KU LEUVEN

BLUEPRINT

MASTER OF BIOMEDICAL ENGINEERING; PREPARATORY PROGRAMME: MASTER OF BIOMEDICAL ENGINEERING

FACULTY OF ENGINEERING SCIENCE

March 2023

Master of Biomedical Engineering

Profile and vision

The Faculty of Engineering Science brings the intellectual and human capital of each individual student to a higher level by offering him or her a research based education in scientific and engineering fundamentals. The Faculty stimulates students to practice in-depth learning by addressing and challenging their 'disciplinary future self', to make them aware of who they wish to become as a professional *(Beruf)* and as members of society in general *(Bildung)*. In order to stimulate the development of the students' 'disciplinary future self', the Faculty provides multidisciplinary programmes that acquaint students with the engineering profession and with related disciplines. We value both breadth and depth of knowledge, expanding the reasoning, communication and problem-solving abilities, in order to prepare students for life-long learning. The research-oriented education is based on research programmes which are defined and developed in close collaboration with recognised international peers and with industry.

The Master of Science in Biomedical Engineering (BME) responds to the increased technological needs in healthcare. These needs result from demographic evolutions such as the ageing population and the challenge to provide better but more complex care while maintaining cost-effectiveness in our healthcare system. High-tech devices, both hardware and software, have become essential in medical practice to support diagnosis, treatment, prevention of disease and biomedical research, and there is a strong societal demand for engineers with a specific training in the field of biomedical engineering.

The programme aims to deliver interdisciplinary-trained engineers that have a broad technological knowledge of different engineering disciplines and sufficient medical knowledge to translate the medical needs into engineering requirements and develop innovative technological solutions. They need to have a thorough knowledge of mathematics and engineering principles, but also have a helicopter view and the ability to constantly train themselves professionally, which makes them attractive to other industrial sectors as well. The master's programme incorporates cutting-edge research topics of an internationally renowned teaching staff spread across several departments and leading strong research groups in the field of biomedical engineering. Their strong ties with the nearby university hospital Gasthuisberg and the biomedical engineering sector are a major asset to the master's programme.

Goals and learning outcomes

The objective of all programmes at the Faculty of Engineering Science is the formation of academically skilled engineers for an active career in a technical industrial environment, the public sector or service sector. The engineer's task is the 'creative and innovative application of science for the design, development, production and exploitation of products and services that are useful to society or the management of those activities'. This academic education is the foundation of the engineering graduate who subsequently evolves through lifelong learning.

The Faculty aims at forming students in the various roles engineers can take: engineers as experts in their discipline, engineers as researchers, engineers as problem solvers and designers, engineers as professionals and engineers in an international context. Furthermore, the Faculty of Engineering Science applies the ACQA criteria for the elaboration of the learning outcomes. The NVAO recognises these ACQA criteria as an operationalisation of the more global Dublin descriptors for academic engineering education. The ACQA framework distinguishes seven areas of competence with regard to method, domain and context, which will be translated into a list of concrete, operational learning outcomes.

This master's programme aims to deliver interdisciplinary-trained biomedical engineers that can act as integrator between medical and technological specialists by translating the medical needs into engineering requirements. Graduates therefore possess a broad analytical and problem-solving mind and can combine knowledge from technical-scientific and medical-scientific domains. These biomedical engineers are able to design and produce medical devices and procedures that can effectively solve medical problems through their integration in clinical practice. The educational programme provides students with a state-of-the-art overview of biomechanics, biomaterials, medical sensors and signal processing, medical imaging and tissue engineering. This broad technological background is essential to prepare the student to work in the biomedical engineering field and also makes graduates of this programme attractive to conventional industrial sectors as well.

Target group

In contrast to profiles in biomedical sciences, the Master of Biomedical Engineering is technologically oriented since the master's programme is built on the bachelor's programme in engineering science. Students are expected to have a strong and broad technological background, combining basic elements from mechanical, electrical, chemical and materials engineering, as well as computer science. Additionally, the students must have a strong interest in applications in healthcare and be motivated to contribute to technological advances in medicine.

KU Leuven students with a bachelor's degree in engineering science and a major or minor in biomedical engineering are unconditionally accepted to the Master Biomedical Engineering. For Dutch-speaking lateral-entry students (mainly bachelor's or master's students in Bioscience Engineering, Biomedical Sciences, Kinesiology, Rehabilitation Sciences, or Medicine; master's students in Engineering Technology; bachelor's students in Engineering Science without major or minor in Biomedical Engineering) a preparatory programme can be followed that can be individually finetuned by the programme director in consultation with the student. For non-Dutch speaking lateral-entry students, a preparatory programme is currently not available.

Each application by a candidate with a non-Flemish degree is evaluated by an admission committee. The committee considers the contents of the bachelor's programme, the grades, the quality of the institute where the previous degree was obtained, and the motivation of the candidate. A language proficiency test is required with minimum scores defined by the University and the Faculty.

Realisation

Structure

The programme is composed of four parts:

- **The common core** provides a common basis in Biomedical Engineering, building further on the basic engineering courses and the basic medical courses on human anatomy, cell biology and physiology of the bachelor's programme. The core courses cover the broad biomedical engineering spectrum and include biomechanics, biomaterials, medical imaging, biosensors, biomedical data processing, numerical modelling, medical equipment, and regulatory affairs. Company visits that are included in some courses expose all students to industrial aspects of biomedical engineering
- **The elective courses** are in part provided as options, i.e., a coherent package of elective courses that allow the students to deepen their knowledge in a particular subfield (including 'biomechanics', 'tissue engineering', 'biomedical data analytics', 'bioinformatics & AI', 'bioelectronics', 'medical physics'). Students augment the obligatory elective courses of their option with courses from another option or with additional free elective courses. Students can also opt to take up an internship in a company or to take part in the ATHENS programme.
- **The general interest courses** broaden the student's views beyond biomedical engineering. These include courses on management, communication, and socio-economic and ethical aspects of medical technology.
- **The project-based learning** courses familiarise the student with the daily practice of a biomedical engineer. These courses, and in particular the master's thesis, allow the students to integrate many of the skills and abilities learned in the programme and to develop their research skills in an interdisciplinary context.

The learning environment

The three main delivery modes (lecture, practical and assignment) are characterised by the role of the lecturer and the student, respectively. The other delivery modes are master's thesis and internship. The programmes combine the most appropriate delivery modes for each course and a proper balance over the entire curricula is envisaged. The general objective is to activate students, stimulate them to work independently or in a group, and to have a good balance between the different delivery modes.

The Faculty and its programmes recognise the importance of a high-quality assessment. High-quality evaluation is therefore fully embedded in the learning environment: it is aligned with the objectives, uses the appropriate evaluation formats, and is adapted so as to fit the characteristics of the students concerned, who also receive feedback in a timely and appropriate manner. The policy document 'Tests and Assessments' describes the policy of assessment at the Faculty:

- alignment with programme and learning outcomes,
- feedback,
- quality assurance, transparency and the ombuds service,
- evaluation of master's theses and internships,
- organisation of assessments, including special provisions for students with a disability.

The implementation of the Faculty's examination regulations, the implementation of the programmes, the choice of assessment modes, the specific learning outcomes, and the internal quality assurance of the programme is the primary responsibility of the Educational Committee of each (cluster of) programme(s). All programme directors of the different ECs take part in the Faculty's Educational Committee.

Learning pathways

The engineer as expert in biomedical technology

The master's programme scores high on acquiring knowledge. As a consequence, graduates know the structure and function of the human body (at different levels: cells, tissue, organs and body) for the purpose of developing medical-technological products and processes that will be used in diagnostic and therapeutic applications. Therefore, they possess a broad and active (i.e., application-oriented) knowledge of biomedical technology. They have mastered the conventional theories and the common experimental and numerical techniques in biomechanics (musculoskeletal biomechanics and bio-fluid mechanics), biomaterials, bioinstrumentation (sensors and actuators), medical imaging and analysis, biomedical data processing, medical equipment (electronic and mechanical) and regulatory affairs. They are able to apply their knowledge of the different interdisciplinary domains (medical and technological) in a creative way, expand it and integrate it in functional systems. Building on this knowledge, they can retrieve a multiplicity of complex information (from scientific literature, own research findings and any already existing alternative solutions to similar or related problems), relate it to their own research question, analyse, interpret, and integrate the information and form a reasoned judgment on it.

This role mainly addresses competence areas 1 (knowledge) and 5 (intellectual skills) of the ACQA criteria.

The engineer as researcher

Research and education are closely related in the Faculty as it is the Faculty's policy to support programmes by strong research activities. The teaching staff of the master's programme has an excellent research record and runs many research projects, both with national and international partners.

This research component manifests itself in the topics covered in the courses, and most clearly in the master's thesis which finalises this research learning pathway and which forms a major part of the programme. To support students in the process, the Educational Development Unit of the Faculty, in co-operation with the Campus Library Arenberg, organises master's thesis workshops about information literacy, intellectual integrity and plagiarism and academic writing.

As a result of this strong research focus, graduates are able to formulate research questions, translate these into a plan of action and evaluate the correctness of research findings and the conclusions drawn from them. In addition, they are able to independently process and apply new insights, methodologies and results within their own or related disciplinary fields. In doing this, they rely on interaction with and advice from experts in diverse technological disciplines and in medicine where necessary. Graduates are capable of detaching themselves, when necessary, from the binding nature of the solution to a problem in order to look for long-term solutions and innovative ways of thinking that provide a strategic advantage in the long run. The research focus of the master teaches them to take a critically constructive position vis-à-vis all new relevant findings and developments they encounter in academic literature and to further explore these in their own research. This implies that the graduates have developed the attitude to actively keep track of new developments and to integrate these into their professional activities.

This role mainly addresses competence areas 2 (research) and 4 (scientific approach) of the ACQA criteria.

The engineer as problem solver and designer

The extensive project-based learning pathway builds upon the learning pathway on 'Problem Solving and Design' already started in the bachelor's programme. It allows students to develop their creative design and problem- solving abilities and to address, research and solve real-life problems. Through this pathway, students learn how to apply research and development methodologies to real situations, leading to a functional product (object, software, procedure) that will be evaluated in function of design requirements. Throughout the design process, they learn how to take the medical, technological, regulatory and economic boundary conditions into account, as well as the capabilities and limitations of the user of a medical-technological product (healthcare provider, patient, etc.). At the end, they are able to creatively and independently process and apply new insights, methodologies and results within their discipline and related interdisciplinary fields in order to design new medical-technological products.

Strong emphasis is placed on transferable and transversal skills such as written and oral communication, working in a team, leadership, project management, responsibility and norms of engineering practice, taking initiatives, and entrepreneurship. In particular, graduates are able to translate technical concepts to medical experts and to actively participate in discussions with medical and technical experts. Other transferable skills as information literacy, intellectual integrity and plagiarism and academic writing are included in the programme through other courses, workshops, etc.

This role mainly addresses competence area 3 (skilled in design), as well as competence areas 6 (ability to collaborate and communicate) and 7 (social and temporal context) of the ACQA criteria.

The engineer as professional

The professional profile of engineers implies that they can use their knowledge and skills to develop, produce, exploit and operate technical realisations in a cost-efficient and responsible way. For engineers, this means mastering all stages of the development and exploitation process under their responsibility at the appropriate level of abstraction. They must possess the necessary skills to complete this process theirselves, as part of a team or to have it executed by others. In addition, they must have an overview of the organisation of these processes as supervisors, not only in their own immediate environment but also with clients and stakeholders. Finally, they are responsible for the cost and cost-effectiveness of the implementation of the technical processes.

Furthermore, the Faculty aims at enhancing the employability of its master's students. In order to reach this goal, the Faculty tries to encourage students in all master's programmes to incorporate both internships and entrepreneurial courses in their elective courses. The entrepreneurial courses are specifically created to provide an alternative way for students to get in contact with industry and/or a professional environment.

The master's programme facilitates exposure of their students to industrial experience in several ways through company and hospital visits, industrial internships in Belgian companies and medical technology centres abroad, through design projects and master's theses completed in industry, and through elective entrepreneurial courses. In this way, they learn how to analyse the societal consequences (economic, social, ethical, environmental) of new developments in biomedical technology in a better way and learn how to integrate these in academic work. Moreover they build up a good understanding of their own role and responsibilities in relation to those of other actors in medicine and health care (healthcare providers, hospital managers, management of healthcare institutions, social security).

This role mainly addresses competence areas 7 (social and temporal context) and 6 (ability to collaborate and communicate) of the ACQA criteria.

The engineer in an international context

The Faculty of Engineering aims at developing an international open policy and atmosphere. Preparing the students for the global labour market is an important focus. The Faculty is not only encouraging its students, researchers and scholars to have an international experience but is also home to a vibrant community of international students, staff and researchers.

The Faculty's and the programmes' international activities are extensive and diverse:

- The Faculty has a strong international reputation and is a member of several distinguished networks of technical universities in Europe such as CLUSTER, CESAER and ATHENS.
- The Faculty offers student mobility and staff exchange on a European (Erasmus) and intercontinental level for one semester or a year. The appointment of an exchange coordinator and a well-documented website offer enough guidance. By having good contacts with a selected number of international universities the high-level quality of the education taken abroad is assured.
- The Master in Biomedical Engineering offers its programme completely in English, thereby improving its international visibility by facilitating access to incoming international students and to Flemish students opting for a sufficient mastery of the English language.
- Within the CLUSTER network the Faculty collaborates with partner universities to offer students the chance to get a dual or double degree.
- The Faculty is also participating in an Erasmus Mundus programme and EIT-KIC programmes.
- The ATHENS network organises intensive short-duration (one week) courses at each member institution.
- Students and researchers get the opportunity to participate in international research projects. Also, students can choose an industrial internship in an industrial company or medical technology centre abroad or select a development cooperation project.

This role mainly addresses competence area 7 (taking into account temporal and social context) of the ACQA criteria.

KU Leuven
Faculty of Engineering Science

Kasteelpark Arenberg 1 bus 2200
B-3001 LEUVEN
tel. + 32 16 32 13 50

KU LEUVEN

FACULTEIT
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