BIOMEDICAL ENGINEERING

LIMITED INITIAL ACCREDITATIONS

FACULTY OF SCIENCE AND ENGINEERING

UNIVERSITY OF GRONINGEN

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This report was finalized on 10 February 2019

REPORT ON THE BACHELOR'S PROGRAMME BIOMEDIAL ENGINEERING OF THE UNIVERSITY OF GRONINGEN

This report takes the NVAO's Assessment Framework for Limited Initial Accreditations as a starting point (September 2016).

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Bachelor's programme Biomedical Engineering

Name of the programme:	NL: B Biomedische Technologie EN: B Biomedical Engineering
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Location(s):	Groningen
Mode(s) of study:	full time
Language of instruction:	English

The visit of the assessment panel Biomedical Engineering to the Faculty of Science and Engineering of University of Groningen took place on 5 and 6 November 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	University of Groningen
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO approved the composition of the panel on 27 August 2018. The panel that assessed the bachelor's programme Biomedical Engineering consisted of:

- Prof. J. (Jos) Vander Sloten, full professor at the Faculty of Engineering Science and vice-dean Internationalisation at the Faculty of Engineering Science at the KU Leuven (chair);
- Dr. I.E.T. (Inge) van den Berg, associate professor and education coordinator at the Division of Laboratories, Pharmacy and Biomedical Genetics at the University Medical Center Utrecht;
- Dr. R.L. (Richard) Kamman, Chief Information Officer (CIO) at Princes Máxima Centre for pediatric oncology in Utrecht;
- Prof. S.C.G. (Sander) Leeuwenburgh, full professor Regenerative Biomaterials at Radboud University Medical Center in Nijmegen;
- V. (Vera) Koomen, master's student Biomedical Engineering at the Eindhoven University of Technology.

The panel was supported by drs. R.L. (Renate) Prenen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The initial accreditation of the bachelor's programme Biomedical Engineering at the Faculty of Science and Engineering of the University of Groningen was conducted alongside the cluster assessment Biomedical Engineering. Between October and December 2018 the panel assessed 10 programmes at 5 universities: Vrije Universiteit Amsterdam, Delft University of Technology, University of Groningen, Eindhoven University of Technology and University of Twente.

On behalf of the participating universities, the quality assurance agency QANU was responsible for logistical support, panel guidance and production of the reports. Peter Hildering, MSc, was project coordinator for QANU. Peter Hildering, MSc, and drs. Renate Prenen acted as secretaries during the site visits. [redacted], and [redacted] acted as second secretary during a number of the site visits.

During the site visit at the University of Groningen, the panel was supported by Renate Prenen, a certified NVAO secretary. During the first day of the site visit, the panel was accompanied by NVAO coordinator Irma Franssen for the initial accreditation of the bachelor's programme Biomedical Engineering.

Panel members
The members of the assessment panel were selected based on their expertise, availability and independence. The panel consisted of the following members:

- Prof. J. (Jos) Vander Sloten (chair)
- Dr. I.E.T. (Inge) van den Berg
- Dr. R.L. (Richard) Kamman
- Prof. J.A.E. (Jan) Eggermont
- P. (Pieter) Wiskerke, MSc
- Prof. S.C.G. (Sander) Leeuwenburgh
- Prof. R.J. (Roland) Pieters
- Prof. A.A. (Amir) Zadpoor
- Vera Koomen, BSc (student member)
- Sophie Hinterding, BSc (student member)

Preparation
On 10 September 2018, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on 3 October 2018. During this meeting, the panel members were instructed on the use of the assessment frameworks. The panel also discussed its working method and the planning of the site visits and reports.

The project coordinator composed a schedule for the site visit in consultation with the Faculty. Prior to the site visit, the Faculty selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to the University of Groningen, QANU received the self-evaluation reports of the programmes and forwarded them to the panel. A selection of theses from the Biomedical Engineering major in the bachelor programme Life Sciences and Technology, from which the new bachelor's programme originates, was made by the panel's chair and the project coordinator. The selection consisted of 15 theses and their assessment forms, based on a list of recent graduates provided. A variety of topics and tracks and examiners was included in the selection. The project coordinator and panel chair ensured that the distribution of grades in the selection matched the distribution of grades of all available theses.

After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. The secretary collected all initial questions and remarks and distributed them among all panel members.

At the start of the site visit, the panel discussed the framework and working method for the initial accreditation, its initial findings on the self-evaluation report and the theses, as well as the division of tasks during the site visit.

Site visit
The site visit to the University of Groningen took place on 5 and 6 November 2018. Before and during the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project coordinator for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project coordinator sent the draft reports to the Faculty in order to have them checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The reports were then finalised and sent to the Faculty and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited initial programme assessments, the panel used the following definitions for the assessment of the standards:

Does not meet the standard
The new programme does not meet the generic quality standard.

Partially meets the standard
The new programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard(s).

Meets the standard
The new programme meets the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

Positive
The programme meets all the standards.

Conditionally positive
A judgement of "Partially meets the standard" with respect to no more than two standards, with conditions being imposed.

Negative
A judgement of "Does not meet the standard" with respect to one or more standards and a judgement of "Partially meets the standard" with respect to three or more other standards.

SUMMARY JUDGEMENT

Intended learning outcomes
The three-years bachelor´s programme Biomedical Engineering (BME) is an interdisciplinary programme organised and supported by the Faculty of Science and Engineering (FSE) in co-operation with the Faculty of Medical Sciences (FMS) and the University Medical Center Groningen (UMCG). It is a stand-alone continuation of the BME major as part of the bachelor's programme Life Science and Technology. The main aim of the programme is to educate students in the basic or elementary principles of biomedical engineering issues and prepare them for a BME or Engineering master's degree programme.

The panel is positive about the programme's profile. It approves of the strong design focus and the intertwining of technical and medical disciplines. It also appreciates the ambition to integrate design and research. However, it felt that this intended integration could be reflected more clearly in the programme's aims and learning outcomes to avoid a dichotomy between research and design within the programme. It appreciated that representatives of the field, experts from partner-universities and current BME major students are closely involved in the setup of the programme. It noticed strong support for the profile, including the choice for an English-taught programme. Considering the ongoing globalisation of BME, the panel also agreed with the English language choice.

The intended learning outcomes of the bachelor's programme BME are in line with the subject-specific reference framework as well as the international Dublin descriptors. However, the panel ascertained that they overlap to a large extent with those of the faculty's master's programme BME and as a result are generally too ambitious. It advises adjusting the outcomes in order to differentiate them from the master's programme and to better reflect the bachelor's level.

Teaching-learning environment
The panel established that the proposed bachelor's curriculum BME is adequately designed and enables the students to achieve the intended learning outcomes. The curriculum consists mostly of compulsory courses, which safeguards the programme's coherence. The minor gives students the possibility to tailor their programme to their individual interests. The content suits a bachelor's level and covers the main areas of BME. According to the panel, the content is sufficiently aligned with the programme-specific learning outcomes. However, it also remarked that the curriculum overview in the self-evaluation report only shows a rough outline of the relationship between the learning outcomes and the programme components. It advises elaborating on this connection in the further development of the programme. It approves with the programme's ambition to integrate research and design knowledge and skills. However, it feels that the balance of and integration between research and design should be improved. It recommends clearly delineating the different learning paths in the programme, including research and design.

The panel is satisfied with the setup of the individual courses. The teaching methods are in line with the learning outcomes and course contents. The panel considers them as not very innovative but sufficiently interactive, due to the small group sizes. Attention should be paid to the scheduling of lectures and working groups and the low attendance of students during classes. The panel advises exploring ways to make the teaching more active and increase student participation.

The panel values the professional, scientific and didactic qualities of the staff and the attention paid to their professionalization. A point of attention raised is the staff´s English proficiency. As the programme will be taught entirely in English, their English language skills should be closely monitored and stimulated. The panel also concludes that the quantity of the staff is sufficient. It considered the student-staff ratio to be acceptable and was pleased to see that investments are being made to recruit more staff. At this moment there is an imbalance in UMCG versus FSE staff. The panel appreciates the management's intention to closely monitor this balance and take further measures if necessary. Finally, the panel ascertained the programme-specific facilities to be adequate. It advises quickly resolving the discomfort that students experience due to the lack of a UMCG pass.

Student assessment
The panel is satisfied with the assessment and evaluation system of the bachelor's programme BME. The formal regulations are clearly set out in the draft Teaching and Examination Regulations and the Rules and Guidelines for Boards of Examiners. It appreciated the various measures that will be implemented to promote the reliability, validity and clarity of assessment, such as the overall assessment programme, the CUAOs and the peer-review principle. The Board of Examiners still has to be formally established. There will be an overlap with the Board of Examiners of the master´s programme BME. The panel would like to see a strong, active and committed Board as there are several challenges in the further development of a new programme.

The panel approved the types of assessment proposed. They are sufficiently varied and suit the content and design of the programme. The thesis evaluation procedure is adequate. There are always two supervisors involved, one of the eight mentors and the daily project supervisor, whereby the mentors play an important role in safeguarding the quality of the bachelor's thesis. However, the panel noted some weaknesses in this system with regard to the independence of the assessments, such as the strong involvement of mentors in supervising students during their theses. It advises elaborating measures to further strengthen the quality assurance of the thesis assessments, for example by promoting calibration sessions among the mentors. With respect to the thesis assessment form, the panel ascertained that it is still being designed. It agreed with the intention to base the form on that of the master´s programme BME, which fits well with the intended integration of design and research. It is also positive about the plan to develop a rubric for the thesis evaluation, as this can have a positive effect on increasing the transparency and reliability of the assessment. It concluded that the completed assessment forms could become more transparent, particularly with regard to the scores for criteria in relation to the final mark and the written clarification. It recommends that these points be taken into account in the further development of the new assessment form.

Achieved learning outcomes
Since no graduates of the new bachelor´s programme BME were available at the time of the site visit, the panel was only able to judge the achieved intended learning outcomes using the current BME major, which cannot be a definitive proof of the new programme's final level. With the aim of generating recommendations for the new programme, it decided to study several theses from the current BME major. It concluded that all theses are of an adequate bachelor's level, but do not clearly reflect the intended integration of research and design. It advises carefully designing and implementing the new thesis guidelines.

The panel assesses the standards from the *Assessment framework for limited initial programme assessments* in the following way:

Bachelor's programme Biomedical Engineering

Standard 1: Intended learning outcomes	Meets the standard
Standard 2: Teaching-learning environment	Meets the standard
Standard 3: Student assessment	Meets the standard
Standard 4: Achieved learning outcomes	Meets the standard
General conclusion	Positive

The chair, prof. Jos Vander Sloten, and the secretary, drs. Renate Prenen, of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in it. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED INITIAL PROGRAMME ASSESSMENTS

Introduction
The bachelor´s programme Biomedical Engineering (BME) is an interdisciplinary programme organised and supported by the Faculty of Science and Engineering (FSE) in co-operation with the Faculty of Medical Sciences (FMS) and the University Medical Center Groningen (UMCG). It is a stand-alone continuation of the BME major as part of the bachelor's programme Life Science and Technology. Formal responsibility for the programme rests with the FSE. Within this faculty, all bachelor's programmes are organised in the Undergraduate School of Science and Engineering and all master's degree programmes in the Graduate School of Science and Engineering. The BME bachelor's degree programme is managed by the director of the Undergraduate School of Science and the deputy director of the programme in concert with the involvement and direction of the Faculty Board. The BME programme's daily affairs are managed via the programme 'triangle', which consists of the deputy director, the programme coordinator and the academic advisor. The content of the BME programme has strong ties with the FSE and FMS/UMCG research institutes. Staff members are appointed to organisational research groups, which are clustered into several research institutes and schools. The programme intends to establish a programme committee and a board of examiners. These bodies will originate from and partly overlap with those of the master's programme BME.

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings
According to the self-evaluation report, the mission of the bachelor´s programme Biomedical Engineering (BME) at the University of Groningen is to educate students in the basic or elementary principles of biomedical engineering issues and prepare them for a BME or Engineering master's degree programme. At the University of Groningen, teaching is intertwined with academic research, and thus, students are familiarized with academic research skills. In line with this, the programme's vision states that research- and design-based teaching must be grounded in the latest academic theories, research outcomes and design methodologies; they will form an integral part of the programme. As such, explicit attention will be paid to the introduction, practice and assessment of academic and engineering skills.

The mission is subdivided into several goals for the BME bachelor's programme: (1) endowing students with the basic knowledge and skills needed to perform thorough problem analyses, draft designs/redesigns, and implement and validate technological products, processes and systems in a medical and technical environment within the field of BME; (2) providing students with an academic training covering autonomous, critical and analytical thinking and acting, including scientific communication in English; (3) offering an interdisciplinary approach as a key element of the programme; (4) paying special attention to teamwork and personal leadership; (5) preparing students for BME or Engineering master's degree programmes. The programme has used its mission, vision and goals to determine and formulate eight intended learning outcomes (cf. appendix 2).

During the site visit the panel discussed the programme's profile with staff, students and representatives of the field. It ascertained that the bachelor's programme in BME at the University of Groningen has a strong focus on the design aspects of biomedical engineering. The programme can be characterized by its aim to integrate design and research skills. It is also distinguished by the fact that engineering and natural sciences expertise from the Faculty of Science and Engineering (FSE) is combined with the medical expertise available from the Faculty of Medical Sciences (FMS)/

the University Medical Center Groningen (UMCG), culminating in a combination of both the technical and medical fields from a research and applications perspective.

In general the panel is positive about the programme's profile. It appreciates the strong design focus, which is in line with the university´s and faculty´s aim to expand its offering of technical and engineering programmes. It is also enthusiastic about the collaboration between the two faculties and the UMCG; it considers the intertwining of technical and medical expertise and practices as a fruitful and distinctive feature of the programme. It approves the programme's ambition to integrate design and research. The panel is convinced that a fusion of both is essential to train BME professionals on an academic level and avoid a dichotomy between design and research. However, it remarked that the mission and vision around the required integration of design and research, as presented in the self-evaluation report, could be expressed more clearly. This mission and vision should ensure a proper balance between research and design in the further composition and organization of the programme's curriculum The panel advises to re-define the programme´s mission, vision and learning outcomes in such a way that they clearly reflect this intended integration.

The panel noted that several groups have been consulted and/or involved in the profiling and setup of the new programme, including students and graduates of the current BME major in the bachelor´s programme Life Science and Technology, representatives of the field, and experts from partner-universities. A feedback meeting with BME major students was held in which they provided comments about their expectations for the new programme and actual experiences of the current major. A Curriculum Committee was established, consisting of representatives from the field, current students and teaching staff. This committee will meet annually to inform the programme management of new developments in the field and provide suggestions for adapting the bachelor's and master's programmes BME to better prepare students for BME careers. In addition, an advisory board has been assembled, composed of programme directors from four European partner-universities with well-respected BME master's programmes. This board advises about the content and connection of the bachelor's and master's programmes BME. The panel appreciates these initiatives. During the site visit, the panel was pleased to observe a strong commitment and support for this new programme among the different stakeholders. It advises consulting the Curriculum Committee about the further development and implementation of the new programme.

In line with university and faculty policy, the programme will be taught in English. Most interviewed BME graduates and representatives from the field are positive about this measure. The panel also agrees in view of the globalisation of BME. The work field is increasingly international, and the majority of the literature is in English.

The panel studied the proposed intended learning outcomes for the new programme and established that they are in agreement with the domain-specific reference framework (cf. appendix 1) and can be linked to the international Dublin descriptors for the bachelor's level. The outcomes are therefore in accordance with national as well as international standards. The panel noticed that the learning outcomes of the bachelor's programme BME are very similar to those of the faculty's master's programme BME. In fact, the learning outcomes 1, 2, 3, 4, 6, 7 and 8 are almost identical. According to the panel, this has resulted in rather ambitious learning outcomes for the bachelor's programme. Some are too ambitious and exceed the intended bachelor's level. For example, learning outcome 4 implies that bachelor students have to be able to execute an R&D plan and adapt it when external circumstances or advancing insights require to do so. The panel recommends revising the outcomes so they are more distinctive from those of the master's programme and more in line with national and international expectations regarding BME bachelor's graduates. The panel also advises to avoid the suggestion in the intended learning outcomes that students obtain the title 'biomedical engineer' after graduation, as this is not a formal title. Besides, the title 'engineer' (ir.) is associated with the master's degree. According to the panel, the learning outcomes can be adjusted by referring to the competences of the 'bachelor of science in biomedical engineering' instead of those of the 'biomedical engineer'.

Considerations
The panel is positive about the programme's profile. It approves of the strong design focus and the intertwining of technical and medical disciplines. It also appreciates the ambition to integrate design and research. However, it felt that this intended integration could be reflected more clearly in the programme's aims and learning outcomes to avoid a dichotomy between research and design within the programme. It appreciated that representatives of the field, experts from partner-universities and current BME major students are closely involved in the setup of the programme. It noticed strong support for the profile, including the choice for an English-taught programme. Considering the ongoing globalisation of BME, the panel also agreed with the English language choice.

The intended learning outcomes of the bachelor's programme BME are in line with the subject-specific reference framework as well as the international Dublin descriptors. However, the panel ascertained that they overlap to a large extent with those of the faculty's master's programme BME and as a result are generally too ambitious. It advises adjusting the outcomes in order to differentiate them from the master's programme and to better reflect the bachelor's level.

Conclusion
Bachelor's programme Biomedical Engineering: the panel assesses Standard 1 as ' Meets the standard'.

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum content and design
BME comprises 180 EC and is offered as a three-year, full-time bachelor's programme (cf. appendix 3). Each year is divided into four blocks of 15 EC. All courses are worth 5 EC, with the exception of the Research course BME (10 EC). The first year offers students foundational knowledge courses in the fields of mathematics, natural sciences and life sciences. In the second year students are introduced to three different aspects of biomedical engineering: diagnostic imaging and instrumentation; biomaterials science and engineering; and medical device design. These three fields coincide with the three minors later in the programme, and the tracks in the master's programme BME. Students follow one course per field in each block of the second year, i.e. three courses per block in total. In this way, students are taught to appreciate the horizontal connection between courses and gain more insight into the three different BME fields. In the first block of the third year, students follow a minor (15 EC). Three minors will be developed, related to one of the three tracks in the BME master's programme, but students are free to choose among them. In the second and third block, students resume following the standard selection of BME bachelor's courses. In the last block students finish their studies with the Bachelor research and design project (15 EC). The panel considers the programme to be well designed. It is made up of a coherent package of compulsory courses that cover the main areas of BME. The content of the courses is of an adequate bachelor's level. The minor, although a relatively small part of the programme, gives students the opportunity to tailor their programmes towards their specific needs and interests.

The self-evaluation report contains a matrix that shows the relationship between the proposed course units and the overall intended learning outcomes. Based on this matrix, the panel ascertained that all outcomes are met by the programme. However, it also found that the matrix shows only a rough outline of the relationship between the learning outcomes and the programme components. This relationship should be further specified for the purpose of constructive alignment, for example by clearly defining which parts of the learning outcomes will be taught and where and on what level of performance they will be assessed.

During the site visit the panel spoke with the staff about the balance between, and integration of, design and research within the curriculum. The curriculum overview, with different colors indicating the engineering, medical/biological, physics/mathematics and research components (see appendix 3), gave the panel the impression that the proportion of research is rather limited compared to design. It also raised the question as to what extent research and design are integrated in the various courses. The staff emphasized that many courses are accompanied by practicals. Within these practicals, students not only apply the knowledge in a practical setting, they also learn and practise academic and research skills like literature review, writing, reasoning and statistics. The programme strives for synergy between design and research in the curriculum. The final Bachelor research and design project, for example, must always include both research and design components, though the focus may differ, depending on whether the student chooses a research study or a design-oriented project (see also standard 3). The panel appreciates this ambition, but indicates that the balance of, and integration between, design and research deserves more attention in the further development and implementation of the programme. It advises working on a clear delineation of the different learning paths in the curriculum from a shared vision on BME, including the teaching and assessment of both research and design.

The courses within a period are scheduled in parallel or sequentially, depending on factors like the timetable and available staff. The panel learned from the conversations with current students and staff that both set-ups have advantages and disadvantages. It understands the dilemmas. When scheduling in the future, it advises carefully looking at the feasibility of the programme and the time given to students to process, incorporate and apply the knowledge and skills.

Teaching concept and methods
The panel studied the information in the self-evaluation report and the course materials on the reading table during the site visit. It noted that the programme does not have a distinctive overall didactical vision that underlies the teaching and learning, but rather relies on traditional teaching methods such as lectures, working groups, and practicals. Although these teaching methods are not considered particularly innovative, the panel approves these teaching methods in view of the small-sized student groups which allows for interactive forms.

The panel advises paying attention to the scheduling of the lectures and working groups. As it learned from current BME major students, most working groups are organized immediately after the lectures. Particularly when they are not well prepared, students experience the working groups as inefficient. According to them, more time between the lectures and working groups would contribute to a better preparation. The panel also advises paying attention to the low student attendance during lectures. It suggests that there might be a connection with the non-committal nature of the lectures and an emphasis on knowledge transfer. It suggests exploring alternative teaching methods to stimulate active learning and student presence.

Teaching staff
The panel studied the composition of the teaching staff who plan to become involved in the bachelor's programme BME as presented in the self-evaluation report. During the site visit it also discussed the quality and quantity of the staff with the management, lecturers and current students. Most of the staff is also involved in the current BME major of the bachelor's Life Science and Technology and/or BME master's programme. The new programme will be based on the existing major. Therefore, as emphasized by the management, the extra time and effort are acceptable. Investments are also being made in extra staff. The student to staff ratio is estimated to be 20:1, which is acceptable to the panel.

The panel is positive about the quality of the staff. It appreciates that almost all staff members have doctorates and engage in original research. They bring their experiences in research, international working environments and professional networks to the BME programme to the benefit of the students. It also appreciates the fact that attention is paid to the didactical expertise of the staff. At the time of the site visit, 80% of the teaching staff involved had obtained the University Teaching

Qualification ('basiskwalificatie onderwijs'). The interviewed students are in general positive about the staff. They appreciate their expertise as well as their accessibility and involvement. With respect to the lecturers´ English language skills, they mentioned experiencing differences in level. Some lecturers are more skilled than others. According to the panel, the staff´s English proficiency should be closely monitored and stimulated. If necessary, further measures should be taken.

The BME lecturers are employed at one of the research institutes of FSE or UMCG. The panel noticed an imbalance; the majority of the staff involved is appointed at the UMCG. According to the management, this has developed historically and at the moment does not lead to any issues regarding the availability and quality of the staff. In the long term, the balance will be closely monitored and steered, taking into account the required expertise, continuity and developments in the field. The panel supports this vision. Furthermore, it noted that, although the UMCG and FSE staff are housed at different locations, they regularly meet to discuss the content, setup and quality of the programme. It feels the programme is to be praised for such a dedicated group of lecturers.

Programme-specific facilities
The programme committee of the master's programme BME will also act as the programme committee of the bachelor's programme BME for reasons of efficiency and to improve the link between the two programmes. The programme coordinator will function both as an adviser and the formal secretary. According to the panel, this is undesirable as it could influence the independent position of the committee. It advises adjusting this situation.

The interviewed BME students were generally satisfied with the programme's facilities. They follow courses at both faculties, which are well equipped. One inconvenience is that BME students do not have an entrance pass for the UMCG building, so they cannot open doors and make use of the coffee machines, for example. The panel advises resolving this problem soon.

Considerations
The panel established that the proposed bachelor's curriculum BME is adequately designed and enables the students to achieve the intended learning outcomes. The curriculum consists mostly of compulsory courses, which safeguards the programme's coherence. The minor gives students the possibility to tailor their programme to their individual interests. The content suits a bachelor's level and covers the main areas of BME. According to the panel, the content is sufficiently aligned with the programme-specific learning outcomes. However, it also remarked that the curriculum overview in the self-evaluation report only shows a rough outline of the relationship between the learning outcomes and the programme components. It advises elaborating on this connection in the further development of the programme. It approves with the programme's ambition to integrate research and design knowledge and skills. However, it feels that the balance of and integration between research and design should be improved. It recommends clearly delineating the different learning paths in the programme, including research and design.

The panel is satisfied with the setup of the individual courses. The teaching methods are in line with the learning outcomes and course contents. The panel considers them as not very innovative but sufficiently interactive, due to the small group sizes. Attention should be paid to the scheduling of lectures and working groups and the low attendance of students during classes. The panel advises exploring ways to make the teaching more active and increase student participation.

The panel values the professional, scientific and didactic qualities of the staff and the attention paid to their professionalization. A point of attention raised is the staff´s English proficiency. As the programme will be taught entirely in English, their English language skills should be closely monitored and stimulated. The panel also concludes that the quantity of the staff is sufficient. It considered the student-staff ratio to be acceptable and was pleased to see that investments are being made to recruit more staff. At this moment there is an imbalance in UMCG versus FSE staff. The panel appreciates the management's intention to closely monitor this balance and take further measures

if necessary. Finally, the panel ascertained the programme-specific facilities to be adequate. It advises quickly resolving the discomfort that students experience due to the lack of a UMCG pass.

Conclusion
Bachelor's programme Biomedical Engineering: the panel assesses Standard 2 as ' Meets the standard'.

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings

Assessment system
The panel studied the assessment information in the self-evaluation report. During the site visit it also reviewed course and assessment materials and spoke with students and staff about the assessments. It is satisfied with the programme's proposed assessment system. The formal regulations regarding examination registration, terms of assessment, and criteria of validity of results are clearly set out in the draft Teaching and Examination Regulations and the Rules and Guidelines for Boards of Examiners. The assessment forms are varied and in line with the learning objectives and type of course elements involved. Written and oral examinations are typically used to assess the students' knowledge acquisition, while project assignments (e.g. lab work, written essays), presentations and reports are typically used to assess their way of thinking and skill development. The majority of course elements are assessed by a combination of assignments and written or oral examinations. In order to train students to work in teams, group work is often made part of the assignments. Learning outcomes, teaching methods and methods of assessment are explained to students in the course element descriptions in the digital course catalogue. All students are obliged to attend the first lecture of each course, during which their respective lecturers provide further assessment details and make themselves available to answer related questions. Consequently, the expected learning outcomes are clear a priori, and students can choose an effective learning strategy.

The faculty's assessment policy and protocol state that the programme must have an assessment policy, which should guarantee that graduates have attained the learning outcomes. Aside from this plan at the level of the programme as a whole, a Course Unit Assessment Overview (CUAO) must be available for each course unit for the relevant lecturers and committees. The CUAO is composed by the course unit coordinator. It gives a systematic description of the links between learning outcomes, modes of instruction, and modes of assessment and marking, as well as the required background knowledge of the students and the position of the course unit within the curriculum. During the site visit, the assessment programme and the CUAOs were still under development. However, examples from the master's programme BME gave a good impression. The faculty's assessment policy also states that, as a rule, examinations and assignments must be drafted and checked by two lecturers (peer review) to ensure that the exam questions are clear, unambiguous and sufficiently assess whether the various learning outcomes of the course unit have been attained. The panel is positive about these measures that will certainly contribute to ensuring the reliability, validity and clarity of the testing.

Students finish their studies with the Bachelor research and design project. They may undertake one of two possible projects: a research-oriented project, in which they focus on performing a research study, or a design-oriented project, in which they focus on designing an engineering solution to a biomedical problem. They conclude their bachelor's project with a written thesis and oral presentation, both of which must be successfully completed in order to graduate. During the site visit, the panel spoke with the staff about the manner of assessing this final project. It strongly agreed with the opinion of the staff that, regardless of the orientation of the projects, all theses should include a research *and* a design component, but that the balance between these two may vary depending on the objectives and results of a project. The panel advises to formalize this opinion

into a clear and unambiguous vision on the balance between both components within the bachelor's project.

The grading of the bachelor's theses is always based on the assessment of two assessors: one of the eight mentors of the bachelor's programme and the daily project supervisor, who can be a local supervisor or an external specialist. The mentors act as the first thesis assessor to safeguard quality and to make sure that the projects meet academic standards. They also act as a back-up daily supervisor if the relation with the local supervisor is problematic. In particular, for all projects performed outside the university, the role of the mentor is even more important. There are usually weekly contacts between the mentor and the student. The panel appreciates this mentoring system. The mentors have an important part to play in safeguarding the quality of the bachelor's thesis. They assess several bachelor's theses each year, enabling them to compare the quality of different theses. Yet the panel also observed a weakness. As a supervisor in a small-scale programme, the mentor usually builds up a relationship with the student. Both the first (mentor) and second assessor (the daily supervisor) are involved with the students on a personal level. The panel wants to point out that this weakens the procedure from a quality assurance point of view, as both assessors consult the student during the process. It also remarked that the mentors are not united in some kind of a formal body. They sometimes consult each other, but this happens occasionally and only on an informal basis. Although the panel does not have any indication that the reliability of the thesis assessment is currently under pressure, it is of the opinion that the thesis quality assurance could be further strengthened. It advises the programme to reflect on this, and to consider incorporating additional measures such as stimulating calibration sessions (formal) among the mentors, and/or separating the mentoring and thesis assessor role for external thesis projects.

With respect to the bachelor's project assessment form, the panel noted that the documentation provided to the panel included the form used in the current BME major. This form is not in line with the intended integration of design and research in the new programme. As explained by the staff, the new form is still being designed. It will be based on the master's BME thesis assessment form with separate categories for practical work, written report and oral presentation. In order to pass, all three categories must be assessed with a minimum of 5.5. A rubric will be developed to elaborate the assessment criteria further. The panel supports these developments. It emphasizes the importance of an assessment form that does justice to the focus on the integration of research and design. The rubric could be an important instrument in enlarging the assessment transparency and reliability. It could also be a useful tool for further calibration of the assessments.

In the BME major's assessment forms that the panel studied as part of the assessment of the programme's realized learning outcomes (see Standard 4), it noted that the correspondence between the scores for criteria (indicated with crosses) and the final grade is not very clear. In addition, the completed assessment forms contained little to no written clarification, affecting the transparency of the assessments. The panel recommends taking these points into account during the development of the new assessment forms.

Board of Examiners
The self-evaluation report states that the Board of Examiners is responsible for the quality of examinations and degree certificates. The new bachelor's programme intends to have a dedicated Board of Examiners, as is customary for programmes within the faculty. The board is appointed by the Faculty Board. Detailed descriptions of the Board of Examiners' specific duties and all legally assigned duties and powers are determined in the protocol for Boards of Examiners and the rules and regulations. The Board, for example, is responsible for the quality control of testing and examinations. It appoints examiners, handles individual cases of fraud and individual requests from students, awards degree certificates and the accompanying diploma supplements, grants exemptions and handles appeals and/or complaints about exams. The Board draws up an annual report of activities and advises the Faculty Board on the Teaching and Examination Regulations.

The board of the bachelor's programme still has to be formally established. During the site visit, the committee spoke with representatives of the BME master's programme Board of Examiners, since the Board for the bachelor's programme will originate from this Board, with several members joining both. The proposed chair for the bachelor's Board was present during this interview. The panel emphasised the importance of a strong, independent and proactive Board of Examiners in the development of a new programme. It would like to advise the forthcoming Board to be actively involved in the design and quality assurance of the programme's assessment system.

Considerations
The panel is satisfied with the assessment and evaluation system of the bachelor's programme BME. The formal regulations are clearly set out in the draft Teaching and Examination Regulations and the Rules and Guidelines for Boards of Examiners. It appreciated the various measures that will be implemented to promote the reliability, validity and clarity of assessment, such as the overall assessment programme, the CUAOs and the peer-review principle. The Board of Examiners still has to be formally established. There will be an overlap with the Board of Examiners of the master´s programme BME. The panel would like to see a strong, active and committed Board as there are several challenges in the further development of a new programme.

The panel approved the types of assessment proposed. They are sufficiently varied and suit the content and design of the programme. The thesis evaluation procedure is adequate. There are always two supervisors involved, one of the eight mentors and the daily project supervisor, whereby the mentors play an important role in safeguarding the quality of the bachelor's thesis. However, the panel noted some weaknesses in this system with regard to the independence of the assessments, such as the strong involvement of mentors in supervising students during their theses. It advises elaborating measures to further strengthen the quality assurance of the thesis assessments, for example by promoting calibration sessions among the mentors. With respect to the thesis assessment form, the panel ascertained that it is still being designed. It agreed with the intention to base the form on that of the master´s programme BME, which fits well with the intended integration of design and research. It is also positive about the plan to develop a rubric for the thesis evaluation, as this can have a positive effect on increasing the transparency and reliability of the assessment. It concluded that the completed assessment forms could become more transparent, particularly with regard to the scores for criteria in relation to the final mark and the written clarification. It recommends that these points be taken into account in the further development of the new assessment form.

Conclusion
Bachelor's programme Biomedical Engineering: the panel assesses Standard 3 as ' Meets the standard'.

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings
Since this is a new programme, there were no graduates at the time of the site visit. In addition, there were no final bachelor's theses which could be used to determine the achievement of the intended learning outcomes. Therefore, the panel studied a representative selection of fifteen theses of the current BME major of the bachelor's programme Life Science and Technology. These theses provided insight into the realization of the intended learning outcomes of the BME major but not necessarily into the realization of the learning outcomes of the new bachelor's programme. In other words, the theses of the BME major are not definite proof of the final level of the new independent bachelor's programme. However, given the fact that the new programme is actually a further development of the current major, the panel decided to review the theses and the accompanying assessment forms completed by the supervisors with the aim of sharing possible observations and

possibly making suggestions and recommendations where relevant. These could be included in the further design of the new independent bachelor's programme.

The panel concluded that the theses meet the expectation of a final project on the bachelor's level. In general, it agreed with the grades awarded by the supervisors. The grading seemed fair and reflected the differences in the students' work. Yet, the panel also observed that the theses differed considerably in terms of design, content, structure and language, which makes it difficult to compare them. Furthermore, it ascertained that all theses do not necessarily cover the same intended learning outcomes. For instance, a practical component is not included as a compulsory part of the theses. Some theses do include a practical elaboration (e.g. software testing), while others are limited to a literature review. Although the associated intended learning outcomes are assessed elsewhere in the programme, the panel considers this difference undesirable for an academic engineering programme, and advices the programme to harmonize this.

During the site visit, the panel spoke with staff members about this perceived dichotomy between research and design in the theses. It learned that BME major students were allowed to do a research-oriented or a design-oriented project. In the former case, the project was a literature review. In the latter case, the student was expected to write a thesis report including the design-analysis phase (e.g. problem definition, aim of the product, design requirements), results and conclusions. The management emphasized that this dichotomy will be removed from the new programme. One of the measures that will be taken is not allowing students to perform literature studies without a practical component. The panel strongly supports this vision, since design and research are strongly intertwined in the field of biomedical engineering. It advises to pay attention to a clear dissemination of the adjusted graduation conditions and criteria.

Considerations
Since no graduates of the new bachelor´s programme BME were available at the time of the site visit, the panel was only able to judge the achieved intended learning outcomes using the current BME major, which cannot be a definitive proof of the new programme's final level. With the aim of generating recommendations for the new programme, it decided to study several theses from the current BME major. It concluded that all theses are of an adequate bachelor's level, but do not clearly reflect the intended integration of research and design. It advises carefully designing and implementing the new thesis guidelines.

Conclusion
Bachelor's programme Biomedical Engineering: the panel assesses Standard 4 as ' Meets the standard'.

GENERAL CONCLUSION

The panel found that the intended learning outcomes (standard 1), teaching-learning environment (standard 2), student assessment (standard 3) and the achieved learning outcomes (standard 4) meet the criteria. Therefore, it concluded that the quality of the new bachelor's programme Biomedical Engineering is positive.

The panel gives the new programme the following recommendations:

Standard 1: learning outcomes
- The intended integration of design and research should be reflected more clearly in the programme's aims and learning outcomes.
- Adjust the learning outcomes in order to differentiate them from the master's programme BME and to better reflect the bachelor's level.
- Change the term 'biomedical engineer' into 'bachelor of science in biomedical engineering'.

Standard 2: teaching-learning environment

- Elaborate on the relationship between the learning outcomes and the programme components by clearly marking which parts of the learning outcomes will be addressed and where and on what level of performance.
- Pay attention to the balance of and integration between research and design.
- Clearly mark the different learning paths in the programme, including research and design.
- Pay attention to the scheduling of lectures and working groups and the low attendance of students during classes.
- Explore ways to make the teaching more active and to improve student interaction.
- Resolve the discomfort students experience due to the absence of a UMCG pass.

Standard 3: student assessment

- Elaborate on measures to further strengthen the quality assurance of the thesis assessments.

Standard 4: achieved learning outcomes

- Stimulate students to integrate research and design in their final Bachelor's project by carefully developing and implementing new thesis guidelines and assessment forms.
- Pay attention to the transparency of completed assessment forms, particularly regarding the scores for criteria in relation to the final mark and the written clarification.
- Harmonize the design and content of the theses.

Conclusion

The panel assesses the *bachelor's programme Biomedical Engineering* as 'Positive'.

The panel recommends that the following degree be awarded to the programme: bachelor of science.

It advises the following CROHO category: Techniek.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

A. Domain specific requirements for level and orientation of graduates

Biomedical Engineering (BME) is an engineering discipline focused at the interface of engineering and life sciences. BME education should include basic general engineering requirements (as for example indicated by ABET) and a thorough understanding of life sciences.

BME programs must demonstrate that their students attain, according to the shared Dublin descriptors:

Knowledge and understanding:

- Knowledge of the basic disciplines mathematics, sciences, and engineering (mechanical, electrical, and chemical engineering and applied physics) to be applied in the field of Biomedical Engineering in a broader sense; i.e. including directly adjacent fields.
- Knowledge and understanding of concepts of physiology, (cell-) biology, anatomy, biochemistry, pharmacology and pathology as applicable in the field of Biomedical Engineering.

Applying knowledge and understanding:

- The capability to apply and integrate advanced mathematics, sciences, and engineering to model and solve complex biomedical problems (see also d).

Making judgments:

- An ability to conduct scientific research in areas of biomedical engineering and technology that are relevant to the advancement of knowledge and insight into fundamental and applied aspects of health and disease.
- An ability to make measurements on and interpret data from living systems, addressing problems associated with the interaction between living and non-living materials and systems.
- An ability to translate a clinical or health-relevant problem or question into an experiment, system, component, or process (design) to meet desired needs and, governed by scientific research or modeling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

Communication:

a. A capability to bridge the gap between fundamental and applied research in biomedical engineering and medical (life) sciences by:
  - Demonstrating an ability to communicate effectively in written and verbal form, and
  - Collaboration in a multidisciplinary setting, which may include clinicians, other healthcare workers and industrialists alike.

b. An awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of his/her research.

Learning skills:

- An ability to develop new concepts within the field of BME.
- An ability to study international scientific research.
- Recognition of the need for, and an ability to engage in life-long learning.

B. Domain specific requirements of the BSc (Cycle 1) and MSc (Cycle 2) programs

The Bachelor's program focuses on general knowledge, based on advanced textbooks and including some aspects informed by knowledge of the forefront of their BME specialization, basic skills and solving recognizable problems.

The Master's program focuses on deepening theoretical knowledge in one or more specific parts of Biomedical Engineering and provides ample experience in setting up, executing and reporting research and design. It leads to an attitude of scientific involvement.

BSc students acquire
Knowledge and understanding in:

- Basic beta disciplines: mathematics, sciences, and engineering (mechanical, electrical, and chemical engineering and applied physics) to be applied in the field of Biomedical Engineering in a broader sense; i.e. including directly adjacent fields.
- Life sciences: physiology, (cell-) biology, anatomy, biochemistry, pharmacology and pathology as applicable in the field of Biomedical Engineering.

BSc students learn to
Apply knowledge and understanding:

a. Of mathematics, sciences and engineering to model and solve simple biomedical problems.

Make judgments:

- Involving the making of measurements on and the interpretation of simple data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems at a basic level.
- Involving the ability to translate simple clinical or health-relevant problems or questions into an experiment, system, component, or process to meet desired needs and, governed by scientific research or modeling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

h. By demonstrating an awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of his/her research.

Communicate:

e. By bridging the gap between fundamental and applied research in biomedical engineering and medical (life) sciences by:

- Demonstrating an ability to communicate effectively in Dutch in written and verbal form, and
- Collaboration in a multidisciplinary setting.

BSc students acquire
Learning skills:

f. As demonstrated in their recognition of the need for, and an ability to engage in lifelong learning at the BSc+ level with a high level of autonomy.

MSc students acquire
Knowledge and understanding:

a. Of in depth biomedical engineering, in a coherent set of specialties, that builds on the basic knowledge acquired in the Bachelor's phase, and that provides a basis or opportunity for originality in developing or applying ideas in this specialization.

MSc students learn to
Apply knowledge and understanding:

a. In order to apply and integrate advanced mathematics, sciences and engineering knowledge as well as specialized knowledge to model and solve complex biomedical problems in new and unfamiliar environments.

Making judgments:

b. In an ability to conduct scientific research in areas of biomedical engineering and technology that are relevant to the advancement of knowledge and insight into fundamental and applied aspects of health and disease.

- An ability to make measurements on and interpret complex data from living systems, addressing the complex problems associated with the interaction between living and non-living materials and systems, and the ability to successfully recognize and address new problems in this field.
- An ability to translate a complex, not well-defined, clinical or health-relevant problem or question into an experiment, system, component, or process to meet desired needs and, governed by scientific research or modelling, to advise in issues like clinical research in biomedical engineering, diagnosis and therapy.

Communicate:

c. With a capability to bridge the gap between complex fundamental and applied research in biomedical engineering and medical (life) sciences by

- Demonstrating the ability to communicate effectively in written and verbal form in Dutch and English, by underpinning knowledge and rationale (restricted scope) to specialist and non-specialist audiences alike, and
- Collaboration in a multidisciplinary setting, which may include clinicians, other healthcare workers and industrialists alike.

d. An awareness of potential societal and ethical implications of scientific research in Biomedical Engineering and, in this context, an ability to critically evaluate the effects of the research carried out under his/her responsibility.

Learning skills

e. An ability to study international scientific research.

f. Recognition of the need for, and an ability to engage in life-long learning at MSc+ level in a manner that may be largely self-directed or autonomous.

C. Description of derivation process of sections A and B

The formulation of the Domain specific requirements have taking into account our mutual aims, requirements, and experiences from other sources. In the past, representatives of the programs participate in international discussions on BME education and accreditation (Europe: the BIOMEDEA project [project leaders: [redacted], [redacted], and [redacted]] under the auspices of EAMBES, the European Alliance of Biomedical Engineering and Science; USA: Whitaker BEES I (2000) and BEES II (2005) summit on BME education and accreditation in Lansdowne, Virginia.

The derivation process included the following steps:

- Comparison with standards derived by the academic BME community
    - Netherlands: compilation of the aims of the BME programs, which were based on international surveys (see below). In-line with basic requirements of engineering programs such as Mechanical Engineering, Applied Physics, etc.
    - Europe
        - European BME programs did not serve as reference, since no fully integrated Bachelor/Master's programs were available at the time.
        - EAMBES
            - IFMBE White paper on harmonization and accreditation of European BME programs,
            - BIOMEDEA conferences, papers and discussions
    - USA
        - The IFMBE-White paper
        - Whitaker Foundation:
            - Information on website
            - First and second BEES summit
        - and personal contacts from:
            - Duke University, Durham
            - Marquette University, Milwaukee
            - Northwestern, Evanston
            - University of Illinois, Chicago
            - Case Western Reserve University, Cleveland
            - Rensselaer Polytechnic institute, Troy
            - Massachusetts Institute of Technology, Boston
            - University of Pennsylvania, Philadelphia
            - Drexel University, Philadelphia
            - Johns Hopkins University, Baltimore
            - University of Utah, Salt Lake City

- Comparison with standards of independent bodies

- NL: BME degree program standards were not available. KIVI, the Dutch engineering alumni association has set up a BME branch, but standards for BME still have to be prepared.

- Europe
    - EAMBES-BIOMEDEA: The process of harmonization of accreditation is ongoing. We are actively participating.
    - EURACE: the European Accreditation of Engineers is active in preparing evaluation standards of engineering programs in Europe. The process is rather similar to that of QANU. However, they formulated no BME standards.
- USA
    - ABET: Accreditation Board of Engineering and Technology. ABET has general engineering standards and specific standards for BME.

- Field of employment
  - NL: no representation yet. Each program has its own External Advisory Board or is setting it up. We used their input. The BME-branch of the Royal Institute of Engineers (KIVI/NIRIA) is active in the field of employment.

It is interesting to note that the BME student societies SvBMT Protagoras (TU/e), Idun (RUG) and Paradoks (UT) are actively seeking contacts with the field of employment.

- Europe: ESEM.
- USA: BMES, lead society for BME in ABET. BMES formulates the specific BMES standards for ABET.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Learning outcomes of the bachelor's programme Biomedical Engineering

A graduate with a Bachelor of Science in BME can:

1. Acquire expertise in Biomedical Engineering

A Biomedical Engineer is able to continuously improve his/her expertise (knowledge and competences) by building on his/her thorough mastery of a specific field of biomedical engineering. This is demonstrated, not only by the Biomedical Engineer's ability to develop and apply new knowledge based on a self-evaluation report on standard knowledge, but more so by increasing or adapting his/her competences by critically and independently reflecting on his/her own thinking, decision making, and acting.

2. Analyse the problem and define aim

A Biomedical Engineer is able to analyse biomedical problems by (re)formulating ill-structured biomedical problems of a complex nature by choosing the appropriate level of abstraction and by critically examining existing theories, models or interpretations, based on the assessment of the scientific value of current research within Biomedical Engineering. The Biomedical Engineer thereby creates a cause-effect model, distinguishes the problems that are fundamental and solvable and defines the aim which has the highest priority.

3. Create a R&D proposal

A Biomedical Engineer is able to design different strategies to obtain the defined aim, and has the skills in, and the affinity with, the use, development and validation of models to allow the Biomedical Engineer to consciously choose the most efficient and effective R&D plan.

4. Execute the R&D plan

A Biomedical Engineer is able to execute a R&D plan and to adapt it when external circumstances or advancing insight requires it. Depending on the project the focus may be more on the scientific approach to increase knowledge and understanding (research) or on the design of new techniques or systems (development) although both aspects are essential in the R&D cycle of innovative products

5. Analyse and interpret the data

A Biomedical Engineer is able to ask adequate questions, and has a critical, yet constructive attitude towards analysing and solving complex real-life biomedical problems. The Biomedical Engineer is able to form a well-reasoned opinion in the case of incomplete or irrelevant data; is able to analyse and interpret the results of R&D in terms of statistics, limitations and the relation to existing literature aiming to contribute to the advancement of knowledge in his or her field of Biomedical Engineering and beyond it.

6. Communicate results

A Biomedical Engineer, as an interdisciplinary specialist, is able to communicate orally and in writing about R&D with colleagues, non-colleagues and other involved parties including health care providers and patients. In addition, the Biomedical Engineer is able to debate about both Biomedical Engineering and the place of Biomedical Engineering in society.

7. Embed the results in scientific and social context

A Biomedical Engineer is able to analyse and to discuss the social consequences (economic, social, cultural) of new developments in Biomedical Engineering with colleagues and non-colleagues; has insight into (debates about) scientific practice and is able to analyse and to discuss the ethical and the normative aspects of the consequences and assumptions of the scientific practice with colleagues and non-colleagues and is able to integrate these ethical and normative aspects in its own work.

8. Demonstrate a professional attitude

A Biomedical Engineer is able to incorporate the knowledge, skills and competences described above and demonstrates a professional attitude by showing a high level of independence, responsibility and commitment. In addition the Biomedical Engineer shows social skills as well as the ability to improve after feedback.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Year 1 BME Bachelor's programme curriculum

Year 1			
1A	**1B**	**2A**	**2B**
Design of biomedical products 1	Microbiology	Medical technology and society	Biomechanics
Basic molecular and cell biology	Practicum incl VMT	Molecules of life	Anatomy & histology
Physiology	Biostatistics	Mathematics for Life Sciences	Material Science
Legend			
Engineering	Medical/biological	Physics/Mathematics	Research

Year 2 BME Bachelor's programme curriculum

Year 2			
1A	**1B**	**2A**	**2B**
Technical drawing, Solid Works	Design of biomedical products 2	Medical implants	Transport in biological systems
Imaging Techniques in Radiology 1	Thermodynamics	Biomedical instrumentation	Programming for Life Sciences (Python)
Biomaterials 1	Biological evaluation of implants	Regenerative medicine	Practicum Chemistry for BME
Legend			
Engineering	Medical/biological	Physics/Mathematics	Research

BME Bachelor's programme curriculum

Year 3			
1A	**1B**	**2A**	**2B**
MINOR	Signals and Systems for IEM and BMT	System Dynamics	Bachelor research and design project
	Electronics	Research course BME	
	Numerical methods		
	Waves & Optics		
Legend			
Engineering	Medical/biological	Physics/Mathematics	Research

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Sunday 4 November 2018

18.00 – 19.30	Discussing initial findings

Monday 5 November 2018

09.00 - 09.15	Arrival
09.15 - 09.45	Panel preparation
09.45 - 10.45	Interview management bachelor & master (incl. short presentation)
10.45 - 11.00	Break
11.00 - 11.45	Interview students bachelor
11.45 – 12.00	Break
12.00 - 12.45	Interview staff bachelor
12.45 - 13.30	Lunch break
13.30 - 14.15	Interview Board of Examiners bachelor & master (incl. chair current bachelor's BoE)
14.15 – 14.30	Break
14.15 - 15.00	Interview Programme Committees (incl. chair current bachelor's PC)
15.00 – 15.15	Break
15.15 – 16.00	Interview management bachelor
16.00 - 17.15	Concluding session bachelor's programme
17.15 - 17.45	Interview professional field and alumni master
17.45 – 18.00	Finalizing conclusion bachelor's programme

Tuesday 6 November 2018

09.00 - 09.45	Arrival, preparation panel
09.45 - 10.30	Interview students master
10.30 – 10.45	Break
10.45 - 11.30	Interview staff master
11.30 - 11.45	Break
11.45 - 12.15	Student demonstrations
12.15 - 13.30	Lunch / internal session
13.30 - 14.15	Interview management master programme
14.15 - 15.15	Concluding session master's programme
15.15 - 15.30	Oral presentation panel's findings (open)
15.30 - 15.45	Break
15.45 - 16.30	Development dialogue
16.30 - 16.45	Wrap up

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied fifteen theses of the major Biomedical Engineering of the bachelor's programme Life Science and Technology. Information on the selected theses is available from QANU upon request.

During the site visit, the panel studied, among other things, the following documents (partly as hard copies, partly via the institute's electronic learning environment):

Folders on the following BME Bachelor courses:
- Anatomy and Histology
- Basic Cell and Molecular Biology
- Biological Implant Evaluation
- Designing biomedical products 1
- Designing biomedical products 2
- Biomaterials 1
- Biomechanics
- Biomedical Instrumentation
- Biostatistics
- Electronics
- Imaging Techniques in Radiology 1
- Practicum incl VMT
- Material Science
- Mathematics for Life Sciences
- Medical Implants
- Medical Technology and Society
- Microbiology
- Molecules of Life
- Numerical Methods
- Physiology
- Practicum Chemistry for BME
- Programming for Life Sciences
- Regenerative Medicine
- Signals and Systems
- System Dynamics
- Technical drawing, Solid Works
- Thermodynamics
- Transport in Biological Systems
- Wave and Optics
- Research course BME
- Bachelor research and design project

Additional materials:
- Education monitor
    - o MSc Biomedical Engineering 2016
    - o Faculty of Science and Engineering (FSE) 2018
    - o Faculty of Science and Engineering (FSE) 2017
- Education Primer
- Teaching and Examination Regulations (Faculty wide part):
    - o Bachelor's degree programmes FSE 2018-2019
    - o Master's degree programmes FSE 2017-2018
    - o Master's degree programmes FSE 2018-2019
- Appendices Teaching and Examination Regulations (programme specific parts):

    - Master’s degree programme Biomedical Engineering 2017-2018
    - Master’s degree programme Biomedical Engineering 2018-2019
    - Proposed new Bachelor’s degree programme Biomedical Engineering
- Assessment plan MSc Biomedical Engineering 2017-2018
- Programme Committee Handbook UG 2017-2018
- Quality Assurance documents for Boards of Examiners FSE
    - Protocol for the duties and powers
    - Quality Assurance Guide
    - Rules and Regulations Board of Examiners
- Quality Assurance Manual for Teaching Staff
- Quality Assurance Manual FSE 2016-2017
- Annual Reports Board of Examiners MSc Biomedical Engineering
- Annual Reports Programme Committee MSc Biomedical Engineering
- Annual Reports Admissions Board MSc Biomedical Engineering
- FSE Manual for quality assurance of education
- Minutes of the Curriculum Committee 2017
- Scores National Student Survey (2017)
- Letters External Advisory Panel
- Guidelines Industrial Internship MSc Biomedical Engineering
- Guidelines Master’s Project MSc Biomedical Engineering
- Scores Master Keuzegids 2018