

Assessment report
Limited Programme Assessment

Bachelor Electrical Engineering

University of Twente

Contents of the report

1. Executive summary	2
2. Assessment process	4
3. Overview of the programme.....	6
3.1 Basic information about the programme	6
3.2 Main facts about the institution	7
3.3 Intended learning outcomes.....	8
3.4 Outline of the curriculum	9
4. Overview of assessments.....	10
5. Findings, considerations and assessments per standard	11
5.1 Standard 1: Intended learning outcomes	11
5.2 Standard 2: Teaching-learning environment	13
5.3 Standard 3: Assessment.....	16
5.4 Standard 4: Achieved learning outcomes	18
6. Recommendations	19
Annex 1: Site visit schedule	20
Annex 2: Documents reviewed	21
Annex 3: Theses reviewed	22
Annex 4: Composition of the assessment panel	23

1. Executive summary

In this executive summary, the panel presents the main considerations which led to the assessment of the quality of the Bachelor programme Electrical Engineering of the University of Twente, which has been assessed according to the NVAO Assessment Framework.

The panel noted that the programme management followed up on the recommendations, made during the previous assessment in 2010. First and foremost, the programme management restructured the curriculum to improve the study pace of the students and to raise student success rates. In addition, the programme management reorganized the internal quality assurance system, clarifying the responsibilities of the Programme Committee and the Examination Committee and introduced scoring or rubrics forms to improve the Bachelor thesis assessments.

The programme's name, Bachelor Electrical Engineering, matches its contents and corresponds to the names of similar programmes.

The panel approves of the programme objectives, welcomes the broad range of technical knowledge, research skills and academic skills the students are to acquire, exemplifying the profile of the modern T-shaped engineer and encourages the programme management to continue educating the engineer of the future. The intended learning outcomes meet the programme objectives, addressing not only in-depth technical knowledge and skills but also describing the knowledge of adjacent fields, academic skills and awareness of the social impact of technology. The learning outcomes of the programme comply with the Meijers criteria of the Dutch Technical Universities and, therefore, meet the requirements of an academic Bachelor programme.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering that the management of the Electrical Engineering programmes of the three Dutch Technical Universities drafted. This Frame of Reference presents a sound and insightful description of this domain and links Dutch Electrical Engineering programmes to authoritative international concepts, notions and trends. The intended learning outcomes meet the requirements of this Domain-specific Frame of Reference.

The panel considers the admission requirements to be in line with legal regulations and the admission procedures of the programme to be very elaborate and effective.

The panel considers the intended learning outcomes to be met in the curriculum of the programme and regards the curriculum to be adequate, as students gain knowledge and skills in the electrical engineering domain, become knowledgeable in mathematics and physics at the required level and acquire relevant academic skills, such as communication, (English) academic writing, some level of system thinking and project management skills. The curriculum is regarded by the panel to be very adequate in terms of breadth of the subjects addressed and depth in which these subjects are studied and to be up-to-date. Programme management, research groups and industry representatives in the Advisory Board keep abreast of new trends and developments.

The educational principles, exemplified in the Twente Educational Model, are effective in promoting students' study activity and in fostering their study pace. Study methods such as lectures, tutorials, lectorials, laboratory sessions and projects are consistent with the goals of the educational principles.

The information provision for the students and especially the study guidance are very good. The student-to-staff ratio of 15.8 allows for intensive lecturing and guidance. The Bachelor coordinator, tutors, lecturers and study advisor guide the students very effectively through the programme. The regular meetings of lecturers within and across modules ensure the curriculum coherence.

The panel considers the student success rates in recent years to be appropriate and regards the efforts of the programme management in this respect to have been very effective.

The panel is very positive about the lecturers in the programme. They are experts in their fields, while the vast majority of them have a PhD and a very substantial number of them possesses BKO-certificates. In addition, the lecturers have a good command of the English language. The panel regards the team of lecturers to be very motivated to participate in this programme. They are very easily approachable, as the students informed the panel.

The panel is impressed by the facilities of the programme. The laboratories, which the panel visited, are state-of-the-art, allowing students to familiarize themselves with today's research in this domain.

The test and assessment policies in the programme are appropriate. The procedures adopted in this respect ensure the quality, validity and reliability of the tests and assessments. This also applies to the procedures for identifying and assessing individual performances of students in group projects. The assessments of the Bachelor assignments are adequate as well. These are graded in integers. In the panel's opinion, this somewhat hampers differentiating across theses. The Examination Committee monitors the test and assessment procedures, the quality of the tests and the students' having achieved the intended learning outcomes of the programme.

Having studied the tests and theses of a number of courses in the modules, the panel concludes these to be satisfactory in breadth and depth and to meet the learning goals of the courses.

One of the Bachelor theses, the panel studied, has been assessed as unsatisfactory. The panel considers this to be an outlier. The Bachelor theses demonstrate that the students have achieved the intended learning outcomes of the programme. Some general observations about the theses' quality may be made. About 30 % of the theses were regarded by the panel to be graded somewhat too high. The panel suggests calibrating the grades of the theses across the research groups. A number of theses were distinctly of good quality. As some theses were written in rather poor English, the panel advises to intensify English language instruction in the programme. Some theses were presented in paper format without appendices. As assessing students' performances is difficult in this case, the panel suggests making the appendices in such cases obligatory parts of the theses.

The figures the programme management collected on the graduates' follow-up education show the graduates are able to continue their studies at Master level.

The panel assesses the Bachelor programme Electrical Engineering of University of Twente to be satisfactory and recommends NVAO to grant re-accreditation to this programme.

Rotterdam, 16 November 2016

Prof. ir. A. van Ardenne
(panel chair)

drs. W. Vercouteren RC
(panel secretary)

2. Assessment process

Certiked VBI received a request to conduct a limited programme assessment for the re-accreditation of the Bachelor programme Electrical Engineering. This request was submitted by the University of Twente.

Certiked requested the approval by NVAO of the proposed panel of experts to conduct this assessment. NVAO have given its approval. The panel composition was as follows (for more detailed information please refer to Annex 4: Composition of the assessment panel):

- Prof. ir. A. van Ardenne, strategic advisor-ASTRON, director Ardenne Consultancy (panel chair);
- Prof. dr. D. De Zutter, professor Electromagnetics, Ghent University (panel member);
- Dr. C.L.M. van der Klauw, director of the research activities and programmes, Philips Lighting (panel member);
- E.E.M. Leo BSc, student Master programme Educational Sciences, University of Amsterdam, (student member).

On behalf of Certiked, drs. W. Vercouteren RC was responsible for the process coordination and for drafting the panel's report. All panel members and the secretary signed a statement of independence and confidentiality.

The panel conducted this assessment on the basis of the standards of the NVAO Assessment Framework of 19 December 2014 (Staatscourant nr. 36791).

The following procedure was adopted. The panel members studied the documents presented beforehand by the programme management, including a number of theses (please refer to Annex 2 and 3: Documents reviewed and Theses reviewed). With respect to the selection and study of the theses, the panel proceeded in line with the NVAO Guidelines for the assessment of final projects during external assessments of 18 February 2015.

Before the date of the site visit, the panel chair and the panel secretary met to discuss the assessment procedures. Before the site visit date, all panel members (a) sent in their preliminary findings, based on the information file submitted by the programme management, (b) a number of questions to be put to the programme representatives on the day of the site visit and (c) their findings about the theses, they had studied. The panel secretary summarized this information.

On 28 September 2016, the panel had a meeting to discuss the preliminary findings concerning the quality of the programme. During this preliminary meeting, the findings of the panel members, including those about the theses were discussed, and a number of questions were added to the list drafted beforehand. On the basis of this input, the panel secretary drew up a final list of questions, which served as a starting point for the discussions with the programme representatives during the site visit.

On 3 October 2016, the panel conducted a site visit on the University of Twente campus. The site visit schedule was in accordance with the schedule drafted beforehand (please refer to Annex 1: Site visit schedule). The programme management communicated the open office hours to the students and staff of the programme. Two students took the initiative to inform the panel on a number of items. The panel has taken this information into account, when drafting their considerations and arriving at the conclusions regarding the programme quality.

In a closed session at the end of the site visit, the panel reviewed each of the findings, weighed the considerations and drew conclusions regarding the quality of the programme. At the end of the site visit, the panel chair presented a broad outline of the findings to the programme management.

A draft version of this report was finalised by the secretary, having taken into account the information presented as well as the findings and considerations of the panel. The draft report was sent to the panel members, who studied the draft report and made a number of changes. Thereupon, the secretary edited the final report. This report was presented to the programme management to be corrected for factual inaccuracies. After having been corrected for these inaccuracies, the report was sent to the institution's Board to accompany their request for re-accreditation of this programme.

3. Overview of the programme

3.1 Basic information about the programme

Administrative information about the programme:

Name programme in CROHO: B Electrical Engineering
 Orientation, level programme: Academic Bachelor
 Grade: BSc
 Number of credits: 180 EC
 Specializations: N.A.
 Location: Enschede
 Mode of study: Full-time
 Registration in CROHO: 56953

Administrative information about the institution:

Name of institution: University of Twente
 Status of institution: Government-funded University
 Institution's quality assurance: Approved

Quantitative data about the programme

Percentage of students who dropped out after one, two or three years (vwo matriculation)

Cohort	2009	2010	2011	2012	2013	2014
Drop-out rate after one year	17 %	11 %	23 %	10 %	5 %	17 %*
Drop-out rate after two years	33 %	17 %	38 %	13 %	5 %*	
Drop-out rate after three years	35 %	17 %	33 %	13 %*		

* preliminary data

Percentage of students who continued their study in the second year and who completed the programme after three, four, five and six or more years (vwo matriculation)

Cohort	2008	2009	2010	2011	2012
Success rate after three years	5 %	5 %	13 %	13 %	32 %
Success rate after four years	10 %	48 %	39 %	61 %	
Success rate after five years	19 %	60 %	68 %		
Success rate after six or more years	33 %	60 %			

Percentage of students who continued their studies in the second year and who completed the programme after three, four, five and six or more years (all students)

Cohort	2008	2009	2010	2011	2012
Success rate after three years	4 %	5 %	12 %	15 %	31 %
Success rate after four years	17 %	46 %	39 %	59 %	
Success rate after five years	26 %	59 %	67 %		
Success rate after six or more years	38 %	59 %			

Lecturers' qualifications

Qualification	MSc	PhD	BKO*
Percentage of lecturers	100 %	98 %	57 %

*BKO means having obtained Dutch University Teaching Qualification. This figure underestimates the lecturer's qualifications, because a number of lecturers have been exempt from this obligation on account of their teaching track record.

The student-to-staff ratio is 15.8.

Number of contact hours per week for each of the years of the programme

Year of the programme	Year 1	Year 2	Year 3
Number of contact hours per week	26.8	22.6	12.8

3.2 Main facts about the institution

The Bachelor programme Electrical Engineering is a programme of the Faculty of Electrical Engineering, Mathematics and Computer Science of the University of Twente.

According to the University of Twente website, the mission statement of the University of Twente is to be the leading entrepreneurial University, to anticipate future developments and to respond rapidly and effectively to the changing world around us. The University's staff are meant to be experts in their field and to assist in setting the agenda for public debate. The University of Twente intends to interact on an ongoing basis with industry, research institutes and government to be able to generate ground-breaking research and world-class innovations. The University wants to produce outstanding graduates who excel by combining expertise from a range of fields, as they design solutions that meet the demands of the future, in the Netherlands and abroad.

More than 9,000 students study at the University of Twente, being subdivided in more than 5,000 Bachelor students and about 4,000 Master students.

The University of Twente comprises five faculties, being the Faculties Science and Technology, Electrical Engineering, Mathematics and Computer Science, Engineering Technology, Behavioural, Management and Social Sciences and Geo-Information and Earth Observation. These faculties offer 20 Bachelor programmes and 34 Master programmes.

3.3 Intended learning outcomes

The intended learning outcomes of the programme are as follows. The graduates of the programme are expected:

Knowledge

- To have knowledge and understanding in the field of electrical engineering, in particular analog and digital electronics, Maxwell theory, classical mechanics, control engineering, communication science and digital signal processing.
- To have knowledge and understanding of programming digital logic & computer systems.
- To have knowledge and understanding of calculus, linear algebra, difference and differential equations, linear systems and probability.
- For those students who choose the module Device Physics, have knowledge and understanding of basic principles of quantum mechanics, electronic components, optical and transducer devices.
- For those students who choose the module Computer Networks, have knowledge and understanding of basic principles of key protocols in communication systems, networks and networked applications.
- To have knowledge on academic level of key theories, methods and practices in the field of electrical engineering.
- To have knowledge of methods for planning, project management, individual and team-based projects.

Skills

- To be able to use modern methods and tools in research and design to describe, analyze, model, implement, test and document systems in the domain of electrical engineering on a scientific basis.
- To be able to assess theoretical and practical issues and substantiate and select appropriate solutions based on literature studies, models, analyses, simulations and tests.

Competences

- To be able to work systematically and methodologically.
- To have the ability to handle complex development- and research-oriented situations in study and work context.
- To have the ability to carry out studies and draw valid conclusions on a scientific basis.
- To be able to independently function in a disciplinary and interdisciplinary collaboration.
- To be able to communicate academic problems and solutions to peers and non-specialists.
- To be able to translate academic knowledge and skills into practical problem solving.
- To be able to study another academic field and to be able to identify research and/or design in that field.
- To be able to identify own learning needs and to structure own learning in different learning environments.
- To have insight in another academic field and to use different approaches for research or design.
- To take account of the temporal and social context of science and technology and to be able to integrate this into their scientific work.

3.4 Outline of the curriculum

In the table below, the programme curriculum has been presented.

Curriculum components	Credits
IEEE: Introduction	15 EC
Electrical Circuits	15 EC
Electronics	15 EC
Fields and Waves	15 EC
Year 1	60 EC
Computer Systems	15 EC
Systems & Control	15 EC
Device Physics or Computer Networks	15 EC
Signal Processing & Communications	15 EC
Year 2	60 EC
Minor	30 EC
Electronic Systems Design	15 EC
Bachelor assignment	15 EC
Year 3	60 EC
Total credits of the programme	180 EC

4. Overview of assessments

Standard	Assessment
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Assessment	Satisfactory
Standard 4: Achieved learning outcomes	Satisfactory
Programme	Satisfactory

5. Findings, considerations and assessments per standard

5.1 Standard 1: Intended learning outcomes

The intended learning outcomes of the programme have been concretised with regard to contents, level and orientation; they meet international requirements.

Findings

In the words of the management of this Bachelor programme, the main objectives of the Bachelor Electrical Engineering programme are to educate students to become electrical engineers who can act independently and in teams as designers or researchers, to be able to handle complex problems in an inherently multidisciplinary context and to be able to communicate the corresponding processes and results. More specifically, students of the Bachelor programme are meant to have domain-specific knowledge in electrical engineering, mathematics, physics and computer science, to have obtained academic skills, design skills and research skills and to have acquired academic reflection skills and communication skills.

In preparation of this external assessment process, the management of the Electrical Engineering programmes of the University of Twente, the Eindhoven University of Technology and the Delft University of Technology drafted the Domain-specific Frame of Reference Electrical Engineering. In this document, the management of these programmes specify the Electrical Engineering domain, especially taking into account the international perspective. For the graduates of the Bachelor and Master programmes in Electrical Engineering consolidated requirements have been compiled. These requirements have been derived from national and international academic and professional sources, such as ABET, the United States-based Accreditation Board for Engineering and Technology and ASIIN, the German Accreditation Organization for degree programmes in Engineering, Informatics, Natural Sciences and Mathematics. In addition, the international IDEA set of qualifications for Electrical and Information Technology were taken into account.

This Bachelor programme addresses all fields, listed in this Domain-specific Frame of Reference. In line with the research foci of the research groups related to the programme, special attention is being paid in the programme to information-related topics, material science-related subjects and biomedical and health topics. Detailed teaching of electrical energy systems and electrical machines subjects are left to the Eindhoven University of Technology and Delft University of Technology programmes Electrical Engineering.

The programme management drafted a series of intended learning outcomes (please refer to the complete list in section 3.3 of this report). In these learning outcomes, technical knowledge and skills, knowledge of adjacent areas, research skills, problem-solving skills, collaboration and communication skills and awareness of the social dimensions of science and technology are listed. Therefore, the learning outcomes specify the competencies of the modern T-shaped engineer, who not only possesses in-depth technical knowledge and skills but has knowledge of related fields, possesses academic skills and is aware of social and ethical aspects.

To demonstrate the correspondence of the intended learning outcomes of the programme to the Domain-specific Frame of Reference requirements, the programme management presented a table from which this correspondence may be derived.

In addition, the programme management has shown the intended learning outcomes to comply with the Meijers criteria, being the Dutch Technical Universities standard for the Bachelor level of the learning outcomes. From a table, presented by the programme management, it may be concluded the intended learning outcomes of this programme meet the Meijers criteria for Bachelor programmes.

Quite recently, the programme management installed an Advisory Board with members representing industry. The representatives of industry with whom the panel met, indicated this Advisory Board to be effective in voicing the industry's views on the programme, leading to an adequate response on the part of the programme management.

Considerations

The panel approves of the objectives of this Bachelor Electrical Engineering programme of the University of Twente. The panel welcomes the broad range of technical knowledge, research skills and academic skills the students are to acquire, contributing to the profile of the modern T-shaped engineer. The programme management is encouraged by the panel to continue educating the engineer of the future.

The panel is particularly positive about the Domain-specific Frame of Reference Electrical Engineering which the management of the Electrical Engineering programmes of the three Dutch Technical Universities drafted. To the knowledge of the panel, this Frame of Reference is the first substantial effort in the Netherlands to define and describe the Electrical Engineering domain. In the panel's opinion, this Frame of Reference presents a sound and insightful description of this domain. In addition, the document links Dutch Electrical Engineering programmes to authoritative international concepts, notions and trends in this domain.

In the panel's opinion, the intended learning outcomes of the programme meet the programme objectives. These intended learning outcomes address not only the in-depth technical knowledge and skills the students are to acquire but also describe the knowledge of adjacent fields, academic skills and awareness of the social impact of technology, thereby adequately describing the knowledge and skills of the T-shaped engineer.

The panel observed the intended learning outcomes to meet the requirements of the Domain-specific Frame of Reference Electrical Engineering and, therefore, to correspond to international concepts and trends in this domain.

The panel ascertained the intended learning outcomes of the programme to comply with the Meijers criteria of the Dutch Technical Universities and, therefore, to meet the requirements of an academic Bachelor programme.

The panel considers the intended learning outcomes of the programme to prepare students for Master programmes in this domain. The participation of industry in the programme is satisfactory, to be deduced, among others, from the position of the Advisory Board within the programme.

Assessment of this standard

These considerations have led the assessment panel to assess standard 1, *Intended learning outcomes*, to be satisfactory.

5.2 Standard 2: Teaching-learning environment

The curriculum, staff and programme-specific services and facilities enable the incoming students to achieve the intended learning outcomes.

Findings

The number of students enrolling in the programme gradually increased over the years from an influx of 51 students in 2009 to an influx of 63 students in 2014. The percentage of female students was about 5 % and in 2014 this was 10 %. The vast majority of the students have as their previous education the Dutch *vwo-diploma*. The remainder of the students are from professional Universities (HBO) or come from countries outside of the Netherlands. The programme management has set as a target the influx of about 100 students.

The entry requirements for the students are to have a Dutch *vwo-diploma*, with the required level of physics and mathematics. Students from professional Universities having completed their first year in the field of electrical engineering or a closely related field, are admitted as well. Other applicants are to take the so-called *colloquium doctum* test. All the applicants should participate in the matching procedures of the programme, entailing among other matching tests. Applicants should be proficient in English, since the programme is English-spoken. Admission procedures are being taken care of by the Admission Office of the University of Twente. Should students fail to succeed during their first year, they may continue their studies at Saxion University of Applied Sciences (HBO).

The programme management presented an elaborate scheme in which the relations between the intended learning outcomes and the curriculum components have been specified. From this scheme, it may be deduced that all of the intended learning outcomes are addressed in one or more modules.

The design of the curriculum has drastically been changed in 2013. This new educational model is called the Twente Educational Model (TEM) and has been implemented in all of the University of Twente Bachelor programmes. The curriculum is composed of ten modules of 15 EC and a minor of two times 15 EC. Each of the modules addresses a specific part of the domain of electrical engineering (for a list of the modules, please refer to section 3.4 of this report). The modules are composed of a number of distinct knowledge and skills components. The modules encompass electrical engineering theory, mathematics and physics, academic skills, such as project management, presentation and writing skills and research problems of limited scope. Mathematics lectures are offered University of Twente-wide. In tutorials, specific electrical engineering-related mathematics topics are elaborated. The 15 EC course *Reflection on Science, Technology and Society* running through the curriculum addresses social and ethical dimensions. In each of the modules, students are to execute a group project, in which they are to apply the knowledge they gained to specific problems and, at the same time, promote their project management and communication skills. Multi-disciplinary elements are introduced in these projects. In the minor, students may select modules, deepening their knowledge of a specific field or may take courses from other Bachelor programmes at the University of Twente or other institutions. In the Bachelor Thesis at the end of the curriculum, students are to conduct a limited scientific research project. The contents of this curriculum are consistent with curricula of renowned universities abroad.

Within the modules of the Bachelor programme, lecturers very regularly meet to discuss the contents of and the relations between their courses and lectures, in order to optimise the consistency across courses and lectures. Module coordinators often meet to discuss the relations between the modules.

The educational principles of the Twente Educational Model are to encourage students to study regularly, to guide them intensively and to foster their study pace. The goal is to enable and stimulate students to complete the modules in time. Students themselves are anxious not to fail modules, since each of the modules constitutes no less than 15 EC.

Study methods in the programme include lectures, tutorials, lectorials, laboratory sessions and projects. Lectorials are a combination of instruction by the lecturer, followed, in the same session, by tutorials with active student participation, guided by several lecturers. In the modules, frequent intermediate, formative tests assist in giving feedback to the students on their study progress. This feedback results in encouraging students to change their approach towards their study. The number of contact hours between university staff members and students is quite substantial, being nearly 27 hours per week in the first year, over 22 hours per week in the second year and almost 13 hours per week in the third year. In the first year, students are to achieve no less than 45 EC. Otherwise, they will be forced to leave the programme, this being the consequence of the binding continuation of studies advice (BSA).

Students may consult the electronic learning system of the programme for information on modules and for uploading homework and thesiss. For content-related issues, students may turn to the Bachelor coordinator. Students are guided through the programme by their tutor, this guidance being intensive at the beginning and being reduced in the course of the programme. To select their Bachelor Assignment, the programme management organizes information meetings for the students. Students may consult the programme study advisor for subjects, not directly related to the contents of the programme. The study advisor monitors the study pace of every student and provides warnings to students in case of a threatening BSA.

The student success rate improved substantially over the last years. Students completing the programme within three years increased from 4 % (cohort 2008) to 31 % (cohort 2012). Students completing the programme within four years went up from 17 % (cohort 2008) to 59 % (cohort 2011). The programme management assesses the success rates of recent years to be satisfactory.

More than 98 % of the lecturers in the programme obtained a PhD and are active researchers in their fields of expertise. About 57 % of the lecturers obtained the Dutch University Teaching Qualification (BKO), testifying to their teaching capabilities. Most of the other lecturers are exempt of this obligation, since they have a long and substantial track record in teaching. All lecturers are to be proficient in the English language (C1 or C2 on the Cambridge English Scale), to be demonstrated by means of an assessment. About 85 % of the lecturers have these English language skills. The other lecturers are in the process of acquiring these skills. Guest speakers from industry highlight new developments in the Electrical Engineering domain. Dutch National Student Survey results show the students in this programme to be satisfied with the lecturers' performances. The students with whom the panel met, confirmed this.

Lecture and project rooms are available. Students have access to laboratories at the University of Twente campus for laboratory work and work on the Bachelor Assignment. In addition, clean rooms have been constructed to accommodate research in micro systems and nano systems. The panel was offered the opportunity to visit a number of the facilities. Students are happy with the facilities, so they told the panel.

Considerations

The panel considers the admission requirements to be in line with legal regulations and the admission procedures of the programme to be very elaborate and effective.

The panel considers the intended learning outcomes to be met in the curriculum of the programme and regards the curriculum to be adequate, as students gain knowledge and skills in the Electrical Engineering domain and at the same time, acquire relevant academic skills, such as communication and project management skills. The curriculum is regarded by the panel to be very adequate in terms of the breadth of the subjects addressed and depth to which these subjects are studied. The panel is convinced the levels of mathematics and physics in the modules are up to standard. In addition, students acquire research skills. The panel is of the opinion that the programme management has succeeded in composing a curriculum, tailored to the needs of the T-shaped engineer. The programme management, research groups and the Advisory Board monitor new trends and developments, which keeps the programme up-to-date.

The educational principles, exemplified in the Twente Educational Model, are effective in promoting students' study activity and in fostering their study pace. Study methods such as lectures, tutorials, lectorials, laboratory sessions and projects are consistent with the goals of the educational principles.

The information provided to the students and the study guidance are up to standard. The student-to-staff ratio of 15.8 is quite favorable and allows for intensive lecturing and guidance of the students. The panel regards the involvement of the Bachelor coordinator, tutors, lecturers and study advisor to be very effective in guiding the students through the programme. The regular meetings of lecturers participating in the modules and, across modules, between the module coordinators ensure the curriculum coherence. The supervision of the Bachelor thesis is adequate.

The panel considers the student success rates in recent years to be appropriate and regards the efforts of the programme management in this respect to have been very effective.

The panel is very positive about the lecturers in the programme. They are experts in their fields, while the vast majority of them have a PhD and a very substantial number of them possesses BKO-certificates. In addition, the lecturers have a good command of the English language. The panel regards the team of lecturers to be very motivated to participate in this programme. They are very easily approachable, as the students informed the panel.

The panel is impressed by the facilities for the students and lecturers in the programme. Having visited some of the laboratories, the panel considers these to be state-of-the-art, allowing students to participate in today's research.

Assessment of this standard

These considerations have led the assessment panel to assess standard 2, *Teaching-learning environment*, to be good.

5.3 Standard 3: Assessment

The programme has an adequate assessment system in place.

Findings

The management of this Bachelor programme adheres to the University of Twente assessment policy. For the programme, an assessment plan has been drafted, listing the procedures to ensure the quality of the tests and assessments. For each of the modules, test schemes are designed, specifying the learning goals of the module, the tests and the weighing factors of these tests. The tests themselves, including the answering models, are drafted by one of the lecturers in the programme who presents the test to another lecturer for review. Test methods adopted in the modules, include written tests and the results of projects. The methods of testing depend on the nature of the learning goals to be assessed. Course files are being introduced. These course files document for each of the courses, among others, the test scheme, test thesiss, answering models, marking rules and evaluation results. Students are informed about the tests and the grading of the items in the test.

Assessing tests is done by examiners, who use answering models in case of written tests and scoring models or rubrics in case of thesiss. These models are derived from the learning goals of the courses. Students are required to pass each of the module components. In some cases, they may compensate fails. Fails may never be compensated by group work results. In case of the projects, the supervisors of the project monitor the individual contribution of each of the students in the group. Individual components such as an oral presentation, may be part of the test. Students' individual results within the group may differ, depending on their individual performances. Students are entitled to a resit for each of the module components. Students who fail the module, may be granted an extra resit. This is decided upon in a meeting with all lecturers in the programme, the Examination Committee being present as well.

For the Faculty of Electrical Engineering, Mathematics and Computer Science, an Examination Committee is in place and rules and regulations governing examinations and assessment have been drafted. For the programme, a sub-committee of this Committee monitors the examination rules and regulations, ensures the quality of the tests and verifies the graduates having achieved the intended learning outcomes. In addition, the Examination Committee appoints the Examiners who will only be appointed, if they have completed the University Teaching Qualification (BKO). Handling cases of fraud or plagiarism is part of the Examination Committee's tasks. All written tests are checked for plagiarism.

The Bachelor assignments at the end of the curriculum are assessed by the Graduation Committee, composed of three examiners, one of whom being the supervisor. One of the examiners comes from another research group than the group in which the thesis was performed. The examiners grade the thesis by means of a scoring model on scientific quality (35 % of the grade), organizational skills (35 %) and oral and written communication skills (30 %). The final grade is the result of discussions among the examiners. The scoring models have been introduced two years ago.

Considerations

The panel regards the test and assessment policies in the programme to be appropriate, as these comply with the University of Twente assessment policy and specify the procedures with respect to the drafting, executing and assessing the tests in the programme. The panel considers these procedures appropriate for ensuring the quality, validity and reliability of the tests and the assessments. The panel is of the opinion that the programme management has put in place solid procedures for assessing the students' results within the modules. The panel is also satisfied with the procedures for identifying and assessing individual performances of students in group projects.

The panel is positive about the position, responsibilities and tasks of the Examination Committee, monitoring the test and assessment procedures, the quality of the tests and the students' achieving the intended learning outcomes of the programme.

The assessment of the Bachelor assignments is regarded by the panel to be adequate. The theses are graded in integers. In the panel's opinion, this somewhat hampers differentiating across theses.

Assessment of this standard

The considerations have led the assessment panel to assess standard 3, *Assessment*, to be satisfactory.

5.4 Standard 4: Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

The programme management listed the grades for the Bachelor Assignments for the last five years in order to illustrate the level achieved by the students. The average grade for these projects was 7.7 in these five years. Occasionally, these result in scientific conference publications.

The panel members studied a total of 15 Bachelor theses and discussed these theses within the panel.

The programme management collected figures on the graduates' follow-up education in recent years. By far most of the graduates (about 90 %) continue their studies at the University of Twente. About 58 % of all of the graduates proceed to the University of Twente Master programme Electrical Engineering and 16 % go to the Master programme Embedded Systems. The remainder enroll in other Master programmes of the University of Twente or choose to go to another university. About 68 % of the students finish their Master programme within three years.

Considerations

Having studied the tests of a number of courses within the modules of the programme which the programme management presented, the panel concludes these tests to be satisfactory in breadth and depth and to reflect the learning goals of the courses.

One of the Bachelor theses, the panel studied, has been assessed as unsatisfactory by the panel. The panel considers this thesis to be an outlier, not representative of the general quality of the theses. The assessment of this thesis corresponds with the grading of the Graduation Committee of the programme, which judged the written and oral communication with the grade 5. In the scoring model this only accounts for 30 % of the final grading. In this case, the scientific quality (35 % of the grade) and organizational skills (35 % of the grade) were rated higher, resulting in a final mark 6. Although the performances of the students and the grades given differ, some general observations about the theses' quality may be made. About 30 % of the theses were regarded by the panel to be graded somewhat too high. The panel suggests calibrating the grades of the theses across the research groups. A number of theses, the panel studied, were distinctly of good quality. Some theses were, however, written in rather poor English. The panel, therefore, recommends intensifying the English language instruction in the programme. Some other theses were presented in the format of papers without appendices. As assessing the students' performances is difficult in this format, the panel suggests making the appendices obligatory parts of the theses, at least for internal reference. In the panel's view, the Bachelor theses, nevertheless, demonstrate the students having achieved the intended learning outcomes of the programme.

In the panel's view, the figures the programme management collected on the graduates' follow-up education show that the graduates meet the demands of the Master programmes and are able to continue their studies at Master level.

Assessment of this standard

The considerations have led the assessment panel to assess standard 4, *Achieved learning outcomes*, to be satisfactory.

6. Recommendations

In this report, a number of recommendations have been listed. For the sake of clarity, these have been brought together below. The recommendations are the following.

- To try and accomplish calibration of the grades of the Bachelor theses across the research groups, participating in the programme.
- To intensify the English language instruction in the programme, as some theses were written in rather poor English.
- To make appendices obligatory parts of the Bachelor theses, which have been written in the format of papers, in order to be able to assess the students' performances adequately.

Annex 1: Site visit schedule

The site visit took place at the University of Twente on 3 October 2016. The site visit schedule was as follows.

08.30 h. – 09.00 h.	Arrival and deliberations panel (closed session)
09.00 h. – 09.30 h.	Dean and programme management Prof. dr. P. Apers (Dean of Faculty Electrical Engineering, Mathematics and Computer Science), dr. ir. M. Bentum (programme director)
09.30 h. – 10.30 h.	Programme management and core lecturers Dr. M. Korsten (Master coordinator, lecturer), dr. ir. C. Salm (Bachelor coordinator, lecturer), D. Boere MSc (study advisor), dr. ir. M. Bentum (programme director), dr. ir. R. van der Zee (chair Programme Committee, lecturer), prof. dr. ir. B. Nauta (chair Electrical Engineering department, module coordinator, core lecturer), prof. dr. ir. G. Krijnen (core lecturer), prof. dr. ir. R. Veldhuis (core lecturer)
10.45 h. – 11.30 h.	Examination Committee Prof. dr. J. Eijkel, dr. ir. J. Broenink, dr. M. Korsten
11.30 h. – 12.30 h.	Lecturers of a various courses and theses' examiners Ir. B. Molenkamp, dr. ir. A. Kokkeler, dr. ir. L. Spreeuwens, dr. ir. M de Jong, prof. dr. J. Schmitz, dr. ir. P.T. de Boer, prof. dr. ir. W. van der Wiel, dr. ir. L. Segerink
12.30 h. – 13.30 h.	Lunch panel (closed session), open office hours 12.30 h. – 13.00 h.
13.30 h. – 14.15 h.	Tour around facilities (various laboratories)
14.15 h. – 15.00 h.	Students and alumni, including Programme Committee members N. Leijen (Bachelor student, Programme Committee), M. Alesandrovic (Bachelor student), J. van 't Hof BSc (Master student), P. van der Ven (Bachelor student), M. Kriele BSc (Master student), M. Refai Mohamed Irfan BSc (Master student), S. Naveen Kumar BSc (Master student), R. Kers BSc (Master student, Programme Committee), M. Ufkes MSc (alumnus, Thales), M. Brehouwer MSc (alumnus, ASTRON)
15.00 h. – 15.45 h.	Representatives from industry Ir. M. Boer (AEMICS, Advisory Board member), ir. P. Eikendal (Use System Engineering), ir. R. Oude Velthuis (Thales Nederland, Advisory Board member), ir. L. Hogendoorn (TMSi), dr. ir. C. Mensink (Teledyne DALSA), dr. ir. R. Roovers (NXP), dr. ir. C. Roeloeffzen (SARTRAX)
15.45 h. – 16.00 h.	Programme management Dr. ir. M. Bentum (programme director)
16.00 h. – 17.30 h.	Deliberations panel (closed session)
17.30 h. – 17.45 h.	Main findings presented by panel chair to the programme management

Annex 2: Documents reviewed

The panel studied the following documents, presented prior to the site visit:

- Critical Reflection Bachelor Electrical Engineering
- Required appendices, as specified by NVAO
- Domain-specific Frame of Reference
- University of Twente institutional quality assurance audit report
- Study Association Scintilla information
- Criticism in former external assessment report, including programme response
- Assessment form Bachelor thesis
- Meijers criteria for academic Master and Bachelor programmes
- Dublin-descriptors
- Faculty of Electrical Engineering, Mathematics and Computer Science rules and regulations
- Rules of examinations and assessment
- Assessment policy
- Cambridge English scale
- Bachelor and Master programme website
- Course catalogue
- Timetable for the programme and example of schedule
- Internal quality assurance for programme
- University of Twente assessment framework
- Quantitative data on programme, provided by VSNU
- Overview of curriculum
- Description of curriculum components

On the day of the site visit, the programme management presented the following documents:

- Literature
- Course material (representative selection)
- Brochures on Twente Educational Model (TEM)
- Tests and examinations (representative selection)
- Examination Committee annual reports
- Programme Committee minutes

In addition, panel members were given access to the programme's electronic learning environment

Annex 3: Theses reviewed

The Bachelor theses of the following 15 students have been selected for review by the panel

- 1112562
- 1124420
- 1097717
- 1207725
- 1080903
- 0207500
- 1218425
- 1498061
- 1114778
- 1218964
- 1209817
- 1377337
- 1164686
- 1127446
- 1305468

Annex 4: Composition of the assessment panel

The assessment panel had the following composition:

- Prof. ir. A. van Ardenne, strategic advisor-ASTRON, director Ardenne Consultancy (panel chair);
- Prof. dr. D. De Zutter, professor Electromagnetics, Ghent University (panel member);
- Dr. C.L.M. van der Klauw, director of the research activities and programmes, Philips Lighting (panel member);
- E.E.M. Leo BSc, student Master programme Educational Sciences, University of Amsterdam, (student member).

Prof. ir. A. van Ardenne, panel chair

Mr. Van Ardenne graduated from Twente University of Technology as a Master of Science in Electronics and Applied Physics. Having completed his studies, he held, among others, positions as a research engineer, scientific project manager, research & development director and technical director at organizations like ASTRON/NWO, Ericsson Radio Systems and NOFIQ Firesystems. From 2006 to 2015, he was adjunct professor Radio Astronomy at Chalmers University of Technology, Gothenburg, Sweden. Mr. Van Ardenne, currently, is working as a strategic advisor to, among others, the Dutch province of Drenthe, in particular advising on research programmes and space-related activities.

Prof. dr. D. De Zutter, panel member

Mr. De Zutter received his Master of Science degree in Electrical Engineering from Ghent University. He was a research assistant at this University, subsequently obtained a PhD and completing a thesis, leading to the degree equivalent of the French Aggrégation. He, currently, is a full professor of Electromagnetics at Ghent University. His main research interests are circuit and electromagnetic modeling of high-frequency interconnections and packaging, electromagnetic compatibility (EMC) and numerical solutions of Maxwell's equations. Mr. De Zutter is a Fellow of the IEEE. Previously, he held the position of Dean of the Faculty of Engineering of Ghent University.

Dr. C.L.M. van der Klauw, panel member

Mr. Van der Klauw graduated as a Master of Science in Electronics Engineering from Delft University of Technology and received a PhD in the area of semiconductor devices (CCD's). Having completed his studies, he joined Philips Research, working on the design and characterization of CMOS devices and processes. Subsequently, he was employed at Philips Flat Panel Displays, being involved in establishing Philips' joint ventures in Korea and Japan. Subsequently he worked as Chief Technology Officer in Philips Television. Mr. Van der Klauw is, currently, in charge of the research programme of Philips Lighting.

E.E.M. Leo, student member

Ms. Leo is a student in the Master programme Educational Sciences of University of Amsterdam. Previously, she completed the Bachelor programme in Educational Sciences at this University. She was, among others, a member of the Educational Committee of her programme and vice-chair of the Student Council of the Faculty of Social and Behavioral Sciences of University of Amsterdam. Ms. Leo participates as a student member on a regular basis in NVAO-accreditation panels.