BACHELOR'S PROGRAMME

MECHANICAL ENGINEERING

FACULTY OF ENGINEERING TECHNOLOGY

UNIVERSITY OF TWENTE

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This report was finalized on 26 March 2019.

REPORT ON THE BACHELOR'S PROGRAMME MECHANICAL ENGINEERING OF UNIVERSITY OF TWENTE

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

ADMINISTRATIVE DATA REGARDING THE PROGRAMME

Bachelor's programme Mechanical Engineering

Name of the programme:	Mechanical Engineering
CROHO number:	56966
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specializations or tracks:	-
Location(s):	Enschede
Mode(s) of study:	full time
Language of instruction:	English
Expiration of accreditation:	31/12/2019

The visit of the assessment panel Mechanical Engineering to the Faculty of Engineering Technology of the University of Twente took place on 10 December 2018.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 20 August 2018. The panel that assessed the bachelor's programme Mechanical Engineering consisted of:

- Prof. K.G.S. (Sören) Östlund, professor of Packaging Technology at the Department of Solid Mechanics of the KTH Royal Institute of Technology (Sweden) [chair];
- Prof. H.J. (Henry) Rice, professor in Mechanical Engineering and head of the School of Engineering, Trinity College, Dublin (Ireland);
- Dr. M. (Maddalena) Velonà, coordinator of studies at the Department of Mechanical and Process Engineering (D-MAVT) at Eidgenössische Technische Hochschule (ETH) Zürich (Switzerland);
- Drs. J.J. (Jan) Steen, consultant Quality of Education at Wageningen University & Research;
- Ir. S. (Sytze) Spijksma, groupleader Mechanical & Industrial Design Engineering at DEMCON Advanced Mechatronics B.V;
- M.M.E. (Maartje) Borst, bachelor's student Mechanical Engineering Eindhoven University of Technology [student member].

The panel was supported by dr. B.M. (Barbara) van Balen, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's programme Mechanical Engineering at the Faculty of Engineering Technology of the University of Twente was part of the cluster assessment Mechanical Engineering. In December 2018 the panel assessed eleven programmes at three universities. The following universities participated in this cluster assessment: Delft University of Technology, Eindhoven University of Technology and the University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. Dr. Alexandra Paffen was project coordinator for QANU. Dr. Barbara van Balen acted as secretary in the cluster assessment. She is a certified NVAO secretary.

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

Preparation
On 9 December 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 9 December 2018. During this meeting, the panel members received instruction on the use of the assessment frameworks. The panel also discussed their 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 Twente, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair and the project coordinator. The selection existed of fifteen theses and their assessment forms for the programmes, based on a provided list of graduates 2017-2018. A variety of topics and tracks and a diversity of examiners were included in the selection. The project coordinator and panel chair assured 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 these amongst all panel members.

At the start of the site visit, the panel discussed its initial findings on the self-evaluation reports and the theses, as well as the division of tasks during the site visit.

Site visit
The site visit to the University of Twente took place on 10 December 2018. 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.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, the following measures were taken:

1. The panel composition ensured regular attendance of (key) panel members, including the chair;
2. The secretary was present at the panel discussion leading to the preliminary findings at all site visits of Delft University of Technology, Eindhoven University of Technology and the University of Twente.

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 these checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty and University Board.

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of both the standards and the programme as a whole.

Generic quality
The quality that, in an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Unsatisfactory
The programme does not meet the generic quality standard and shows shortcomings with respect to multiple aspects of the standard.

Satisfactory
The programme meets the generic quality standard across its entire spectrum.

Good
The programme systematically surpasses the generic quality standard.

Excellent
The programme systematically well surpasses the generic quality standard and is regarded as an international example.

SUMMARY JUDGEMENT

Standard 1
The bachelor's programme of Mechanical Engineering is provided by the Faculty of Engineering Technology, one of the five faculties of the University of Twente. Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems and processes that accomplish a desired objective in a safe, ethical and sustainable fashion. The overall learning goals cover science (mathematics, physics and thermodynamics), engineering (materials, solid and fluid mechanics, dynamics), and design (specifications, synthesis, modelling and optimisation, manufacturing, evaluation). The panel appreciates that the programme integrates fundamental disciplines with practice and theory with engineering tools. The intended learning outcomes are formulated in line with this vision and indicate sufficiently what could be expected from programmes at a bachelor's level.

The panel concluded that the intended learning outcomes meet the Dutch qualifications framework and tie in with the international perspective of the requirements set by the professional field and the discipline. It feels, however, that the intended learning outcomes are formulated on a rather general level and could be more specific.

Standard 2
The bachelor's programme has a duration of three years and is designed according to the Twente Education Model (TOM). TOM is based on thematic modular project education, student-driven learning (SDL) and a focus on three professional roles: researcher, designer and organiser. The programme contains 12 thematic modules of 15 EC. The themes are based on the engineering disciplines: mechanics, fluid mechanics, heat transfer, energy, systems and control, dynamic systems, design and construction. Most modules contain a project and courses aimed at content knowledge and skills. A skills learning path and several content learning paths run throughout the modules and connect to the projects. At the end of the third year, students perform an individual research assignment in one of the research groups of the Department to apply the knowledge gained during their bachelor's programme.

The programme deploys a mix of teaching methods in line with the educational principles of TOM, such as lectures, tutorials, practicals, a combination of lectures and tutorials, tutor sessions, guided self-study and independent self-study.

The panel finds the alignment between the intended learning outcomes and the curriculum to be very good. It is very positive about TOM and the project-based learning that structures the curriculum. Coherence in the programme is enhanced by the modules and the skills and content learning lines. In general, the programme is very well-organized, taking the student's learning of both disciplines and skills seriously. The panel finds it positive that the teaching staff is involved in the mentor system in the first year. Although the percentage of students who graduate on time is still rather low, the panel is convinced that the programme is viable.
The quantity and the quality of the teaching staff are good. The panel likes the direct working relation between staff and students and the clear open door policy. It commends the management's endeavours to preserve the ethos of personal contact with students despite growing student numbers.

Standard 3
The programme has an adequate quality assurance system. The assessment policy is very well documented and transparent. There are procedures in place to assure the validity and reliability of the tests. The Examination Board is adequately performing its legal duties and responsibilities. The panel was impressed by the strong involvement of the Board in the assurance of the assessment quality.

Standard 4
The panel studied a selection of 15 bachelor graduation assignments to assess whether the graduates had achieved the intended learning outcomes. Almost all bachelor graduates proceed to a master's programme and are well prepared for this. The panel found the level of the bachelor assignments to be good and, in particular, liked the societal reflection included.

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

Bachelor's programme Mechanical Engineering

Standard 1: Intended learning outcomes	satisfactory
Standard 2: Teaching-learning environment	good
Standard 3: Student assessment	good
Standard 4: Achieved learning outcomes	good
General conclusion	good

The chair, prof. Sören Östlund, and the secretary of the panel, dr. Barbara van Balen, 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.

Date: 26 March 2019

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

General remarks cluster Mechanical Engineering

This report constitutes part of the limited programme assessment of the NVAO Assessment cluster Mechanical Engineering representing 11 bachelor and masters programmes in Mechanical Engineering, Automotive Technology, Marine Technology, Offshore and Dredging and Materials Science and Engineering at University of Twente, Eindhoven University of Technology and Delft University of Technology. The findings for each programme are based on the self-evaluations performed by each programme and site visits taking place on December 10-14, 2018.

In the self-evaluation reports and during the site visits, the evaluation panel has encountered many knowledgeable and dedicated programme managers, skilled and engaged teachers, well-educated and enthusiastic students and successful alumni. It is therefore with great pleasure that we can conclude that the overall outcome of the evaluation panel ends on a positive note.

All programmes are based on intended learning outcomes well set in national or international perspective of the requirements currently set by the professional field and the discipline, programme managers, teachers and students work hard to create a motivating and dynamic teaching and learning environment, all programmes have elaborated assessment plans and the achieved learning outcomes are good. Many of the theses read by the evaluation panel are indeed of very high quality, and graduates from the eleven programmes in general have very good career opportunities.

There is of course always room for improvements, and, particularly, the processes around internships, the overall study times and the high dropout rates are areas that should be given continued high attention. The increased internationalisation of the programmes, the growth in number of students and the level of the students are other challenges that needs consideration in the coming years. However, it is the opinion of the assessment panel that the programmes in the Assessment cluster Mechanical Engineering are well prepared to meet these.

On behalf of the Mechanical Engineering Assessment Panel,
Sören Östlund (Chair)

Governance structure of the Faculty

The bachelor's and master's programmes of Mechanical Engineering are embedded in the Faculty of Engineering Technology, one of the five faculties of the University of Twente. The Faculty is managed by the Faculty Board, consisting of the dean, the vice-dean of education, the vice-dean of research, the portfolio holder of operations and a student-assessor. The Mechanical Engineering programmes are managed by a programme director, supported by a bachelor coordinator and a master coordinator. The Faculty of Engineering is organised into five departments: Biomechanical Engineering (BE), Design, Production and Management (DPM), Mechanics of Solids, Surfaces and Systems (MS3), Thermal and Fluid Engineering (TFE) and Civil Engineering (CE). These departments are responsible for research and education. With the exception of the Civil Engineering department, all departments are involved in teaching the Mechanical Engineering programmes. This report concerns the assessment of the bachelor's programme Mechanical Engineering; the assessment of the master's programme is described in a separate report.

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
Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems and processes that accomplish a desired objective in a safe, ethical and sustainable fashion. Modern mechanical engineering is characterised by increasing multi-disciplinarity, i.e. overlap with life sciences, electrical and chemical engineering. The collaborating technical universities[1] in the Netherlands as well as ABET[2], OECD[3], and ASME[4] agreed that the overall learning goals of mechanical engineering programmes should cover science (mathematics, physics and thermodynamics), engineering (materials, solid and fluid mechanics, dynamics), and design (specifications, synthesis, modelling and optimisation, manufacturing, evaluation). The bachelor's degree programme Mechanical Engineering of the University of Twente (UTwente) uses the conceptual framework of the tuning-AHELO in engineering (Assessment of Learning Outcomes in Higher Education) of the OECD as the basis of the intended learning outcomes of the programme. The intended learning outcomes (ILOs) of the bachelor's programme are organised according to mechanical engineering competences and academic, professional and regulatory competences.

In the self-evaluation report and during the site visit, the programme management expressed its ambition to integrate fundamental disciplines with practice and theory with engineering tools, which is much appreciated by the panel. The ILOs are formulated in line with this ambition and sufficiently indicate what could be expected from programmes at a bachelor's level. The programme conducted interviews with professionals in the field to evaluate the ILOs. The results of the alumni survey were also used for this evaluation. Its conclusion is that the ILOs are still up to date and consistent with the demands of industry. The panel also ascertained that they meet the internationally accepted description for academic bachelor's programmes, the Dublin descriptors, which are elaborated for the engineering programmes into the 4TU (Meijers) criteria[5]. The ILOs are in line with the ABET, OECD and ASME requirements. However, the panel thinks that they are formulated on a rather general level, and give limited information about the domain. The panel recommends specifying them for the mechanical engineering programme.

The programme has an Industrial Advisory Board consisting of representatives from industry (e.g. Apollo Tyres, Philips, Tata Steel, Thales and Demcon). This Board meets with representatives from the mechanical engineering programmes twice a year to exchange ideas and give advice on educational as well as research-related matters. Consultation of the professional field is organised.

Considerations
The panel concluded that the intended learning outcomes meet the Dutch qualifications framework. They sufficiently reflect the academic bachelor's level. The alignment with the ABET, OECD and ASME requirements demonstrates that they tie in with the international perspective of the requirements set by the professional field and the discipline.

The panel thinks that the intended learning outcomes could be phrased more specifically to the domain of mechanical engineering; thus, they would give even more direction to the construction of the courses and the curriculum. They are specific enough to fulfil the requirements for standard 1, though.

[1] University of Technology Delft, University of Technology Eindhoven, Twente University and Wageningen University.
[2] ABET – Criteria for accrediting engineering programs
[3] OECD – tuning –AHELO conceptual framework of expected/desired learning outcomes in engineering
[4] ASME – An Environmental Scan for ASME and the Global Summit on the Future of Mechanical Engineering.
[5] https://www.ram.ewi.utwente.nl/embedded2017/doc/Meijers_summarised.pdf

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 1 as satisfactory.

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
The curriculum
The bachelor's programme is designed according to TOM (Dutch abbreviation of Twente Onderwijs Model): the Twente Education Model. TOM is based on thematic modular project education, student-driven learning (SDL) and a focus on three professional roles: researcher, designer and organiser. A skills learning path as well as several content learning paths are integrated in the curriculum. SDL can be described as the curricular foundation that supports and encourages students to develop self-determination and the 'willpower' to steer their own academic progress. It allows students to take control and regulate their learning, and to adapt their behaviour to correspond to their chosen goals and values.

The aim of the bachelor's programme is to provide the student with the basics and a broad view of the field in Mechanical Engineering. The programme has a duration of three years and is divided into 12 thematic modules of 15 EC each. The themes are based on the engineering disciplines: mechanics, fluid mechanics, heat transfer, energy, systems and control, dynamic systems, design and construction. Each module (with the exception of the minor and the bachelor's thesis) contains a project and courses aimed at content knowledge and skills. The first year has a selective function and is shared by all students. This is reflected by the fact that the four modules of the first year together provide the students with a broad introduction, allowing them to decide early on if mechanical engineering matches their interests and intellectual abilities. The main part of the second year is also shared by all students, as nearly all subjects are compulsory.

The third year allows for differentiation depending on the student's interests. Students choose a broadening (in a different discipline) or deepening (in a specific area of mechanical engineering) minor programme of 30 EC. The minor can also be followed abroad, as an exchange programme at another university. Students can choose to devote one of the minor modules to a large project such as the Solar Team Twente or the Green Team. To finalise their bachelor's programme, students carry out a bachelor assignment during the last two modules. They choose a research problem from one of the research chairs involved in the programme and go through the entire research cycle.

A skills learning path runs throughout the modules and is connected to the projects. Furthermore, several content learning paths have been integrated in the curriculum, e.g. the design learning path. Research is integrated in the modules, scientific papers are used as course material, and research is part of the projects. During the analysis phase of a project, students perform a literature review as input for their design.

The programme deploys a mix of teaching methods in line with the educational principles of TOM, such as lectures, tutorials, practicals, a combination of lectures and tutorials, tutor sessions, guided self-study and independent self-study. In the first year of the bachelor's programme, 782 contact hours are scheduled. The policy is that self-governing increases during the course of the bachelor's programme; hence the plenary contact hours in the first year decline to individual consulting hours at the student's request by the end of the programme.

The panel studied the overview of the curriculum provided in the self-evaluation report and the course descriptions in the study guide and concluded that there is a good alignment between the intended learning outcomes and the curriculum. This alignment is further strengthened by the skills and content learning lines. The panel learned during the site visit that the modular structure of the

programmes enhances the consultation and tuning between the teachers and the connection between the courses in the modules. This structure results in a cohesive programme. The panel likes the thematic project education in integrated modules. It directly forces the student to apply the learned theory in practice and to explore the relations between the subjects. The encouragement of students to develop self-determination and willpower to steer their own progress is highly appreciated from both the personal and the industry point of view. Overall, the programme is very well organised, taking the student's learning of both disciplines and skills seriously.

Students and study progress
Since 2017-2018 the programme has been taught in English. English was chosen to establish an internationally mixed student cohort and to prepare students for a global society. Dutch students report that they have no difficulties with the language, and some Dutch students deliberately chose the programme in Twente because of the English and the international environment. The number of incoming students was stable before 2016. Since the programme switched to English in 2017-2018, the number increased considerably from 100 to 164 and then 240 in 2018-2019. On average, one-third of the students drop-out in the first year, which is in line with the government policy that the first year is open to all qualifying students. The percentage of students nominally graduating (within 3 years) has grown to 30%, and the percentage of students graduating within 4 years remains stable at 55%. In comparison with the other Mechanical Engineering programmes in the Netherlands, these percentages are relatively high. The panel members find this percentage too low, however, and not being familiar with the Dutch culture in this regard, they were somewhat puzzled by the indifferent attitude most students and teachers showed when confronted with these figures. The reasons for study delay are, according to the students and the teachers, mostly related to deliberate choices for extracurricular activities, such as participating on the board of the study association, student projects or part-time paid work. The panel noted that the programme management, including the study advisors, ensures that there are no impediments in the programme inhibiting the students from finishing their studies on time. The programme has a staff mentor system in the first year. All students will have a least one individual talk with this mentor and are called to meet the study-advisor about their study progress if they do not pass the first module. In the second year students with study delay are again closely monitored. The University of Twente offers several university-wide training programmes to support students with developing study skills or reducing stress. During the site visit students also confirmed that the programme is feasible. The panel appreciates the efforts of the programme management to stimulate study progress and timely graduation.

Teaching staff
Most of the programme is taught by the scientific staff of the Faculty of Engineering Technology. The mathematics courses are given by lecturers of the Faculty of Electrical Engineering. All lecturers are required to successfully complete the University Teaching Qualification (UTQ), 83% of the staff has already obtained this qualification, and the rest of the staff is working on it. Of the lecturers, 88% has a PhD degree and is involved in both teaching and research. The panel likes the small scale, the direct working relation between staff and students, and the open door policy of staff, which was described by staff and students during the site visit. The programme management confirmed that the personal approach is a unique feature of the Twente programme, a feature they strive to maintain despite the increasing student numbers. The panel thinks that this will increase the workload of the teaching staff, although the programme management has taken several measures to cope with the growing student numbers, including recruiting new teaching staff, appointing an extra study advisor and hiring new officers. According to the programme management, there are sufficient financial resources to recruit new staff, but the market for recruitment is limited. The panel supports the plans of the Faculty management on gender balance in direct recruitment but noted that the gender diversity in the teaching staff could be improved. Mechanical Engineering is still a male-dominated programme, with the percentage of female students quite low at 10%.

The students are positive about the fundamental teaching skills of the staff and are also very pleased with the close contact and the open door policy. Overall, the panel thinks that the quality of the teaching staff is good, and it appreciates that the management wants to preserve the personal

approach to students despite growing student numbers. It recommends, however, paying close attention to the potentially increased workload of the teaching staff.

Considerations
The curriculum of the bachelor's programme Mechanical Engineering enables the students to achieve the intended learning outcomes. In fact, the panel finds the alignment between the intended learning outcomes and the curriculum to be very good. It is very positive about TOM and the project-based learning that structures the curriculum. Coherence in the programme is enhanced by the modules and the skills and content learning lines. Overall, the programme is very well-organised, taking student's learning of both disciplines and skills seriously.

The panel noted that the programme management, including the study advisors, ensures that there are no impediments in the programme inhibiting the students from finishing their studies on time. It considers it very positive that the teaching staff is involved in the mentor system in the first year. Although the percentage of students who graduates on time is still rather low, the panel is convinced that the programme is feasible.

The quantity and the quality of the teaching staff are good. The panel likes the direct working relation between staff and students and the open door policy. It appreciates that the management wants to preserve the personal approach to students despite growing student numbers. It recommends paying close attention to the increasing workload of the teaching staff. It also supports the Faculty's policy to attract more female teaching staff.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 2 as good.

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

Findings
Student assessment
All courses and modules are examined. For the modules a combination of different assessment methods is used. Most modules contain a group assignment as well as individual written tests with open questions and individual or group presentations and oral examinations. All information about the examinations and the assessments are described in assessment plans. The students report, both in their evaluations and in the interview with the panel, that they find the information about the assessments to be clear. They are aware of the assessment methods and the criteria. For the bachelor end project, students write a research paper and a reflective paper. During a final seminar session, the results are presented orally to staff members and fellow students. The papers are assessed by a committee of three staff members consisting of the supervisor(s) and at least one professor or associate professor as chair of the committee. The assessment is based on a prescribed format.

Assessment policy
Quality assurance of the assessments takes place according to the assessment policy document. This document describes how the Plan-Do-Check-Act cycle is followed to assure assessment quality. This policy describes that for each module or course an assessment plan has to be drawn up, all exams should have answer models and scoring forms, and course and module assessments should be evaluated. The results of these evaluations are followed up by the programme management and teachers and monitored by the Examination Board. The panel has seen the models, the score forms, and the assessment plans and finds them to be very well documented. During the site visit the panel checked whether the assessment policy and plans are applied and was convinced that they are.

Examination board
The Examination Board has the legal task to assure the quality of examinations and thesis assessment. It performs this task by ensuring that every test or examination is checked by a peer lecturer. Afterwards the tests are subject to statistical analysis. The Board safeguards the relation between the learning outcomes of courses, the education methods and assessment methods, draws up guidelines for extra resits and temporal validity of separate module components, investigates cases of suspected fraud/cheating, determines and sanctions fraud cases, appoints examiners and advises about the EER (Education and Examination Regulations) and the pass/fail regulation of the bachelor's modules.

The panel had a meeting with the Examination Board during the site visit and learnt that the Board also checks assessment dossiers and aims to continuously improve the methods to perform these screenings. The screenings often lead to recommendations to the programme management and the teaching staff. The panel was impressed by the hands-on involvement of the Board in the assurance of the assessment quality and concluded that it closely controls the processes.

Considerations
The panel established that the bachelor's programme Mechanical Engineering has an adequate quality assurance system. It finds the assessment policy to be very well documented and transparent. There are procedures in place to assure the validity and reliability of the tests. The panel concluded that the examinations, tests and thesis assessment are transparent, valid and reliable. It also ascertained that there are assessment forms in place, which are very well elaborated and used by the teaching staff.

The panel established that the Examination Board is performing its legal duties and responsibilities diligently and was impressed by its strong involvement in the assurance of the assessment quality.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 3 as good.

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

Findings
The panel studied a selection of 15 bachelor graduation assignments to assess whether the graduates had achieved the intended learning outcomes. It concluded that the bachelor graduates did indeed achieve the academic bachelor's level. The assignments showed that the bachelor students have acquired knowledge of the various fields of mechanical engineering and the skills to use this knowledge effectively, as well as the ability to solve technical problems using a systematic approach that includes analysis, the formulation of sub-problems and the evaluation of the implementation. The panel liked the societal reflection, in particular, that is a mandatory part of the assignments. In this reflection the graduates show their attitude and ability to evaluate the impact of their work. Due to the project-oriented education throughout the entire curriculum and the bachelor's thesis in the form of an academic research paper, students are well prepared (on a bachelor's level) for both future academic work and a career in the professional field.

Almost all bachelor graduates proceed to a master's programme, usually the master's programme Mechanical Engineering at the UTwente or at other universities or other master's programmes. The alumni of the bachelor's programme felt well prepared for their master's programme. Almost no bachelor graduate enters the workplace. Those who do are well prepared for working in the professional field, but they face strong competition from graduates of applied universities (4 years, and more practically oriented bachelor's programme).

Considerations
The panel concludes that graduates of the bachelor's programme Mechanical Engineering have achieved the intended learning outcomes. It found the level of the bachelor assignments to be good and in particular liked the societal reflection elements included. The grading of the bachelor projects appears to be consistent, recognising excellence with higher grades, and with weaker theses still achieving the prescribed learning outcomes. The graduates are well prepared for the master's programme Mechanical Engineering at UTwente and other master's programmes Mechanical Engineering abroad. Overall, the panel finds that the graduates achieved a high academic level and assesses this standard as good.

Conclusion
Bachelor's programme Mechanical Engineering: the panel assesses Standard 4 as good

GENERAL CONCLUSION

The panel assesses standard 1 as satisfactory and standards 2, 3 and 4 as good. It was very positive about the teaching-learning environment offered to the students. The project-based learning, the TOM model, the personal approach and the close contacts between teaching staff and students makes the programme very attractive and effective. The panel was furthermore positive about the assessment system and the level achieved by the graduates. Following the NVAO decision rules, the panel's general conclusion is that the programme is assessed as good.

Conclusion
The panel assesses the *bachelor's programme Mechanical Engineering* as good.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Introduction
Mechanical Engineering studies the analysis and synthesis of structures, machines, devices, systems and processes that accomplish a desired objective in a safe, ethical and sustainable fashion. Mechanical engineers therefore improve the quality of life, address societal challenges, and improve industrial competitiveness. No profession unleashes the spirit of innovation like engineering. From research to real world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. There is great variety in fields of application: from small to large scale, static and dynamic, from deep-sea to space, to name a few. Modern mechanical engineering is characterized by increasing multidisciplinarity, i.e. overlap with life sciences, electrical and chemical engineering etc. This necessitates a systems approach in which the various fields of expertise reinforce one another, giving rise to world leading mechatronics, nanomanufacturing, robotics, precision agriculture, shipbuilding and more. The Netherlands stands out in this respect, which, along with a strong entrepreneurial spirit, partly explains its innovative power.

Curriculum
Between the technical universities, active collaboration and exchange of students and faculty takes place. The three curricula in Mechanical Engineering in the Netherlands, at Delft University of Technology, Eindhoven University of Technology and University of Twente, comply with the definitions in ABET, OECD and ASME. The curriculum is based on a solid scientific foundation, deep engineering knowledge, and agile engineering design skills. A variety of modalities is used, such as courses and projects, designed to mutually stimulate each other; i.e. the knowledge from the courses is to be applied in the projects, and conversely, in their design projects students will experience the need for and utility of basic knowledge and engineering methodology.
Overall learning goals cover science (mathematics, physics and thermodynamics), engineering (materials, solid and fluid mechanics, dynamics), and design (specifications, synthesis, modelling and optimization, manufacturing, evaluation).

The Bachelor curriculum is composed of three key components:
1. Basic science (mathematics, physics, thermodynamics)
2. Engineering courses (solid and fluid mechanics, dynamics, control)
3. Design projects (integration of the above analysis tools in a synthesis-oriented group effort, along with dedicated knowledge acquisition and soft skill training). Projects are structured accordingly, with integration of design specification, synthesis, modelling and optimization, manufacturing, evaluation and presentation techniques.

The Bachelor includes a one-semester Minor of choice or elective programme plus a Bachelor end project, i.e. a research or design project performed in small groups or individually.

The Master curriculum is composed of one year of courses in a MSc track, plus a second year of internship (optional in some cases) and graduation project including a literature study, in which students mature to independent engineers or researchers. In some cases (part of) a graduation study is done in a company or another lab (abroad). In several cases a graduation study results in a scientific publication.

Criteria for a Mechanical Engineering programme
The engineering field requires an understanding of core concepts including solid and fluid kinematics, thermodynamics, control, materials science, and structural analysis. Mechanical engineers use these core principles along with tools like computer-aided engineering and product lifecycle management to design and analyse manufacturing plants, industrial equipment and machinery, heating and cooling systems, transport systems, aircraft, watercraft, robotics, medical devices and more. The field has continually evolved to incorporate advancements in technology, and mechanical engineers

today are pursuing developments in such fields as composites, mechatronics, additive and intelligent manufacturing and nanotechnology.

The fundamental subjects of mechanical engineering include:
- Statics and dynamics
- Solid mechanics and strength of materials
- Materials engineering
- Mathematics including calculus, differential equations and linear algebra
- Thermodynamics, heat transfer, energy conversion
- Fluid mechanics and dynamics
- Mechanism design (including kinematics and dynamics)
- Manufacturing engineering (technology and processes)
- Design engineering (including CAD/CAM)

Mechanical engineers are also expected to understand and be able to apply basic concepts from chemistry, physics, chemical engineering, civil engineering and electrical engineering. Most mechanical engineering programmes include multiple semesters of calculus, as well as advanced mathematical concepts including differential equations, partial differential equations, linear algebra, abstract algebra, and differential geometry, among others.

The domain specific requirements are translated into intended learning outcomes of the programme.

BSc	MSc	DSRF
Mechanical engineering competences at academic level		
a. Comprehensive and thorough technical and scientific knowledge of the various fields of mechanical engineering (mechanics, fluid mechanics, heat transfer, energy, systems and control, dynamic systems, design and construction) and the skills to use this knowledge effectively.	a+. Advanced level of knowledge within at least one sub discipline and the ability to apply this knowledge in design and research in this area.	Basis and Engineering Sciences
b. Thorough knowledge of methods, paradigms and tools to analyse and interpret data.	b+. Ability to design and conduct experiments, to develop models and simulations.	Engineering Practice
c. The ability to contribute to the solution of technological problems using a systematic approach that includes analysis, the formulation of sub problems and the evaluation of the implementation.	c+. Ability to identify, formulate and solve engineering problems by designing and developing innovative solutions, including evaluating the feasibility.	Engineering Analysis
d. The ability to integrate theory and practice from various sub disciplines.		Basis and Engineering Sciences
e. The ability to apply techniques, skills and modern "engineering tools" when these are relevant to the engineer's practice.		Engineering Practice
f. The ability to design a system, component or process that meets the set requirements and prerequisites.		Engineering Design
Academic, professional and regulating competences		
g. The ability to effectively communicate with professionals about one's own work and its relevance and impact in various contexts.		Generic Skills
h. The ability to operate as part of a (interdisciplinary and/or international) team, to take initiative, and to recognise and fill gaps in one's knowledge.	h+. Ability to work independently on a design or research assignment	Generic Skills
i. The ability and attitude to evaluate the impact of one's own work from a technological, social and ethical perspective and take professional responsibility for one's decisions.	i+. Insight in the complex working of modern industrial organisations	Generic Skills
j. The ability to continue one's education in a subsequent master programme.	j+. Ability to decide about the first step in one's professional career	Generic Skills
k. The attitude and ability to maintain and continuously improve one's academic and professional skills (life-long learning).		Generic Skills

APPENDIX 3: OVERVIEW OF THE CURRICULUM

The BSc programme (180 EC) has a duration of three years and is divided into 12 thematic modules each of 15 EC.

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Monday 10 December 2018

Time	Activity	Participants / remarks
8.30 - 9.00 hrs.	Arrival, welcome, studying course material (reading table)	
9.00 - 9.45 hrs.	Programme management (incl short presentation)	Programme director, Bachelor Coordinator, Master Coordinator, Study adviser Bachelor, Study adviser Master
9.45 - 9.50 hrs.	Panel deliberation	
9.50 - 10.30 hrs.	Bachelor Students	Two first year students, two second year students, two third year students
10.30 - 11.15 hrs.	Master Students & Alumni	Six master students and two alumni
11:15 - 11.30 hrs.	Panel deliberation	
11.30 - 12.30 hrs.	Staff Bachelor and Master	
12.30 - 13.30 hrs.	Panel deliberation, and warm lunch	
13.30 - 14.00 hrs.	Programme Committee	
14.00 - 14.30 hrs.	Examination Board	
14.30 - 15.00 hrs.	Panel deliberation	
15.00 - 15.45 hrs.	Formal management	Dean Engineering Technology and Vice Dean Education
15.45 - 17.15 hrs.	Drafting preliminary conclusions	
17.15 - 17.30 hrs.	Oral feedback from chair	

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the bachelor programme Mechanical Engineering. 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):

- Education and Exam Regulations Bachelor and Master programme
- Reports Industrial Advisory Board
- SDL Brochure
- Survey Professional Field
- Alumni Survey
- Benchmark Mechanical Engineering
- TOM brochure
- Module Assessment Plans Bachelor programme ME
- Module Assessment Plans Master programme ME
- Annual Report Examination Board 2016-2017, 2017-2018