALUATION REPORT
OF *BIOMEDICAL ENGINEERING (621H16001)*
STUDY PROGRAMME
at Kaunas University of Technology

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DUOMENYS APIE ĮVERTINTĄ PROGRAMĄ

Studijų programos pavadinimas	<i>Biomedicininė inžinerija</i>
Valstybinis kodas	621H16001
Studijų sritis	Technologijos mokslai
Studijų kryptis	Bendroji inžinerija
Studijų programos rūšis	Universitetinės studijos
Studijų pakopa	antroji
Studijų forma (trukmė metais)	Nuolatinė (2)
Studijų programos apimtis kreditais	120
Suteikiamas laipsnis ir (ar) profesinė kvalifikacija	Biomedicinos inžinerijos magistras
Studijų programos įregistravimo data	2007-02-19

INFORMATION ON EVALUATED STUDY PROGRAMME

Title of the study programme	<i>Biomedical Engineering</i>
State code	621H16001
Study area	Technological Sciences
Study field	General Engineering
Kind 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 Biomedical Engineering
Date of registration of the study programme	19-02-2007

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I. INTRODUCTION

Programme evaluated

The programme evaluated is a second-cycle study programme in Biomedical Engineering (hereinafter BME) from Kaunas University of Technology (hereinafter KTU), Lithuania. KTU is one of the largest universities in the Baltic States, providing studies at Bachelor, Master and Doctoral level. KTU consists of 13 faculties offering fields of study in engineering and technology, arts and humanities, economics and management. The faculties are further divided into 74 departments with specialist institutes and centres in Mechatronics, Information Microsystems and Nanotechnology and Biomedical Engineering for example.

The Biomedical Engineering programme is based in the Faculty of Telecommunications and Electronics (hereinafter FTE). Within this faculty the Department of Signal Processing and (hereinafter SPD) and the KTU Biomedical Engineering Institute (hereinafter BMI) are tasked with the implementation of the BME programme.

During this evaluation the FTE is undergoing the process of merging with the Faculty of Electrical and Control Engineering. The merger will preserve the current study programme with the overall goal to improve the study quality within the faculties. The administrative merger of the Faculties, such as restructuring of departments and modernisation is due to be completed the end of 2014.

Evaluation Team

The evaluation team was assembled February-March 2014. The team leader is Prof. dr. Aleksandar Jovanovic, Vice-rector, University of Pristina Serbia. The other members of the evaluation team are: Prof. dr. Dalia Giedrimiene, University of Saint Joseph, CT, USA; Prof. Lajos Borbás, Budapest University Technology and Economics (BME), Hungary; Dr. Graham Gavin, Dublin Institute of Technology, Ireland; Dr. Julius Griskevicius, Associated Professor and Head of Department of Biomechanics, Vilnius Gediminas Technical University, Lithuania. The student team member was Birute Lasaite.

The procedure of evaluation

After the establishment of the evaluation team the process of evaluation began with the Self-Evaluation Report and supporting documentation being made available to the expert team in March 2014. The members of team examined the self-evaluation report and prepared a preliminary report, highlighting positive areas and indicating areas for clarification, problem questions or discussion points.

The experts were able to further evaluate the programme during a site-visit at Kaunas University of Technology on April 25th 2014. This on-site evaluation included meetings with programme leaders, management, teaching staff, current students, graduates and employers. Following this the expert team held a group meeting to discuss the documented evidence and outcomes of site-visit and the evaluation report was prepared.

II. PROGRAMME ANALYSIS

1. Programme aims and learning outcomes

The medical device technology sector is one of the main areas of growth within Europe and indeed globally. The industry is defined by its multidisciplinary nature, requiring traditional mechanical, electronic and manufacturing engineering, bioengineering, coupled with the sciences and clinical expertise.

Lithuania, like many European countries, has seen a significant growth in the medical sector and currently has over 200 companies involved in medical devices. These are involved in a range of activities crossing the medical technology domain from design through to manufacture, installation and maintenance of a wide range of devices, from diagnostic through to therapeutic systems.

Given the changing demographics, particularly aging populations and the resulting pressures placed on healthcare systems, coupled with general financial constraints, there is an increasing demand for innovation in advanced diagnostic systems, in e-health, remote/telemedicine and in developing technologies that reduce the demand placed on health service resources. There is a clearly established need for biomedical engineers with the appropriate skill-sets, both within Lithuania, and across Europe as a whole. KTU FTE have ideally positioned themselves to deliver a Masters in Biomedical Engineering, given their own expertise, current academic partnerships (Lithuanian University of Health Sciences, LSMU), research institute involvement (BMI) and industrial partnerships (Santaka Valley) and partnerships in development.

KTU is currently the only university delivering a Master in Biomedical Engineering and, as such, has placed itself at the forefront of biomedical engineering in Lithuania, addressing key national and international strategies. In addition to providing a multi-disciplinary learning, the programme offers an attractive opportunity to engineers across Lithuania to progress their education. This includes opportunities to increase multidisciplinary learning and also female participation; currently the programme has a good gender balance.

The programme aims are clearly aligned with academic/ professional requirements and with the needs of the labour market; and are appropriate for a graduate level programme. The learning outcomes of the programme are in line with international recommendations, divided into six categories: (1) knowledge and understanding; (2) engineering analysis skills; (3) engineering design skills; (4) research skills; (5) engineering practice skills and (6) transferable skills.

The programme learning outcomes are consistent with the programme aims and within Blooms Taxonomy focus on the appropriate higher cognitive domains of analysis, synthesis and evaluation, as required in second cycle programmes. The programme has high level analytical/technical learning outcomes, encouraging learning in a multi-disciplinary field and this is to be commended.

Perhaps greater detailed outcomes in the area of “employable” skills could be outlined, particularly in design processes in a regulated industry such as the medical device sector. While some modules include sections on these topics there are few clear outcomes linking these valuable skills to programme aims. The programme aims and learning outcomes include learning in “design”. Given that the design of medical devices occurs in highly regulated environments

(FDA, EU MDD etc.), with clear associated documentation control processes, greater content could be included and explicitly stated as a learning outcome.

The BME programme, aims and learning outcomes, are publically available and published on the KTU website (<http://ktu.lt/tef>) and students have internal access to programme documentation and module descriptors

The second-cycle study programme Biomedical Engineering leads to the qualification Masters of Science of Biomedical Engineering, once the learning outcomes have been achieved. The title of the programme, the programme aims and the learning outcomes are all consistent with each other and with the clear skills-needs established. Based on the programme aims and learning outcomes graduates of the programme should be well positioned to advance their careers through direct employment or further studies.

2. Curriculum design

The curriculum design meets the legal requirements for Masters Degree Study as outlined in the General Requirements for Master Degree Study Programmes. Both the ECTS volume and duration the programme are appropriate: volume is 120 ECTS and duration is 2 years. The programme has an even distribution of subjects over all semesters (30 ECTS per semester; max 5 subjects per semester) with a good balance of theoretical (60% taught modules) and scientific research subjects (40%). Independent work and self-directed learning makes up at least 30% of the workload of each subject.

The programme has a good balance of core specified subjects (48 ECTS Core subjects) while facilitating specialised electives (available from 6 available modules) where the students can choose 2 (12 ECTS). The programme also allows for 12 ECTS to be filled by free electives from any Masters Degree Study programme. This is a worthwhile opportunity for students to engage in learning not directly related to their programme. *It is recommended that the Faculty should explore the reasons why students are choosing a limited range of electives across the KTU and establish processes to encourage wider selection.*

The Final Degree Project is worth 30 ECTS, assigned to writing a presentation of this project, but also has two lead in Research Projects (Research Project 1 + Research Project 2; 18 ECTS). *It is recommended that there should be a more formalised methodology to aid students in selection of their final thesis.* Research work is stimulated and promoted. The staffs are engaged in scientific research and industry based projects. As part of these Research Projects and indeed the final thesis students are often producing significant scientific research and this is to be commended. *It is recommended that a certain number of credits should be given for scholarship activities, such as preparation of posters and presentations for conferences and journal paper writing.* The scientific quality of the graduates is further demonstrated through the good number of graduates that continue their studies to Ph.D.

The overall curriculum is very focussed in the theoretical area of medical electronic diagnostic equipment, imaging, sensors and signal processing. The overall content facilitates learning at a master's level with significant theoretical and analytical knowledge. The programme's historical development is primarily in the area of electronic systems and signal processing. Indeed, the programme resides in the FTE and is implemented by the SOD and BMI. The programme aims and learning outcomes, however, appear to be stated broader than this. Biomedical programmes can often focus in broad areas of mechanical, electronic (often

diagnostics) or tissue engineering, usually based on the host institutions expertise. This programme is heavily focussed in the electronic diagnostic/ imaging area. While it is positive that there is a clear programme focus; *it is recommended that the students would benefit from some additional content in the curriculum that includes broader technologies in biomedical technology based applications both, diagnostic and therapeutic.*

The programme, in addition to strong theoretical and analytical, content includes a number of more applied practical subjects. In particular, Electronic Medical Instrumentation and the elective modules, Clinical Engineering, Radiation Protection & Safety have significant learning applicable to clinical engineering practice in hospitals.

In technical engineering and testing roles in industry and particularly in engineering design roles, where Masters graduates are often employed, there is a need for graduates to have strong technical and analytical skills, coupled with knowledge of design theory and practice, biomaterials, manufacturing processes and regulatory affairs. While in some cases there are no dedicated modules in these topic areas, there are a number of learning outcomes within modules that introduce these topics, such as in Methodology of Biomedical Engineering.

There appears to be some duplication across a number of modules, including the core and elective modules (signal processing and imaging modalities). *It is recommended that the curriculum be revised to eliminate some duplication of content in the programme.* Perhaps with streamlining and greater continuity of modules there is the opportunity to introduce more content in the highly relevant industry design skills and associated regulatory documentation. One additional broad suggestion may be the inclusion of content in Human Factors Design (Usability Engineering). This is a very important part of new product development, driven by recent changes in regulatory requirements, particularly in electronic diagnostic devices used in non-clinical settings; how the device is used, how data is returned/ displayed and in medical apps for example.

The programme must be praised for the high analytical and theoretical content and for the inclusion of modules that are very current with modern trends in healthcare devices and systems. In particular, the Medical Telemetry Systems module has learning that is very applicable to development of e-health, remote and tele-health care systems, aging population devices. Indeed, the inclusion of encryption methodologies is again very current.

The module descriptors are clearly laid out and demonstrate how module learning outcomes are mapped to programme outcomes. Teaching methods appear reasonably diverse across most modules and include lectures, practical, laboratory work, team/group work, field trips and site visits and self-directed learning and research. The overall ratio of lectures to practical work is good. There is use of student-centred learning approaches utilising seminars, problem based learning, practical laboratories and some team based activities and this leads into study / assessment methods such as colloquiums, homework, research paper reviews, presentations and report writing.

The overall scope of the programme is appropriate to ensure that the learning outcomes are of a suitable level and achievable with the 2 year time frame. The Masters degree in biomedical Engineering is at a high level and will produce graduates with strong research and analytical skills.

3. Staff

The Biomedical Engineering programme is delivered by both the Department of Signal Processing and the KTU Biomedical Engineering Institute. These two organisational structures also share 4 academic members. The teaching staff consists of 6 professors (5 KTU + 1 LUHS), 6 associate professors and 1 lecturer. The programme meets the legal requirements that at least 20% of the subjects be taught by full professors. Further, 93% of the study programme is delivered by professors or associate professors in full-time positions. The turnover of programme staff is also low, with only 1 newly appointed associate professor and 1 member becoming a Prof. Emeritus in the assessment period. While this is positive in ensuring continuity of programme delivery it is also important that staff remain up-to-date on emerging trends in the biomedical field, both scientific and industry led.

The staff participate in continuous professional development, as regulated by the Qualification Requirements for Employees, with the goal of improving skills and competency in practical, scientific and educational activities. This is a planned process and there is clear evidence of the training plan for all staff for the next number of years (2013-17). Training options for staff facilitate broad activities, all benefitting the Biomedical Engineering programme, including industrial internships, scientific research, web-based virtual learning environments and distance learning module. *It is recommended that all teachers should be encouraged by faculty administration to engage in pedagogical training.* Of mention, also, and to be commended, is the ability of staff to communicate in many European languages such as English, German, Russian and French. This broad academic and practical skill set ensures that the programme can achieve its aims and objectives.

The academic qualification level of staff is very good with all but 1 member (currently pursuing a PhD) holding a PhD qualification. All academic staff on the programme are research active with a strong record of publications in scientific journals and international conferences. The staff publish scientific papers in top international peer-reviewed journals (7-8 scientific publications per year avg.) and regularly attend a broad range conferences presentations and publications. There does, however, appear to be a drop off in academic research output i.e. scientific papers in recent years 2012-13. University and national policy should continue to support teaching staff to continuously engage in research. This is of great benefit to students, in general, as they get to engage with high level research.

There are a number of research projects running within the Department of Signal Processing and the KTU Biomedical Engineering Institute. The staff should be commended on the continuous growth in funding and financial support for research projects and this figure has grown year on year over the assessment period. The attainment of funding through innovative cheques is a very useful exercise and although the net funding is small, these projects have industry partners (as do other funded projects) and, as such, ensure that the staff are continuously engaging with current trends in their sector. This proactive research by staff ensures students also have opportunities to engage with industry, small indigenous companies, with a real benefit to Lithuania. It is also important to ensure that there is interaction between the staffs' research activities and the industry involved and the Biomedical Programme students, where possible.

The lecturing staff are engaged with study programmes such as Erasmus and there has been a reasonable level of exchange of staff between international academic institutions, particularly with Sweden, Greece and Bulgaria. This should continue to be encouraged and

heightened. These activities, coupled with the above research, enhance the staffs' engagement with other universities, ensuring exchange of ideas beneficial at both research and academic teaching levels.

Indeed these affiliations, with additional funding, have facilitated expertise in the form of visiting lecturing staff from Elche University, Spain and Vienna University of Technology, delivering lectures on and benefiting the students on the programme. Also, the module Systems of Human Physiology is delivered by a lecturer from the Lithuanian University of Health Sciences. *It is recommended that incoming and outgoing mobility of students and staff could be further to developed.*

The professional profile of the staff is further strengthened by the fact that a number of staff are professionally affiliated with organisations such as the Lithuanian Science Council and the Institute of Electrical and Electronic Engineering (IEEE). They are regularly involved in the organisation of major conferences and are members of the scientific committees of a number of journals. Some staff members have recently published academic books and launched start-up companies.

The above demonstrates that there is a good balance between direct teaching and other related activities all which demonstrate a proactive staff with the strong capability of ensuring the aims of the programme are met and the students have a good learning experience.

4. Facilities and learning resources

The faculty structure is currently undergoing re-organisation, as a result of the merger with the Faculty of Telecommunication, and during the years 2011-13 there has been a significant upgrading of equipment and laboratories. The staff and the faculties have been very successful in obtaining funding from various sources to assist in maintenance and upgrading. 3 million Lt from EU money has been assigned to renewal and new acquisition of equipment and software as part of the merging process. While research centres such as the KTU Biomedical Engineering Institute and new projects such as the National Complex Programme of Mechatronics and Telecommunication Technologies have also raised 3m Lt and 700,000 Lt, respectively, for research works and biomedical engineering related equipment. These resources are then available for students of the BME programme. This process of sourcing funding directly for programmes and equipment or indirectly through research funding is to be commended.

Specifically, the programme has an appropriate number of classrooms and laboratories (13) for the delivery of the programme. The study process is organised to ensure compliance with the rules of occupancy for second-cycle study rooms ensuring maximum numbers students in lecture, tutorials and laboratories are not exceeded. All these classrooms are equipped with multimedia tools and some have smart board technology also.

Additional study spaces are available both in the faculty library and in the central library of the university consisting of individual study desks (204 places), with a number of those having computers and internet access (42 places). There is also a computer laboratory in the Department of Signal Processing (12 places). There is free wireless internet access within the faculty as many students have their own laptops. The staff have also shown proactivity in sourcing equipment, software and literature through donations from major electronics manufacturers. In addition, much of this software has agreed student licensing so students can work in their own time. Software such as Matlab, Labview and Altium Designer and respective

electronic kits are available to download or borrow. There are opportunities afforded to students, with the very positive experience, to spend time in the specialised laboratories belonging to researchers/ institutes. This is a wonderful learning experience and affords the opportunity of engaging with PhD students and researchers.

Many other specialised and related laboratories and facilities exist as part of research groups and other scientific activities within the faculty, such as the KTU Biomedical Engineering Institute, Ultrasound Science Institute etc. Students have opportunities to closely liaise with researchers and have access to experimental equipment for projects. There is also a Design and Experimental Laboratory where Masters Students can work on final year projects.

There is a library at the faculty building and also a central library of KTU. In addition to study space and computer access, the libraries have a well organised collection of appropriate publications, related to the programme. There is a consultation process where the library engages with academic staff to ensure collections updated and advise staff of new publications and exhibitions.

The library has a well-structured web page where a database of physical hard copies of books and journals can be searched. Also, the university is subscribed to over 50 online databases for electronic content such as e-journals e-books (Sciencedirect, Wiley Online, IEEE Explore etc.) Students also can avail of access to other libraries via the Central Library where material can be requested. Locally departments maintain textbooks in specialised disciplines and these can be borrowed by students.

The staff of the programme BME also prepares structured up-to-date course material such as notes, lecture slides and homework made available to the students through a variety of means. This is often done via printed versions, email, through the college's virtual learning environment (Moodle 2), departmental web pages or those maintained by lecturers. The virtual learning environment is a powerful resource and more staff should be encouraged to have their lecture material available and utilise to its full potential. *It is recommended that the interactive and assessment potential of VLE moodle should be used in a more effective way.*

Overall the facilities and resources are suitable and appropriate for the BME programme but it is important that continuous upgrading of facilities and literature and improvement is facilitated through funding and policy making.

5. Study process and student assessment

Admission to the programme is carried out in accordance with the requirements of second cycle studies at KTU. The basic requirements are a bachelor's qualification or equivalent in Biomedical Engineering, Electric/ Electronics Engineering, Informatics Engineering, Mechatronics and Biophysics.

Admission is based on first cycle studies (weighting of 0.8) and also on an evaluation of scientific activities (weighting of 0.2); these include publications, conference programmes, documents of awards etc.). All admission policies are publicly available on the University website and admission publications. The staff is active in advertising the programme, preparing documentation and in presenting these at faculties within KTU and in other universities with related disciplines. Students enter the programme on state-funded and private (fee-paying) strands and the entry requirements to both are the same. The number of state funded places is based on the scientific performance of the Faculty. The staff should be commended on continued

scientific activities and this has resulted in the programme having 14 places allocated to state-funded students on average annually.

Places are filled each year by students from various faculties within KTU and from other universities, such as Vilnius University and Klaipeda University. A number of international students have attended the programme in recent years. There continues to be strong competition for places on the programme and overall average scores on entrants has increased over the years evaluated (2007-2012) with the average entrance score of 6.56 in 2012. Of particular note is that the programme manages to attract a good number of female applicants and this is to be commended and further encouraged. *It is recommended that given that the students have a wide variety of backgrounds they would benefit from additional introductory modules course to equalise the class.*

The programme duration is two semesters of 16 weeks according to an academic calendar centrally prepared by the University. Timetabling regulations ensure that the workload is fairly distributed, over a day (max 8 academic hours) and, over a week (max 26 academic hours). The majority of teaching takes place at KTU, however, the students do have the added benefit of taking classes and some laboratory & project work in the Lithuanian University of Health Sciences. This is a great opportunity for students to engage in clinical based subjects, such as Human Physiological Systems, in a dedicated learning environment.

All students have access to academic support structures such as library services, a counsellor for studies and the Academic Advisory Centre. These can assist students with academic guidance or assist with issues arising out of their studies. There are also additional non-academic support services such as financial assistance, psychological or mental health counselling services, students union and wide range of sporting clubs and arts & cultural groups and a careers centre. Additional financial support is available through scholarships based on social, motivation or academic achievement. These scholarships are awarded at national and university level.

The majority of modules on the programmes involve a mix of theoretical and practical activities and as such assessment methodologies often include continuous assessment and end of semester exams. Students are only allowed to take an exam after they have successfully completed all the tasks of the semester. The criteria for the module, learning process and assessment criteria are clearly outlined to the students at the beginning of each module. Module descriptors are also available on-line.

As part of the overall learning experience talented students are integrated into research activities on externally funded projects, both scientific and industrial. Several students from the programme have had opportunities and worked with the KTU Biomedical Institute and found researcher from the Ultrasound Institute, Monitoring technologies etc. Students on the BME programme are encouraged to take part in scientific conferences, competitions and events; staff have been very proactive in their approach to student participation. Students of the programme have been very successful in major international awards such as the Analog Design Contest 2012 & 2013 and university level competitions like the Rector's Prize.

KTU and the FTE are involved in the Erasmus programme and currently have bilateral agreements with 15 European Universities. Students have opportunities to travel and study as part of this programme or through other relationships with universities in Estonia, Sweden and Finland where they can engage in short intensive courses. These are great relationships and

should be encouraged further with funding and other resources. *It is recommended that more promotion should be given to shorter duration internships opportunities for students.*

Continuous assessment methodologies and final examination sessions are the primary mode of assessing modules and the process is transparent and well defined. Students have opportunities to retake examinations, modules and the appeal results based on certain criteria. While assessment methodologies are diverse; *it is recommended that in the assessment of student performance there must be a clear assessment methodology for team activities also.*

The final degree thesis (30 ECTS) and lead in research projects (18 ECTS) are a major component of the programme and is the culmination of an independent study process beginning in Semester 2. This process ensures that students engage with the literature, conducting a research phase prior to progressing into the applied part of their project. The overall outcome is an analytical paper based on scientific research. This is publically defended with the panel consisting of 6 members with grading based on the final degree project (weighting of 0.7) and the defence (weighting of 0.3). This process ensures good standardisation and prepares graduates for further studies, employment in academia or industry. A focus of the assessment is on critical thinking and the student's ability to engage with the questioning based on their chosen project area.

The rate for successful completion of the programme indicates that students who continue into the second year of the programme tend to graduate. There is a high drop-out rate during the first semester and perhaps this is related to pre-perceptions of the programme not being the same as the actual experience, challenging content, admission strategy, workload or external factors.

Graduates of the BME programme have had good success in gaining employment in areas such as medical equipment development, clinical engineering, service and support roles. 52% of graduates are employed in biomedical engineering related fields. Of the current (2013) cohort 50% (7/14) have already gained employment in the field. Future trends and needs of employers are equally positive with employers indicating a strong demand for biomedical engineering graduate. 22% of graduates continue their studies to third-cycle.

6. Programme management

The programme has clear internal and external procedures for the evaluation and monitoring of the programme, continued improvement and compliance with best international practice. The implemented quality assurance system is based on the Common Assessment Framework and Standards and Guidelines for Quality Assurance in the European Higher Education Area. The programme is managed in accordance with University guidelines.

The BME programme is supervised by the Study Programme Committee whose members include the heads of the 4 departments of the Faculty and the director of the Biomedical Engineering Institute. The BME programme has a co-ordinator who is tasked with overseeing the study programme and improvements. The quality of lecturers is within guidelines and managed by Board of Departments Teachers and the Commission runs public tenders and competition for vacancies. The programme undergoes external evaluation at least every 6 years and this is managed by the Centre for Quality Assessment in Higher Education.

There is a System of Internal Quality Assurance of Studies which includes self monitoring of the programme, programme development, feedback from students and staff and

subjects are reviewed on a 3 year basis. Feedback forms from students are taken at the end of every semester and summative results are used for the assessment of study works and lecturers.

External stakeholders and employers are also involved in programme evaluation and development during meeting organised by the Deans Office and Faculty Council.

III. RECOMMENDATIONS

1. It is recommended that the Faculty should explore the reasons why students are choosing a limited range of electives across the KTU and establish processes to encourage wider selection.
2. It is recommended that there should be a more formalised methodology to aid students in selection of their final thesis.
3. It is recommended that a certain number of credits should be given for scholarship activities, such as preparation of posters and presentations for conferences and journal paper writing.
4. It is recommended that the students would benefit from additional content in the curriculum that includes broader technologies in biomedical technology based applications both, diagnostic and therapeutic.
5. It is recommended that the curriculum be revised to eliminate some duplication of content in the programme.
6. It is recommended that all teachers should be encouraged by faculty administration to engage in pedagogical training.
7. It is recommended that incoming and outgoing mobility of students and staff could be further to developed.
8. It is recommended that the interactive and assessment potential of Virtual Learning Environment moodle should be used in a more effective way.
9. It is recommended that given that the students have a wide variety of backgrounds they would benefit from additional introductory modules course to equalise the class.
10. It is recommended that more promotion should be given to shorter duration internships opportunities for students.
11. It is recommended that in the assessment of student performance there must be a clear assessment methodology for team activities also.

IV. SUMMARY

The programme of Biomedical Engineering is the only one of its kind in Lithuania and clearly meets the growing needs of the medical device sector for highly qualified engineers with a multi-disciplinary skill set covering engineering, science and clinical knowledge.

Lithuania, like many European countries, has seen good growth in the medical sector and currently has over 200 companies involved in medical devices. These are involved in a range of activities crossing the medical technology domain from design through to manufacture, installation and maintenance of a wide range of devices, from diagnostic through to therapeutic systems.

The Biomedical Engineering programme is very well designed and includes both core learning at a very high level, while including modules focussed on emerging trends in the medical device sector, such as telehealth and remote healthcare systems. The programme aims are clearly aligned with academic and professional requirements and with the needs of the labour market; and are appropriate for a graduate level programme. The learning outcomes of the programme are in line with international recommendations, and are consistent within Blooms Taxonomy focussing on the appropriate higher cognitive domains of analysis, synthesis and evaluation, as required in second cycle programmes. The programme has high level analytical/technical learning outcomes, encouraging learning in a multi-disciplinary field and this is to be commended. The programme overall has a strong scientific focus and shows clear evidence of suitably preparing graduates for direct employment in high level roles or further study to PhD level. Perhaps greater detailed programme outcomes in the area of “employable” skills could be outlined, particularly in design processes in a regulated industry such as the medical device sector (FDA, EU MDD etc.), with clear associated documentation control processes.

The curriculum design meets the legal requirements for Masters Degree Study in both volume and duration and has an even distribution of subjects over all semesters. There is a good balance of theoretical class work, scientific research subjects, and applied projects, independent work and self-directed. The programme has a good balance of core specified subjects while facilitating specialised and free electives. The Faculty should explore the reasons why students are choosing a limited range of electives across the KTU and establish processes to encourage wider selection.

There is a significant Final Degree Project and two lead in Research Projects that encourage research that is of high quality and many students publish work and present at conferences. There should be a more formalised methodology to aid students in selection of their final thesis and that a certain number of credits should be given for scholarship activities. The high scientific quality of the graduates is further demonstrated through the good number of graduates that continue their studies to Ph.D. While it is appropriate that a programme of this nature has a strong focus in electronic diagnostic devices, the students would benefit from some additional content in the curriculum that includes broader understanding or exposure to biomedical technology, both, diagnostic and therapeutic.

There appears to be some duplication across a number of modules, including the core and elective modules (signal processing and imaging modalities). The curriculum should be streamlined to eliminate this repetition in the programme and perhaps utilise freed additional time to increase more applied learning in design theory and regulatory affairs and broader technologies. Engagement with employers both at programme design and evaluation is good and

could be further developed. The programme must be praised for the inclusion of content that are very current with modern trends in healthcare devices and systems such as e-health, remote and tele-health care systems, aging population devices and the inclusion of encryption methodologies

The module descriptors are clearly laid out and demonstrate how module learning outcomes are mapped to programme outcomes. Teaching methods are reasonably diverse and the overall ratio of lectures to practical work is good. There is use of student-centred learning approaches utilising seminars, problem based learning, practical laboratories and some team based activities and this leads into study/ assessment methods such as colloquiums, homework, research paper reviews, presentations and report writing. This could be further developed by ensuring that all teachers are encouraged by faculty administration to engage in pedagogical training and the interactive and assessment potential of the virtual learning environment moodle should be used in a more effective way.

The staff are highly qualified, with both industry and academic knowledge, and in their teaching and engagement with students. They encourage scientific activities, facilitate industry relations and assist students in finding employment or progression to third cycle programmes. The staff encourage and participate in transfer and exchange programmes and it is recommended that incoming and outgoing mobility of students and staff could be further developed.

The overall facilities ensure that students have a well-resourced learning experience in both academic and non-academic needs. The laboratory equipment and general teaching resources are very good and students are also exposed to research facilities such as the Biomedical Engineering Institute.

There continues to be strong competition for places on the programme based on overall average scores on entrants and numbers applying. Of particular note is that this engineering programme manages to attract a good number of female applicants and this is to be commended and further encouraged. Given that the students have a wide variety of backgrounds it is suggested that they would benefit from additional introductory modules course to equalise the class early in the programme.

As part of the overall learning experience, in addition to traditional class room activities, students are integrated into research activities on externally funded projects, both scientific and industrial, students from the programme have had opportunities and worked with research institutes, students on the BME programme are encouraged to take part in scientific conferences, competitions and events; staff have been very proactive in their approach to student participation.

KTU and the FTE are involved in the Erasmus programme and currently have bilateral agreements with 15 European Universities. It is recommended that more promotion should be given to shorter duration internships opportunities for students where students might be more willing/ able to participate. Broad assessment methodologies are utilised throughout the programme and while assessment methodologies are diverse the students would benefit from more team-based learning and that in the assessment of student performance there must be a clear assessment methodology for team activities. The programme has a good quality assurance process in place incorporating students' and teaching staffs' reflections on module development and overall programme direction and improvement.

Overall the programme management and teaching staff are to be praised on a very good applicable programme providing an excellent learning experience for students in the vibrant and modern growth area of medical device technology.

V. GENERAL ASSESSMENT

The study programme Biomedical Engineering (state code – 621H16001) at Kaunas University of Technology is given a **positive** evaluation.

Study programme assessment in points by evaluation areas.

No.	Evaluation Area	Evaluation Area in Points*
1.	Programme aims and learning outcomes	4
2.	Curriculum design	3
3.	Staff	4
4.	Material resources	4
5.	Study process and assessment (student admission, study process student support, achievement assessment)	3
6.	Programme management (programme administration, internal quality assurance)	4
	Total:	22

*1 (unsatisfactory) - there are essential shortcomings that must be eliminated;

2 (satisfactory) - meets the established minimum requirements, needs improvement;

3 (good) - the field develops systematically, has distinctive features;

4 (very good) - the field is exceptionally good.

Grupės vadovas:
Team leader:

Prof. dr. Aleksandar Jovanovic

Grupės nariai:
Team members:

Prof. dr. Lajos Borbas

Prof. dr. Dalia Giedrimienė

Dr. Graham Gavin

Doc. dr. Julius Griškevičius

Birutė Lašaitė

<...>

V. APIBENDRINAMASIS ĮVERTINIMAS

Kauno technologijos universiteto studijų programa *Biomedicininė inžinerija* (valstybinis kodas – 621H16001) vertinama teigiamai.

Eil. Nr.	Vertinimo sritis	Srities įvertinimas, balais*
1.	Programos tikslai ir numatomi studijų rezultatai	4
2.	Programos sandara	3
3.	Personalas	4
4.	Materialieji ištekliai	4
5.	Studijų eiga ir jos vertinimas	3
6.	Programos vadyba	4
	Iš viso:	22

* 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

Studijų programa *Biomedicininė inžinerija* – vienintelė tokio pobūdžio programa Lietuvoje. Ji neabejotinai atitinka augančius medicinos prietaisų sektoriaus poreikius, mat jam reikia aukštos kvalifikacijos inžinierių, turinčių daugiadisciplininių gebėjimų inžinerijos ir mokslo srityje, taip pat klinikinės praktikos žinių.

Lietuvoje, kaip ir daugelyje Europos šalių, medicinos sektorius auga. Šiuo metu daugiau kaip 200 įmonių veikia medicinos prietaisų srityje. Jos vykdo įvairią veiklą medicininės technologijos srityje: įvairių prietaisų kūrimas, gamyba, diegimas ir techninė priežiūra, diagnostika ir terapinės sistemos.

Studijų programa *Biomedicininė inžinerija* labai gerai parengta ir apima pagrindinius aukščiausio lygio mokymo elementus; jos modulių metu dėmesys skiriamas kylančioms tendencijoms medicinos prietaisų sektoriuje, kaip antai telekomunikacinės sveikatos priežiūros paslaugos ir nuotolinės sveikatos priežiūros sistemos. Programos tikslai aiškiai suderinti su akademiniais ir profesiniais reikalavimais, taip pat su darbo rinkos poreikiais. Jie atitinka magistrantūros lygio programai taikomus reikalavimus. Programos studijų rezultatai atitinka tarptautines rekomendacijas ir Bloomo taksonomijos principus, pagal kuriuos dėmesys skiriamas atitinkamoms aukštesniosioms kognityvinėms analizės, sintezės ir vertinimo sritims, kaip reikalaujama antrosios studijų pakopos programose. Pagirtina, kad pagal programą siekiama

aukšto lygmens analitinių ir techninių studijų rezultatų, skatinančių mokytis daugiadisciplininėje terpėje. Studijų programoje daug dėmesio skiriama mokslui, ir turima pakankamai įrodymų, kad absolventai tinkamai parengiami tiesiogiai dirbti aukštos kvalifikacijos darbą arba toliau tęsti studijas trečioje studijų pakopoje. Galbūt galima būtų išsamiau apibūdinti gebėjimus, kuriuos galima bus panaudoti darbo rinkoje kaip programos rezultata, visų pirma per kūrimo procesus tokioje sureguliuotoje pramonės srityje kaip medicinos prietaisų sektorius (Maisto ir vaistų administracija (FDA), ES direktyva dėl medicinos prietaisų ir pan.) su aiškiai susietais dokumentų kontrolės procesais.

Studijų programos apimtis ir trukmė atitinka teisės reikalavimus, taikomus magistro lygio programai, dalykai nuosekliai paskirstyti per visus semestrus. Teorinės paskaitos gerai dera su mokslinių tyrimų dalykais, taikomaisiais projektais, savarankišku darbu. Programoje pagrindiniai dalykai gerai suderinti su pasirenkamaisiais. Fakultetas turėtų išsiaiškinti priežastis, dėl kurių KTU studentai renkasi tiek nedaug pasirenkamųjų dalykų, ir sukurti procesus, kad pasirinkimas būtų didesnis.

Studijų programoje rengiamas vienas baigiamojo darbo projektas ir dar du reikšmingi mokslinių darbų projektai. Juos įgyvendinant skatinami aukštos kokybės moksliniai tyrimai, studentai spausdina savo darbus ir pristato juos per konferencijas. Reikėtų parengti labiau formalizuotą metodologiją, pagal kurią studentai galėtų pasirinkti savo baigiamąjį darbą. Be to, už užklasinę veiklą jiems turėtų būti suteikiama kažkiek kreditų. Aukšta absolventų mokslinių laimėjimų kokybė pasireiškia ir tuo, kad didelis absolventų skaičius toliau tęsia trečiosios pakopos studijas. Nors įprasta, kad pagal tokio pobūdžio programą didelis dėmesys skiriamas elektroninės diagnostikos prietaisams, studentams būtų naudinga, jeigu mokymo programa būtų išplėtotą ir apimtų platesnį biomedicininės technologijos – diagnostinės ir terapinės – elementų spektrą.

Keletas pagrindinių ir pasirenkamųjų modulių (susijusių su signalų apdorojimu ir vaizdavimo būdais) kažkiek dubliuojasi. Mokymo programa turėtų būti išgryninta, siekiant pašalinti pasikartojančius dalykus, o atsiradusį laisvą laiką skirti taikomiesiems dizaino teorijos, reguliavimo klausimų ir platesnių technologijų mokymams. Palankiai vertinama tai, kad rengiant programą ir ją vertinant dalyvauja darbdaviai. Ši veikla turėtų būti toliau plėtojama. Pagirtina, kad programa apima šiuolaikines kryptis sveikatos prietaisų ir sistemų srityje, kaip antai elektroninės sveikatos priežiūros paslaugos, nuotolinės ir telekomunikacinės sveikatos priežiūros sistemos, senstantiems gyventojams skirti prietaisai ir šifravimo metodika.

Modulių aprašai aiškiai išdėstyti. Iš jų matyti, kaip modulių studijų rezultatai atitinka programos rezultatus. Pagrįstai taikomi įvairūs mokymo metodai, o tarp teorinių paskaitų ir praktinio darbo išlaikyta gera pusiausvyra. Pagal programą taikomi į studentus orientuoti mokymo metodai: seminarai, problemų sprendimais paremtas mokymasis, praktinės užduotys laboratorijoje ir kažkiek komandinės veiklos. Jie siejami su tokiais studijų vertinimo metodais kaip įskaitos, namų darbai, mokslinių darbų apžvalgos, pranešimai ir ataskaitų rašymas. Šią kryptį galima būtų toliau plėtoti, užtikrinant, kad visi dėstytojai ir fakulteto administracija dalyvautų pedagogų mokymuose ir veiksmingiau panaudotų virtualios mokymo aplinkos „Moodle“ interaktyvumo ir vertinimo galimybes.

Dėstytojų kvalifikacija aukšta, jie turi akademinį žinių, taip pat žinių apie šią pramonės šaką, ir jomis dalijasi su studentais. Jie skatina mokslinę veiklą, padeda užmegzti ryšius su šios pramonės šakos atstovais, padeda studentams susirasti darbą arba tęsti studijas trečioje pakopoje.

Dėstytojai ragina ir skatina studentus dalyvauti mainų programose. Rekomenduojama toliau plėtoti atvykstančių ir išvykstančių studentų bei dėstytojų judumą.

Bendrosios patalpos ir jų ištekliai puikiai tenkina akademinis ir neakademinis studentų poreikius. Laboratorių įranga ir bendrieji mokymo ištekliai labai geri. Be to, studentai gali pasinaudoti Biomedicininės inžinerijos instituto mokslinių tyrimų įranga.

Tarp norinčiųjų studijuoti pagal šią programą vyksta didelė konkurencija. Svarbu pažymėti, kad ši inžinerijos programa sugeba pritraukti nemažai merginų. Tai pagirtina ir turi būti toliau plėtojama. Atsižvelgiant į didžiulę studentų ankstesnio išsilavinimo įvairovę, jiems praverstų papildomas įžanginio kurso modulis, kad visi būtų vienodai susipažinę su būsimąja studijų programa.

Be tradicinių paskaitų studentai dalyvauja mokslinių tyrimų veikloje, taip pat projektuose, kuriems skiriamas išorinis finansavimas. Studijuodami pagal šią programą studentai turėjo galimybę dirbti su mokslinių tyrimų institutais, taip pat jie yra skatinami dalyvaujti mokslinėse konferencijose, konkursuose ir renginiuose. Dėstytojai skatina studentus kuo aktyviau dalyvauti.

KTU ir Telekomunikacijų ir elektronikos fakultetas dalyvauja *Erasmus* programoje ir šiuo metu turi dvišalius susitarimus su 15 Europos universitetų. Rekomenduojama didinti trumpesnės trukmės stažuočių pasiūlą studentams, kad jie turėtų daugiau galimybių jose dalyvauti. Programoje taikomi įvairūs vertinimo metodai. Kadangi vertinimo metodai įvairūs, studentams būtų naudingas labiau komandinio pobūdžio mokymasis, o vertinant studentų studijų rezultatus, reikėtų aiškiai išskirti ir komandinę veiklą. Programoje numatytas geras kokybės užtikrinimo procesas, pagal kurį atsižvelgiama į studentų ir dėstytojų nuomonę apie modulio kūrimą, taip pat bendrąją programos kryptį ir tobulinimą.

Apskritai programos vadovus ir dėstytojus reikia pagirti už labai gerai taikomą programą, pagal kurią studentams suteikiamos puikios galimybės mokytis dinamiškoje ir modernioje medicinos prietaisų technologijos srityje.

III. REKOMENDACIJOS

1. Rekomenduojama fakultetui išsiaiškinti priežastis, dėl kurių KTU studentai renkasi tiek mažai pasirenkamųjų dalykų; sukurti procesus, kad pasirinkimas būtų didesnis.
2. Rekomenduojama parengti labiau formalizuotą metodologiją, pagal kurią studentai galėtų pasirinkti savo baigiamąjį darbą.
3. Rekomenduojama, kad už užklausinę veiklą, kaip antai konferencijų plakatų bei pranešimų parengimą, taip pat žurnalų straipsnių rašymą, būtų duodama kažkiek kreditų.
4. Rekomenduojama, kad studentų mokymo programa būtų išplėtota ir apimtų daugiau dalykų, susijusių su diagnostinėmis ir terapinėmis taikomosiomis programomis, susijusiomis su biomedicinos technologijomis.
5. Rekomenduojama peržiūrėti studijų programos sandarą, siekiant pašalinti pasikartojančius dalykus.

6. Rekomenduojama, kad fakulteto administracija skatintų visus dėstytojus dalyvauti pedagogų mokymuose.
7. Rekomenduojama toliau plėtoti atvykstančių ir išvykstančių studentų bei dėstytojų judumą.
8. Rekomenduojama veiksmingiau panaudoti virtualios mokymo aplinkos „Moodle“ interaktyvumo ir vertinimo galimybes.
9. Atsižvelgiant į didžiulę studentų ankstesnio išsilavinimo įvairovę, rekomenduojama organizuoti papildomą įžanginio kurso modulį, kad visi būtų vienodai susipažinę su būsima studijų programa.
10. Rekomenduojama skatinti trumpesnės trukmės stažuočių pasiūlą studentams.
11. Rekomenduojama vertinant studentų mokymosi rezultatus numatyti aiškią komandinės veiklos vertinimo metodologiją.

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