# Assessment policy Electrical Engineering

Version 2.1, July 2021

## List of abbreviations and acronyms

| | |
|---|---|
| AEB | (Chair committee exams bachelor) *Adviescommissie Examens Bacheloropleidingen* |
| AEM | (Chair committee exams master) *Adviescommissie Examens Masteropleidingen* |
| BC | Bachelor College |
| BKO | Basic Teaching Qualification for Teachers (*Basiskwalificatie Onderwijs*) |
| CBE | Examination Appeals Board *(College van Beroep voor de Examens)* |
| CBL | Challenge Based Learning |
| CM | Chain Manager *(within ESA)* |
| CvB | College van Bestuur |
| CSA | Center for Student Administration |
| DBL | Design Based Learning |
| DSFR | Domain Specific Frame of Reference |
| EC | Examination Committee |
| EE | Electrical Engineering |
| ESA | Education and Student Affairs |
| GS | Graduate School |
| ITK | Institutional audit internal quality assurance (*Instellingstoetskwaliteitszorg*) |
| JPC/GOC | Joint Program Committee (*Gemeenschappelijke Opleidingscommissie)* |
| MESA | Manager ESA |
| NVAO | Dutch Flemish Accreditation Organization (*Nederlands-Vlaams AccreditatieOrgaan)* |
| OER | Program and Examination Regulations |
| OC | Program Committee (*Opleidingscommissie)* |
| STEP | Secure Test Environment Protocol |
| TA | Teaching/Teacher assistant |
| TS | Teacher support officer, an educationalist who helps teachers with education innovation |
| WHW | Dutch Higher Education and Scientific Research Act *(Wet op het Hoger Onderwijs en Wetenschappelijk onderzoek)* |

# Contents

This document is an updated version of the Assessment policy document of the department of Electrical Engineering (EE) 2015. The update of the institutional TU/e Exam framework as well as recent developments with respect to assessment at the department form the basis of the changes made in the departmental assessment policy.

Version 2.1

Advice:

| | |
|---|---|
| Version 2.1 | Chair Examination Committee, program directors, manager ESA |
| Version 2.2 | Examination Committee EE June 30, 2021 |
| Version 2.3 | Program Committee OC July 2, 2021 |
| Version 2.4 | Departmental Council July 7, 2021 |
| Version 2.4 | Departmental Board August 26, 2021 |

Approved by:
Departmental Board d.d. August 26, 2021

Relevant documents and decisions:
TU/e Exam framework, 2019
TU/e Code of scientific conduct, 2014
Central Examination Regulations TU/e, 2021

## Document administration:

The management, assurance and updating of this document is the responsibility of the program directors of the EE department. The document "Assessment policy, Department of Electrical Engineering" is reviewed annually and updated when necessary.

## Version management

| | | |
|---|---|---|
| 1.0 | FB-EE | 6 June 2015 |
| 2.4 | FB-EE | 26 August 2021 |

# 1. Introduction

This document is an updated version of the assessment policy document of the Electrical Engineering department drafted in 2015. In this document, the vision and policy of the department is described, with a focus on assuring and safeguarding the quality of assessment within the programs offered by the department, taking into account the guidelines as described in the document 'TU/e Exam framework 2019'.

Within the EE department, the Program Committee (OC) is responsible for safeguarding the quality of education. The Examination Committee (EC) is responsible for safeguarding the quality of assessments. The responsibility for safeguarding the quality of the organization of written final tests is taken at institutional level. With reference to the document 'TU/e Exam framework 2019', Appendix 1 shows the responsibilities of different stakeholders with respect to assessments.

The department offers two programs, accredited by the NVAO: The BSc program in Electrical Engineering (CROHO-number 56953) within the Bachelor College comprising the majors Electrical Engineering and Automotive Technology. And the MSc program in Electrical Engineering (CROHO number 60353) which is part of the Graduate program Electrical Engineering.

In view of NVAO re-accreditation of the programs, an accreditation committee reviewed the programs in 2016. The committee has given both degree programs a final assessment of Satisfactory (standard 1 Intended learning outcomes was evaluated Good, standard 2 Teaching-learning environment, standard 3 Assessment and standard 4 Achieved learning outcomes were evaluated as satisfactory). In its assessment report, the committee expressed that the intended learning outcomes are fully covered in the curriculum. Students acquire knowledge of disciplines like mathematics and physics and knowledge and skills of electrical engineering, both at the required level, obtain research and design skills, gain professional skills, such as communication and planning skills and are acquainted with social, ethical and business aspects. The curriculum is coherent and up-to-date. The program intended learning outcomes meet the objectives. In the panel's view, these learning outcomes specify the competencies of the modern T-shaped engineer. The learning outcomes meet the requirements of the Domain-specific Frame of Reference and comply with the requirements of an academic Bachelor program. The panel has observed the intended learning outcomes to meet the requirements of the Domain-specific Frame of Reference Electrical Engineering and to comply with the requirements of an academic Master program. In addition, the learning outcomes appropriately prepare students for careers in industry and in research in the Electrical Engineering domain.

The department of EE views this as a substantiation that the departmental assessment policy and its implementation in the degree programs is sound and effective.

# 2. Vision on education and assessment

## 2.1 Vision on education

The EE department is fully committed to the mission and vision of Eindhoven University of Technology (TU/e). TU/e strives to be a research-driven and design-oriented university of international standing, where excellent research and excellent education go hand in hand. TU/e focusses on a balanced approach towards education, research and valorization of knowledge in the areas of engineering science and technology. The outlines of TU/e's vision on education are described in the booklet 'Engineers for the Future', published in 2013. Core elements of this vision include:

The pursuit of excellence, in which the connection between education and research is the central pillar.

- Small-scale education and master-apprentice interaction as key components of academic education.
- Internationalization of the student population and a greater diversity of students.
- Teaching that is driven by student demand, with a stronger tutoring role for the teaching staff.
- An important role for ICT in teaching large groups of students and in lifelong learning.
- Professional development of the educators that transcends basic university teaching qualifications.
- Greater emphasis on multidisciplinarity.
- Greater emphasis on output qualifications in education and in educational quality assurance.
- In due course, a considerable expansion of TU/e education aimed at lifelong learning and a substantial involvement of the business world.

With these core elements in mind, TU/e has defined guidelines for the structure of bachelor programs (Guidelines Bachelor College) and graduate programs (Guidelines Graduate School). At the basis, research and education are intertwined, especially in the master's program. In the bachelor's degree program, a common basis is laid for the master's program and tracks, supported by courses in mathematics and physics. Students conclude the program with a Bachelor Final Project conducted in the research groups within the department or at partner institutions. In the master's program, the specialization paths and master tracks offered by the department are directly linked to the research focus areas of the department and the graduation project forms a substantial part of the program.

Both programs are an elaboration of clearly formulated learning outcomes defining the competences of graduates. These learning outcomes not only describe the scientific knowledge and skills, but also competences with respect to conducting research and design, communication and societal awareness (see Appendix 2a, b). The learning outcomes of the programs comply with BSc/MSc requirements as formulated by the Meijers criteria, as shown in Appendix 3a, b.

## General objective of the programs

Electrical engineering is the science of applying electricity and magnetism in designing and analyzing artifacts, including the abstractions that can be useful for that. It has been a generally recognized field for over a century. Over this period focus has changed almost continuously and the developments in the recent decades are no less than revolutionary.

Career paths are very diverse, since Electrical Engineering plays a key role in the global society. Nine out of twelve potentially disruptive technologies listed by McKinsey in 2013 are directly connected to EE: the mobile internet, the internet of things, advanced robotics, autonomous and near autonomous vehicles, next-generation genomics, energy storage, 3D printing, advanced oil and gas exploration and recovery, and renewable energy. Materials science, physics, electronics, photonics, computer engineering and computer science are becoming more connected or overlapping and they blend with application areas such as energy, healthcare, mobility and transport, safety and security, leisure and sport. No educational program can reasonably cover all these subareas explicitly, so the aim must be to teach a core that enables graduates to specialize in any of them, in conjunction with the necessary academic skills, within time and effort boundaries considered by peers and employers to be adequate.

The mission of the Department of Electrical Engineering is as follows:

*The department of Electrical Engineering will offer top-class academic education to talented people in the domain of Electrical, Electronics and Information Systems Engineering Science & Technology. The department of Electrical Engineering will be the prime research partner for industry and societal organizations at her core disciplines.*

As a result, the overall objective of the program is to train and educate talented people so that they are prepared to embark upon a professional career on an academic level in the field of Electrical Engineering. Appendix 2 outlines the core subjects and curriculum trajectories.

## Departmental themes

The programs also reflect the department's strategic choice to focus on four large societal themes. 'Connected World', 'Care and Cure', 'Smart and Sustainable Society' and 'Automotive Technology'. The themes were envisioned to create a clearer picture of the department's activities, and have, for example, been used to define bachelor elective packages and Bachelor Final Projects (BEP).

| | |
|---|---|
| **Connected World** | addresses the exponentially growing societal hunger for communication. The department has achieved a world-leading position in research related to this development. |
| **Care and Cure** | addresses the major societal challenge coming with an ageing society. Most of the activities in health technology currently have a prominent EE signature. |
| **Smart and Sustainable** | addresses the enormous challenges with respect to a smooth and |

| | |
|---|---|
| **Society** | scalable transition from fossil fuel-based energy supply to sustainable energy supply. |
| **Automotive Technology** | addresses the need for a next generation in mobility systems. Autonomous cars, trains, high-efficiency energy conversion, and congestions all need an EE approach. |

The themes do not take the form of specific courses, but color or structure the program where appropriate, for example when choosing electives or project topics.

For the bachelor program, the objective is basic knowledge. For the master program, the aim is the forefront of this knowledge.

The department themes have been specifically implemented in two locations of the bachelor program:

- The Bachelor Final Project is an individual project, which students choose from a set of options within the area of one of the themes;
- There are five coherent elective packages for bachelor students (one for Care & Cure, Connected World and Smart Sustainable Society, two for Automotive Technology).

Apart from that, the Automotive Technology theme has found its implementation in a full track of the EE bachelor program. This is merely a consequence of the TU/e Strategic Areas and the vision of TU/e that the future mobility strongly relies on Electrical Engineering. For the Automotive area, there is one introductory elective package and two advanced packages.

### Artificial Intelligence Engineering Systems

If all goes according to plan, a new master program Artificial Intelligence Engineering Systems (AIES) is scheduled to start in September 2022. It will be the first program in the Netherlands that explicitly links the fields of artificial intelligence and engineering systems together. AIES will be a true interdisciplinary master program that can be followed by bachelor students from seven TU/e departments. The department of Electrical Engineering will act as coordinator of the master program AIES. The Master's program combines common knowledge that is offered in a core package of courses on mathematics, learning in artificial intelligence, data science, systems engineering, human interaction & ethics and programming, with specialized knowledge in six tracks. Students choose a specific track in the program till their graduation project. The tracks are built around high-tech systems and robotics, mobility, health applications, smart cities, AI foundation and science applications, and manufacturing systems.

Prior to the intended accreditation of the new master's program on AIES, the Department of Electrical Engineering and the Department of Mechanical Engineering initiated independent tracks on AIES in 2020; each with about twenty students. These tracks will be merged into the interdisciplinary master program.

## 2.2 Vision on assessment

The visions on education and assessment are closely linked. The department's vision does not stand alone. The vision has been developed conform the exam framework of TU/e. The educational vision is portrait in the educational vision of 2030.

The department has drawn up its assessment policy based on the guidelines defined at institutional level. At TU/e, assessments are used to test the level at which the student has mastered the material (a tool of learning) as well as to help students to learn (a tool for learning). A set of agreed rules enable a careful balance between the judgment (summative) and assistance (formative) function of tests. Summative assessments are delivered at the end of the course, whereas formative assessments occur throughout the course (in most cases during guided self-study sessions), to encourage students to study regularly and provide insight into their progress.

All curriculum components are assessed using an assessment method appropriate to the curriculum component (see the course descriptions published in OSIRIS course catalogue). By using a variety of study methods and corresponding assessment methods, the department aims to sufficiently assess knowledge, understanding, applied knowledge and skills. In design-based learning (DBL)/challenge-based learning (CBL) projects where students work in teams, group assessment as well as individual assessment takes place. The assessment of skills occurs throughout the curriculum in the different courses and during the graduation projects (BEP/internship/master graduation). Except for experimental work, all final examinations are offered twice a year.

Examiners are appointed on the basis of profiles drawn up by the Examination Committee and are responsible for the quality of assessments. Examiners are all academic staff members and experienced in setting up, grading and evaluating assessments. The examiner is typically the responsible lecturer of the curriculum component concerned. The competency "Testing and assessment" of the University Teaching Qualification Program (BKO) is viewed as the preferred qualification for examiners. PhD students and post-doctoral researchers, if they have the right expertise, can offer valuable assistance in testing and assessment under the supervision of an examiner. However, the deployment of assistants demands a number of requirements and measures to guarantee reliability and validity and to restrict the chances of fraud.

In the position of Teaching Assistant, students can be deployed under the responsibility of the examiner in question for assessment tasks and logistical support. Teaching Assistants enrolled in a Bachelor's or Master's program can be deployed under conditions as specified in the Regulations of the Examination Committee of Electrical Engineering.

### Assessment as a tool for learning

Since the introduction of the Bachelor College, the EE department has integrated formative assessment in all first-year courses in the form of mid-term tests counting up to 30% of the final grade. For some second-year and third-year study components formative assessment is still being used or students receive feedback on and insight into their progress during a study component.

Formative assessment is used in EE courses to activate students, but also to provide them with sufficient information on their progress with the aim of having the students manage their learning

and study behavior. This approach is materialized in the form of mid-term tests. Formative assessment is also used so that students get feedback during instruction and homework assignments. Feedback of mid-term tests is thus not only operationalized by giving feedback in the form of a score. In addition, the inspection moments both after the mid-term and final test offer opportunities for feedback and learning.

The assessment instruments used at the EE department vary per course as the assessment form is aligned with the learning outcomes and teaching methods. We find, therefore, courses in which the assessment form is carried out with open but also multiple-choice math questions (with or with the MentiMeter); short weekly quizzes with Canvas/OnCourse; diagnostic test questions to provide feedback on deficiencies, and inform about how to reach the desired level; and homework assignments, etc.

For courses with a project-assignment character in which not only knowledge but also skills and products (i.e. engineering systems design) are assessed, the form of assessment varies. For example, to test the skills and to provide formative feedback, rubrics (criteria in which levels of performance are defined) are used extensively. Rubrics are valuable tools to better ensure transparency, objectivity and inter-rater reliability. Other assessment forms to provide insight in progress are criteria list, peer assessment, or tutorials.

Regarding the bachelor and master thesis, criteria regarding different aspects, both content and skills, are applied at the EE department.

### The summative function of assessment

The summative function of assessment is used to determine whether the student has acquired the expected level of the course and bachelor year with the overall goal of administering a qualification in relation to the end terms of the study program.

***Table 1. Assessment methods used for different study methods***

| Study methods | Assessment methods used |
|---|---|
| **Lectures and/or instructions** | A combination of written exam (open book or closed book), (group) assignments, and /or oral exam. Use of mid-term and final (digital) assessments. |
| **Design-based learning projects (DBL)/ Challenge-based learning projects (CBL)** | A combination of various methods to be determined by lecturers: individual testing of theory by means of written exam (optional), skills assessment, registration of attendance, peer review, individual input in final discussion, individual contribution to group process, final discussion with the group, written reports, oral presentations and/or posters, skills assessments. |
| **Bachelor Final Project** | Oral test of theory and experiments (before, during and after execution), execution of project/experiments, written report, presentation. See for detailed information below. |
| **Internship** | Final report, presentation, student's communication during (the preparation for) the internship. See detailed information below. |
| **Master graduation project** | Oral test of theory and experiments (before, during and after execution), execution of project/experiments, written report, presentation. See for detailed information below. |

## Mid-term assessment

The department has a long history of mid-term tests in the first year of the bachelor. In the last few years, mid-term assessments have evolved from small formal examinations into feedback mechanisms. Teachers are experimenting with online systems or with traditional paper-based homework which is reviewed and graded, without the strict requirement that the work is done individually. In addition, we also implement diagnostic tests in order to identify deficiencies in prior knowledge and provide students with additional material to obtain the expected level. Depending on the learning outcomes (i.e. remembering, understanding, applying, analyzing, evaluating and creating) assessment forms, such as electronic multiple-choice quizzes and open questions, written examinations, oral presentations, design and project-based assignments, are selected.

## Bachelor Final Project (BEP)

In the Bachelor Final Project (BEP), students carry out an individual project of 10 ECTS and have the possibility to choose for an extension of 5 ECTS. These BEP projects are implemented at the end of the second semester of the third year of the Electrical Engineering (EE) and Automotive Technology (AT) bachelor programs, and every student has to work individually on his/her BEP. The assignments have a connection with the themes at the EE department. The BEP addresses the bachelor's expected end qualifications: the projects require the application of theory from the major EE into a realistic design in the area of electrical engineering while applying design skills and defining models. Students work in real-life projects and are to structure and specify the ill-defined problem, to make choices and communicate the result with peers and experts. The skills training included in the project is also aimed at that level. Relevant to the BEP is that the content and intended learning outcomes lead to final qualifications of our bachelor program.

The Bachelor Final Projects are assessed by an appointed panel of scientific staff from the department. The use of a panel results in a well-calibrated assessment process. The protocols are

included in the education and examination regulations. The protocols are accompanied by lists of criteria, an instruction for the numerical rating and the model of the evaluation form.
The direct supervisor of the student acts only as an advisor. There are standard evaluation forms. The Examination Committee oversees compliance with the protocols. If forms are not adequately filled out by the assessors, the student administration asks them to do so.

The BEP-assignments provide students with sufficient connection with current research activities within one of the research themes. This experience allows the students to achieve the end qualifications. The assessment of the individual BEP therefore includes the following criteria:

- The student shows insight into his/her own specialization. The student has to have a thorough knowledge of the theoretical knowledge of the Bachelor program and must be able to use this in practice.
- Design and research qualities: We grade quality/quantity of the work, originality/innovation, creativity/inventiveness, academic approach/critical approach.
- Execution/professional attitude: This aspect regards the planning, organization and implementation of technical meetings, networking and pro-activeness to carry out the research.
- Communication (report, presentation and defense): The written report needs to contain clear statements about the work as well as a clear formulation of the conclusions. During the oral presentation the student will be judged on the panel presentation and defense. The skills assessed at the end of the undergraduate program are also aligned to the expected end qualifications. These skills test the student's end level in terms of:
    - The application of basic theoretical knowledge from the Bachelor course in a concrete assignment.
    - The ability to structure and specify.
    - The application of design methods and draft models.
    - The making of choices and the reflection upon the chosen method.
    - The way to communicate results and discuss them with peers and experts.

## Internship

The internship is a 15 credit research or design project on a topic related to Electrical Engineering, supervised by a staff member of the department of Electrical Engineering. The internship is the ideal opportunity for an international and industrial experience. An internship may be preceded by lab trainings in order to be able to safely handle equipment and emergency situations. For the assessment, an internship evaluation form is being used on the categories: specialization, research and design, execution, report, presentation and defense. The internship supervisor assesses and grades the internship. The Professional Skills academic writing and presenting scientific information are integrated in the internship assessment. In case of insufficient results extra training by means of SkillsLab workshops or trainings on Academic Writing and/or Presenting can be advised.

## Master graduation project

The graduation project is a 45-credit research project on a topic related to Electrical Engineering, supervised by a scientific staff member of the department of Electrical Engineering. It can be carried out in a form and at a location agreed upon by student and supervisor. A graduation project takes 32 weeks full-time and without breaks.

A student is allowed to start with the graduation project if at most 10 credits of the study program, excluding the core courses, remain to be completed. Students need to register for their graduation

project with the consent of their supervisor. A registration involves the start and end date of the project, the research group or organization where the project is carried out, the title of the project and short description, the supervisor(s) and daily coaches of the project.

The length of the graduation project is monitored by the CSA EE. Extensions of the end date of the graduation project should be made in written to the Examination Committee with a motivation given by the supervisor. Extensions can be allowed to a maximum of two months.

Halfway the graduation project the supervisor is required to initiate the composition of a graduation committee. Any such committee consists of at least three voting members and is possibly extended with advisory members. The rules for the composition of the graduation committee are detailed in the Regulations of the Examination Committee of Electrical Engineering. The proposed graduation committee needs approval by the Examination Committee who appoints the members of the committee. After approval, the student is required to present the work, halfway in the project phase (16 weeks after the start of the project), to the graduation committee for feedback. This halfway presentation is used to provide suggestions and feedback on professional skills, on the report, technical suggestions on relevant literature, establish contacts, or discuss preferred research directions in the project. The final assessment (presentation and defense) is organized by the end date of the project and has a report, a public presentation and a non-public defense of the work as its main deliverables. The assessment of the work is performed on the basis of the following criteria:

1. Specialization (a student-centered evaluation).
   An assessment of the quality of the literature review, the level of specialized knowledge, disciplinary knowledge and the ability to connect the problem definition to the research field (or to sub questions).
2. Research and design (a work-centered evaluation).
   Formulation of research questions, quality and quantity of established results, creativity, originality and innovative value of the work, critical attitude toward results, methods, scope and perspective of the research.
3. Execution (a process-centered evaluation).
   Level of independence, commitment and dedication, time planning and effectiveness.
4. Report (a documentation-centered evaluation)
   Readability of the report, problem formulation, quality of content, structure and organization.
5. Presentation and defense (a communication-centered evaluation).
   The coverage of research outcomes, presentation skills, quality of supporting material, discussion skills.

The final grade of the graduation project is the mean value of the five subgrades of these categories (rounded to half integers). Students pass the graduation project if the final grade is 6.0 or higher. The final grade is only calculated if each category is completed with a minimum of 5.0 otherwise it shall be marked as NMR ‘not met requirements’ (NVD, ‘niet voldaan’). The complete assessment guidelines are specified in the Regulations of the Examination Committee of Electrical Engineering.

### The alignment between learning outcomes and assessment forms

Education and assessment are the core elements of the EE study program. Within the courses the didactical concept of aligning the learning outcomes with the teaching and learning methods, together with the assessment forms, is applied. This educational concept is central to the University Teaching Qualification program (BKO). The educational forms are consistently selected to support students to acquire the learning outcomes. Likewise, the assessment forms are chosen to measure students' performance. In doing so, the large variety in educational forms within the courses (e.g. interactive lectures, lab-trainings, tutorials, projects, etc.) are combined with assessment forms and instruments (computer tests, project work, quizzes, rubrics, etc.).

## 2.2.1 Vision on digital assessment

Due to the growth in the number of students, the experience with the corona pandemic, along with the practice of activating students during lectures, there are several numbers of initiatives for digital assessments. These experiences are related to the use of Canvas as a digital learning environment. A recent development within TU/e is the implementation of digital assessment for formative and summative testing. The following digital tools are being used:

- Canvas quizzes: for formative and summative assessment.
- Canvas SpeedGrader/peer assessment: for formative (feedback coming from teacher and/or peer group) and summative assessment.
- Ans Delft: digital test on paper or online, which gives transparent feedback to both the lecturer and the student.
- Mentimeter (to interact with students in class) for questions during classes, which gives direct feedback to both the lecturer and students.
- OnCourse: digital test in combination with STEP sticks.
- blended-learning methods such as pen casts (recording of digital-pen or handwritten work-out of exercises) and web lectures (short lectures), in an experimental stage, as a means of concisely explaining small topics from courses.

The department uses these methods for different purposes:

1. As formative mid-term assessments to enhance students' learning by providing them with timely feedback on their learning.
2. As a tool to engage students during lectures and provide teachers with insight on students' understanding by delivering short digital assessments during these lectures.
3. As summative assessment in a modular setting to foster active learning during the whole education period.
4. As a means to make more time available for students' supervision by reducing the time needed for grading exams.

To secure a safe assessment environment, TU/e has developed, in conjunction with a partner from the software industry, the Secure Test Environment Protocol (STEP) which is currently used for summative digital assessment.

Lecturers at the department of EE are assisted in setting up and implementing digital assessment by the departmental teacher support officer (TS). Instruction materials are published on the Canvas page 5EE00 Teacher Support Electrical Engineering.

## 2.3 Vision on fraud

A TU/e diploma is highly valuable. Students, society and the labor market need to be able to trust the value of this diploma. At TU/e, it is made clear to students that committing fraud[1] is incompatible with the conduct that is expected of them as future scientists and engineers. The Code of Scientific Conduct developed by TU/e is a point of reference for TU/e fraud policy. This code was based on the national VSNU Code of Conduct, which states that: "(employees of) institutes that fulfill a societal role are held to a proper exercise of their duties". TU/e has an integral policy on fraud consisting of four elements for the purpose of maintaining a culture of academic integrity:

1. Informing: The boundaries of what is permissible is communicated to the student in a clear manner by the university starting from the first year of enrolment: banners and flyers during exam weeks, email prior to the start of the exam period, information provision during mentor sessions to all first year students. During each written exam, students are informed which tools they may use, and which documents they may consult in case of open-ended exams. This information is included in the cover page of the written exam. In case of mid-term assessments, projects and assignments, students are informed that plagiarism is unacceptable.
2. Prevention: Any situations conducive to fraud will be avoided by the university and its students. For example, during final tests sufficient invigilators are set in; for summative e-assessments the Secure Test Environment Protocol (STEP) is used; to prevent students committing plagiarism, it is mandatory for BSc students to take a workshop (offered by the Information and Expertise Center) about how to use correct referencing and paraphrasing.
3. Detection: The University will ensure that in case cheating occurs during examinations this is detected by invigilators and reported to the Examination Committee involved. Reports and assignments are checked for plagiarism with the use of appropriate software packages (currently Ouriginal).
4. Imposing sanctions: In the event of fraud, sanctions will be imposed on the offending students that, in light of the breach of trust, are appropriate to the type of fraud committed. During AEB/AEM meetings, chairs of Examination Committees exchange cases about fraud and corresponding sanctions.

In the case of suspicion of fraud, the Examination Committee of the department in question is responsible for dealing with the student. Due to the share of elective courses and the supra-departmental basic courses, where there is collaboration in multidisciplinary teams, an action protocol has been designed for supra-departmental courses, to ensure equal treatment of students from different study programs and to prevent setting precedents.

[1] Any action or failure to act on the part of a student that makes it partially or completely impossible for the examiner to form an accurate opinion of the student's knowledge, understanding and skills, and/or deliberate attempts on the part of a student to influence any part of the examination process for the purpose of influencing the results of the examination is considered as fraud. Plagiarism is a specific type of fraud. This equally applies to any facilitating or complicit actions of student assistants in committing fraud by students.

In the case of the suspicion of fraud by student assistants both the Examination Committee and the supervisor of the student assistant are responsible for dealing with them. A protocol has been developed to guide this process.

# 3. Safeguarding the quality of assessment

## 3.1 Quality assurance cycle

In order to safeguard the quality of the programs, the EE department has a quality assurance system in place which consists of the following steps:

1. Drafting an education plan and corresponding assessment plan for the whole program. These plans are described in the Program and Education Regulations with corresponding evaluation plan, the Examination Regulations, the education guide, OSIRIS Catalogue and in Canvas.
2. Executing the education plan: delivering courses and projects that constitute the curriculum and facilitating the necessary means for teachers and students.
3. Executing the evaluation plan: discussing the outcomes of the evaluations with stakeholders and defining which actions need to be taken in order to address points of concern that arise from these evaluations.
4. Checking whether the actions mentioned under 3 are executed before the next delivery of the specific part of the curriculum.

Appendix 3 shows how the different responsibilities with respect to quality of assessments are divided between Examination Committee and management.

## 3.2 Assuring the quality of assessments

The primary responsibility for the quality of assessments is with the examiners. The Examination Committee is responsible for safeguarding the quality of assessments.

Each assessment should meet the following criteria: transparency, validity, reliability and efficiency:

**Transparency** prior to the start of the course, students are clearly informed about how and on what they are assessed. A brief description is published in OSIRIS catalogue; a detailed description is published on Canvas, either through the syllabus of the course or an assessment plan.

**Validity** the assessment covers the learning objectives. In validity, content (congruent with the learning objectives), level (the level of difficulty) and representativeness play a role.

**Reliability** the assessment makes a meaningful distinction between the students who have a good or less good command of the learning objectives. The quality of the assessment plays a role here (distinctive character, minimal chance of gambling, clarity), the circumstances under which the test is administered (standardization and objectivity) and the way in which the results are assessed (objective, accurate, realistic).

**Efficiency** There are two sides to efficiency: the amount of assessment moments, the spreading of deadlines etc. must be in proportion to the learning process. Efficiency also relates to the effort of the lecturer in relation to assessing the achievement of the learning outcomes by students.

Table 2 shows the measures taken to assure the quality of assessments.

*Table 2. Measures taken by the department to assure the validity, transparency, reliability and efficiency of assessments*

| | Measures taken before the exam |
|---|---|
| **Transparency** | In OSIRIS catalogue the assessment format is described. Prior to the start of the course, it is clearly mentioned in OSIRIS and Canvas how the course will be assessed and how the final grade is calculated. |
| | In each written assessment, the total score for the assessment as well as per question is clearly stated. |
| | Each written assessment contains a cover page with instructions for students and invigilators. |
| | Students are offered the opportunity to take practice exams which are representative of the actual exam. |
| **Validity** | In the assessment plan of the course, examiners describe how the different learning objectives are assessed. |
| | The lecturer defines beforehand how the subjects covered in the course are assessed and the level of learning objectives to be tested (e.g. knowledge, comprehension, application, analysis, synthesis, evaluation). |
| | The assessments are reviewed by at least one peer. Examiners can ask PhD students who supervised the guided self-study sessions to make the assessment prior to assessment delivery to check its validity. |
| | A copy of the exam which is reviewed by two examiners is handed in to the Examination Committee one week before the exam takes place. |
| **Reliability** | For each assessment examiners should have a model answer with a marking scheme. |
| | There are at least two examiners involved in composing and grading assessments. In most cases, each examiner will grade a specific part of the assessment. PhD students may be involved in checking exams under supervision of the responsible examiner. Final grading is always done by an examiner who is nominated by the Examination Committee. |
| **Efficiency** | Each quarter, the department makes an inventory of dates of mid-term tests and deadlines for reports and presentations and communicates this to the lecturers involved in the quarter for a certain year. Furthermore, in the final exam planning exams are spread as much as possible over the exam weeks.<br>TU/e has made a number of tools available (ANSDelft, OnCourse, Canvas quizzes) to make the assessment process less time-consuming for lecturers. |

## 3.3 Safeguarding the quality of assessments

### The Examination Committee

The Examination Committee is a statutory body and is appointed by the Departmental Board. The Committee is independent and is the highest authority with regard to safeguarding the standard of the degree program, including matters such as testing and fraud and all other aspects that are necessary to ensure that students who are awarded a degree have attained the outcomes for the relevant programs.

The Examination Committee determines, in an objective and expert manner, whether students have fulfilled the conditions set out in the Program and Examination Regulations (OER) with regard to the knowledge, understanding, competences and skills that are necessary to obtain a degree.

The composition of the Examination Committees is such that the required independence and expertise are guaranteed. For the Electrical Engineering Department, there is one joint Examination

Committee for the bachelor program EE, the Master program EE and the bachelor program AT. The committee consists of

- a chair
- a deputy chair
- three other members
- one external member, who is familiar with the role of the examinations committee, but who does not have teaching duties in the degree program(s) for which the Examination Committee is responsible and is charged, in any case, with safeguarding the independence of the Examination Committee.

The Examination Committee is supported by an official secretary. The Examination Committee meets at least once a month, except in the month of July.

It is a (one) task of the Examination Committee to safeguard the quality of the examinations and final examinations (Article 7.12b, under a, of the WHW) and to establish procedures and instructions within the framework of the OER for assessing and determining the results of examinations (Article 7.12b, under b, of the WHW) (T). It performs this task in a proactive and reactive manner, such that it can form an independent opinion of the quality of examinations and final examinations in terms of reliability, validity, transparency and feasibility.

Furthermore, the Examination Committee is proactively involved in the quality assurance processes and procedures at the department. The proactive role of an Examination Committee is shaped by, among other things:

- Consultation twice a year between the chair and vice chair of the Examination Committee, chair of the Program Committee, the program directors, manager ESA, policy advisor education and the dean of the department.
- Actively monitoring the assessment process within the department.

The chair of the Examination Committee is member of the AEB/AEM and provides input from this advisory board to the Examination Committee.

The Examination Committee issues an annual report that is discussed together with the department board. Possible actions taken for improvement are described in the annual report for education. The annual report includes also the resolutions of the Examination Committee to shape or improve the safeguarding of quality of exams for the next report period.

For more information the Regulations of the Examination Committee of Electrical Engineering can be consulted.

### The Program Committee

The (joint) Program Committee has an advising role regarding the quality of education, including assessment. Through student representatives, input about feasibility of the assessment plan and assessment methods can be gathered and discussed. The result of this discussion is shared with the program director and Examination Committee.

### Measures for safeguarding the quality of assessments

The Examination Committee takes specific measures for safeguarding the quality of an assessment, see Table 3. In this process, the quality assurance committee assists the Examination Committee by providing students' opinion as to whether the assessments were representative of the learning

objectives of the curriculum component, whether the students had enough time to finish the examinations, and whether the questions were clearly formulated. Furthermore, the quality assurance committee provides the Examination Committee periodically with an analysis of the results of examinations.

*Table 3. Measures taken by the Examination Committee to check the validity, transparency, reliability and efficiency of assessments*

| | Measures taken after the exam |
|---|---|
| **Transparency** | Through course surveys, students can report any irregularities that occurred during the exams. Every quarter, the Examination Committee receives a report of these irregularities and takes necessary actions when needed. |
| | The invigilators make a short report of each exam session. An overall report of all exams taken during the exam period is sent by ESA to Examination Committees. In case of irregularities, the Examination Committee takes further actions needed based on these reports. |
| **Validity** | Through course surveys, students give their views on the representativeness of the assessment. The Examination Committee receives an overview of these findings each quarter and takes necessary actions when needed. |
| | In case of irregularities (complaints, success rates are too high (>90%) or too low (<60%), the Examination Committee may start an investigation. |
| | Every three years, the department organizes a session with external experts to review exams and corresponding marking schemes, and a random selection of students' detailed exams and project reports. |
| **Reliability** | Examiners analyze the assessment results and in case of ambiguous or poor performing questions adjust the marking scheme after informing the Examination Committee. Examiners assure that no student is disadvantaged after adjustment of the marking scheme. |
| | The department organizes approximately 3 years after the NVAO accreditation an external review of exams of EE courses. Pilots will be performed during which randomly selected courses will be screened by external experts. |
| **Efficiency** | Through course surveys, students give feedback about the study load within the course and quartile and whether the assessment methods used are appropriate. |

### Safeguarding the quality of examiners

The quality of examiners is safeguarded through monitoring and through the provision of feedback on the quality of exams and assessments. The Examination Committee is responsible for the appointment of examiners. Examiners are appointed on the basis of expertise, experience competence. Examiners preferably completed the "Testing and Assessment" module of the BKO.

The dean of the department is accountable for the quality of the examiners. Responsibility for the quality of examiners lies with the examiners and with the educational directors. The Examination Committee is consulted on the quality of examiners and the Program Committee and the departmental board is informed about the quality of examiners, when necessary.

### Safeguarding a safe process for exam construction, taking, grading and archiving

In recent years TU/e has implemented specific software that facilitate exam construction and grading (OnCourse, AnsDelft). Teachers are assisted by Teacher Support officers and in some cases Teaching/teacher assistants (PhD students and postdocs for summative assessment and Student assistants for building large question banks for formative assessments). Another development is a new process for printing and archiving exam papers which is currently being implemented. Teachers can have their tests printed by a print and scan service. In view of these new processes, TU/e has

updated the document Central Exam Regulations @TU/e and drafted instruction manuals for teachers. Responsibilities and actors in safeguarding the validity, reliability, and transparency of assessment are described in the assessment policy document and the TU/e Central Examination Regulations.

| | Regulations where safety measures are described |
|---|---|
| **Exam construction** | Assessment policy, department of Electrical Engineering 2020<br>Module 'Assessment' in BKO program plan |
| **Exam taking** | Assessment policy, department of Electrical Engineering 2020<br>Central Exam Regulations TU/e, 2019 |
| **Exam grading** | Module 'Assessment' in BKO program plan |
| **Exam archiving** | Program and Exam Regulations |

Monitoring of the quality of assessment takes place, in the first instance, by the Quality assurance officer of the EE department (ESA-EE). Monitoring is done partly based on the corresponding quarter course evaluations (i.e. students' questionnaires) and reports of the program committee and by inspection of course pass rates, grade averages and grade distribution. ESA-EE takes action with specific regulations to control that the quality of assessment is maintained according to standards determined by the department. The Examination Committee reviews the evaluations, reports and the actions taken thereon, and requests the program director to take on additional actions as necessary.

## 3.4 Assessment plan

All courses include an assessment plan consisting of an overview of the main assessment components. The plan is reviewed every year. The basic information about the assessment is included in OSIRIS, the TU/e educational information system. The Education and Examination Regulations (OER) refers to this information in OSIRIS. This means that this information is also considered an integral part of these Regulations.

In the boxes below an overview is provided of core information per course in OSIRIS:

***Core information included in OSIRIS***

1. The academic year, the quarter in which a course is taught and the timeslot
2. The course code
3. The name of the course
4. The number of credits in ECTS
5. The level of the course
6. Course type (Bachelor College / Graduate School)
7. Department and capacity group
8. Lecturer
9. Follow-up subjects
10. Language
11. Course contents
12. Materials
13. Instructional modes (instructions with notebook, lectures, etc.)
14. The test types (written final exam, electronic final test, quizzes, mid-term test, individual instruction, group assignment, assignment with notebook, presentation / lecture, peer review skills test, report)
15. The form and the weighting of the assessment components
16. Entrance requirements
17. Course and test enrolment
18. The weights of all exam components
19. Contact e-mail.

Furthermore, the assessment dates are mentioned in MyTimetable. The Department Board will determine a timetable for written final tests in the first and second quarter of the degree program before August 15, which will be published no later than August 15. Written examinations in the third and fourth quarter will be published no later than December 15.

Detailed information about the assessment of each course that needs to be included in the study guide. Below an overview of the elements that are described in a study guide is presented:

***Core information included in study guide***

1. Setup of assessment
2. Test content
3. Learning goals
4. Determining results/marking periods
5. Dates of feedback and inspection
6. The form, the date and the weighting of the assessment components
   a. In case of group work: assessment criteria
7. The retake

With respect to the information provided in the boxes above, it becomes clear for the students in advance what is tested (in alignment with the learning outcomes or subjects of the course), how the learning outcomes are assessed, when the examinations are taken, the resit, together with what the

consequences are regarding the achievement or non-achievement of an assessment. Furthermore, relevant information included hereby is the weighing of the different mid-term assessment and how this weighing takes part in the final grade of the course, how it is assessed (and by whom), etcetera. Such a description provides transparency and allows the Examination Committee to carry out their control duties accordingly.

The total description of the courses is reviewed by the Program Committee (OC) prior to them being included in OSIRIS. The information about testing and assessment is submitted to the Examination Committee. Thus, the Examination Committee has the possibility to fulfill its controlling role regarding the mid-term assessment in advance.

In addition, the OC and EC have an advisory role towards the OER, in which this information on assessment is an important element. The Program Committee (OC) has the right to approve or reject the OER, and the OER is ultimately adopted by the EE Department Board.

## 3.5 Procedures for the draw up, take up and revision of quality of assessments

The assessment procedures are described in the examination regulations of the study programs. The examination regulations drawn up by the Examination Committee include the guidelines for drawing up, taking, assessing and analyzing tests. Other guidelines for the assessment are the Binding Study Recommendation (BSA).

Below an overview of the guidelines for written final examinations is provided:

### Procedure for the construction of final exams

The following procedures are followed by the EE department in the construction of final tests:

1. The assessment is developed by the examiner of the course or under his/her supervision.
2. The learning outcomes/contents of the course are used as starting point for the assessment. The examiner ensures that the test questions involve a representative investigation on the learning outcomes of the course.
3. The test includes an overview of the point scores per question that can be earned for each component. The answer and correction model are also prepared in advance.
4. The assessment is reviewed, discussed and approved by at least two teachers including the examiner, or under supervision of the examiner The other assessment elements of the course may be of a specific nature that the use a uniform procedure for the preparation thereof is not practical. Obviously, the requirements of transparency, validity, reliability and efficiency are applied to the total exam, but the assessment elements have to be revised.
5. The teachers inform the students, on the study guide, on the assessment method and system. Students have the opportunity to practice with similar type of exams (e.g. through old exams).

Adjustments in the planning of examinations are only allowed with the permission of the Departmental Board.

## Procedures to conduct final tests

Procedures for conducting final written tests at the EE department are:

***Procedures for handling in exam questions and answer model***

ESA EE ensures adequate facilities for the examinations with regard to the number of participating students and the specific characteristics of the exam. The teacher ensures that there are enough exemplars of the test in the location where the examination takes places. After the examination has ended the tests are collected by the teacher and/or the invigilator and taken by the teacher.

***Procedures for invigilators***

Presence of the faculty staff (i.e. teachers) during the examination: there should be present at least one teacher, expert in the subject matter, during the examination. If the examination is spread over several rooms, the subject matter expert must be present within 5 minutes. There are also invigilators present, but the subject matter expert is the one who can give answers regarding ambiguities of the exam questions, the aids and materials which are allowed, and clarify some issues. In case of '*force majeure'* and the teacher of the course cannot be present, the responsible teacher of that course must find a suitable replacement with enough subject knowledge and instruct him/her adequately. Instruction invigilators: In case that the faculty staff (i.e. teachers) do not want that students take the answer sheets and the scratch paper home after the exam has been completed, they can indicate this on the front page of the test. The exam is made on official TU/e paper. Scratch paper is not allowed to be taken, in principle, and it is not checked in any case.

Retrieving the test: Teachers should collect and take with them the tests at the end of the examination. If this, nevertheless, does not take place, the tests are taken by the Internal Affairs Department and included in the safe deposit box. The teachers are requested to collect the tests as soon as possible.

## Procedures for the revision of final tests

The procedures for assessing within the EE department are:

1. The tests of some of the participating students are checked using the answer model. After this first round has taken place, the answer model, if necessary, is adjusted.
2. If several teachers are involved in the revision and assessment of the test, they look preferably at their own question in all the tests instead of that they divide the tests among themselves and look at different questions.
3. The responsible teacher ensures that the procedures for the inspection of the students' tests take place within the adequate regulations.

## Procedure for the revision, handing in and administration of results

The results of all written tests should be made known within 15 working days after the test and will be announced in OSIRIS. The results of study components in the exam period in quarter 4 and the interim period that are part of the propaedeutical phase must be submitted no later than five working days after the examination period (and before 1 September).

The results of mid-term tests are made known within 5 working days, and in any case, not later than 5 days before the final tests. Teachers enter results digitally through Osiris Lecturer. Examinations in the form of a report, lab or assignment are not allowed to exceed the exam period of the quarter in which the study component is scheduled.

The department has a procedure for the late check-out of examinations:
- Two days before the closing date of the announcement of the results, if the results are not registered, the teacher receives an e-mail from the CSA-EE asking when the results can be expected. In case of '*force majeure*', the teacher (supported by reasons) can request the Examination Committee to allow a longer review period.
- At the end of the examination period, an overview of the examinations which has exceed the marking period, with deadlines and updated dates of publication, is sent to the Examination Committee, to the program directors and to other committees.

Thus, the Examination Committee will gain an insight of the extent of the problem and can then act consequently according to its tasks and responsibilities.

### Communication with students

Communication with students about examinations is done in different ways and channels. For each course the learning outcomes, educational assessment methods, and the re-inspection time are explicitly communicated to the students (e.g. via OSIRIS and CANVAS).

### Communication regarding regulations, complaints, fraud and plagiarism

Official information and documents such as the TU/e Academic Integrity and the TU/e Fraud Policy (inform, prevent, detect and sanction) is made known and available for students through the digital education guide: https://educationguide.tue.nl/programs/bachelor-college/majors/

On this website the links to the student statute, the OER and the RE are stated.

The Examination Committee studies the complaints and decides to take action.
In case of a serious complaint about a decision by the Examination Committee or the examiner (e.g. a mark), or if the admission to a master's program or binding study advice is concerned, the students can submit an appeal to the Examinations Appeals Board (CBE).

The RE mentions in art. 7.1 "Appeals to the CBE" and in art. 7.2 'Complaint against an examiner' the procedures students should follow to lodge complaints about an examiner to the Examinations Appeals Board.

### Measuring results: Instruments to measure the quality of exams

Assessment questions should meet the principle of validity. The table below gives an overview of the instruments that can be used to measure the representativeness (content validity) of assessment questions. It also indicates what the policy is within the department with respect to these instruments.

***Table 4. Instruments and policies concerning the measurement of the representativeness (content validity) of test questions***

| Instrument | Who | Policy at EE |
|---|---|---|
| Before: Making a test matrix. The matrix shows the relation between learning outcomes and questions part of an exam, given a particular subject and given a certain level (e.g. factual knowledge or application). This matrix reflects the goals of the assessment or components. | Lecturer | This instrument is increasingly used, especially by faculty staff, i.e. teachers, who have completed a course on 'Test construction' in the context of the BKO. This is strongly encouraged. |
| Before: Control by peers (fellow teachers) on content, form and response model (in case of open questions). | Peer review | Review by at least one peer is required. |
| Afterwards: Post-hoc analysis of test questions based on exam results. | Teacher / Test Expert / Quality assurance assistant | Support Central & EE department educational experts. |
| Afterwards: Course evaluations, feedback year councils | Quality assurance officer, SBE, students | Through the students (1st, 2nd, 3rd year council, pre-master or master board), comments go directly to the Program Committee about the representativeness of the tests. The Examination Committee receives complaints from students and deals with them personally or through the Program Committee. |
| Afterwards: Peer review (external) with the Electrical Engineering departments at the technical universities of Delft and Twente. | Examination Committee / quality assurance assistant | A pilot project was implemented on peer review of BEP reports. We want to keep using this method and implement it in courses. The aim is to monitor the final level and to exchange best practices. This is still in progress). |

Regarding the quality of exams, transparency is an important starting point. Transparency, in the context of assessment, is related to the methods and processes. These processes and procedures should be clearly visible to the students, and students should be informed about those. Table 4 gives an overview of the instruments that can be used in the measurement of the quality of the exams. The policy is also given with respect to these instruments.

***Table 5. Instruments and policy on measurement of transparency of examinations***

| Instrument | Who | Policy at EE |
|---|---|---|
| Before: Mandatory assessment instruction | Faculty staff (i.e. teacher) | Each final written exam includes a cover page where |

| | | |
|---|---|---|
| | | the assessment instructions for students and invigilators are displayed |
| Before: providing exams for practice | Faculty staff (i.e. teacher) | These are made available by teachers. Furthermore, the study association THOR maintains a database of recent tests regarding a large number of courses. |
| Afterwards: Course evaluations, curriculum evaluations, feedback year councils. | Quality assurance officer, students | Through the student (1st, 2nd, 3rd year council or Master Board). The Examination Committee receives complaints from students and deals with them personally or through the Program Committee. |
| Afterwards: Reports of invigilators. After each test period, the Examination Committee receives a report regarding the irregularities that have occurred during the examinations. | Education and Student Affairs | If necessary, the teacher will be contacted via the Examination Committee and/ or Program Committee. |

When reviewing the exams, the issue of the reliability is particularly of interest. Reliability depends on the degree to which the exam results are consistent regardless of the purpose. The metrology accuracy or reliability of an exam can be interpreted according to the classical test theory in two ways:

1. the degree to which agreement between two assessors is reached.
2. the extent to which scores with repeated measurement and by the same assessor are consistent.

In the table below an overview of the instruments and the EE policy with regard to the measurement of the reliability of the exams is provided.

***Table 6. Instruments and policy on measurement of reliability tests***

| Instrument | Who | Policy at EE |
|---|---|---|
| Answer Model | Peers | There must be a response model, which is approved in advance by peers. |
| Consultation between raters | Lecturers team | In case of multiple evaluators consultation should take place to agree on the reviewing assessment process. Preferably questions are divided, and not all the tests. |
| Post-hoc analysis of tests | Teacher /Assessment Expert | It is strongly encouraged. With the appointment of an assessment expert at the TU/e, a test analysis can be requested by the EC or the teacher, to show quality of tests from different perspectives. |

# 4. Safeguarding the attainment of the learning outcomes of the program

To safeguard the quality of the assessment of the bachelor's final project, the internship and the master's graduation project, the EE department has drawn up protocols for the assessment procedures that are included in the Examination Regulations. The protocols are accompanied by lists of criteria for the assessors, and the model of the assessment form to be used. The protocols clearly establish by whom, when and how the assessment should be made (including which aspects should be considered to what extent and which sub-parts of the assessment may or may not be compensated by other sub-parts of the assessment). The procedure in the event of an insufficient grade is described as well. Following the recommendations of the NVAO accreditation committee the assessment forms for the bachelor's final project and the master's graduation project now include more space for examiners to add extensive written comments about students' performance. Furthermore, the different levels for professional skills are part of the assessment and have been specified in a rubric as described in the document 'Professional skills Audit'.

The assessment of the Bachelor Final Project is done by two examiners being a(n) (assistant/associate) professor at the EE department, one of which being the supervisor of the project. The assessment of the internship in the Master's is done by the responsible lecturer in consultation with the external supervisor. For the graduation project in the master, the assessment is done by a committee. The committee has to consist of at least three voting members, at least two from EE, not all three from one EE group. The graduation supervisor and panel chair must be different persons.

The use of the assessment forms according to the prescribed model is mandatory. The Examination Committee has access to all assessment forms and supervises compliance with the protocols. Each graduate has to sign the TU/e code of scientific conduct and include this form in the report of the Bachelor Final Project/MSc thesis.

The Examination Committee is revisiting the grading system, the grading process and the meaning of grades for all types of student projects in the curricula of the department. Not only Master projects are taken into account, the process for all three types of projects (BEP, internships, Master) will be fine-tuned. An overview of grades of graduation projects and final bachelor projects over the preceding three years is reported and analyzed to see if there is any misbalance in the awarded grades in the different research groups over the years to avoid mark inflation and systematic bias.

The Bachelor Final Project and graduation project are evaluated through curriculum surveys. In these evaluations, students can give their opinion on various aspects of the BSc and MSc graduation, the supervision and the evaluation of the thesis. For the internship, separate surveys are held at least once in three years. Once in two years, a survey is sent to recently graduated alumni. In this survey, alumni are asked, among other things, about how well the program has prepared them for their career.

## Stakeholders involvement

The best indicator of the quality of graduates of our study program is the time they need to find a job in their field of expertise. Generally, all of our students found a job within a few months, most of whom already found a job at a much earlier stage. Through regular alumni surveys and the alumni

monitor, the EE department regularly monitors the connection between the study program and the labor market. The department has an Advisory Board which advises on education as well as research issues. This Board consists of representatives of the major employers for graduates of our programs (such as NXP, ASML, Philips and TNO). They actively take part in discussions about the level and content of the programs. Finally, there is intensive contact with the alumni association of the EE department, whereby the connection between education and the labor market is a major topic of conversation.

# 5. Innovation towards 2030

Moving towards 2030, TU/e is making room for a completely new education setting (including assessment), such as digitization and Challenge-Based Learning. TU/e works towards giving future students more room to define their own learning path and will learn more and more in an interdisciplinary setting. In view of these developments, TU/e has made a number of funds available to teachers to start experiments in their teaching. This bottom-up approach is supported by an early involvement of the program director to ensure that in such experimental settings the degree certificate quality is guaranteed, but also to gain insight on the effect of the experiments on students' learning on the one side and education support processes on the other side.

The vision of 2030 portraits that engineers are to solve societal problems, have research skills, develop creative and critical skills, and work in teams. The most prominent educational concept to develop the skills of the engineers of the future will be Challenge-Based Learning (CBL). In addition to DBL, it also encloses an educational approach to develop a number of competencies (e.g. design, communication, among other things) that support students' development and application of the theory in practical assignments. Furthermore, CBL will have the character of an open-ended project. Part of the learning goals will be defined by the students themselves as part of their personal development and the learning outcomes will not exactly be known beforehand.

With the revision of the Bachelor's program Electrical Engineering CBL will play a major role. The planning is to start a revised first year in September 2022. A curriculum committee is working on scenarios based on discussions with interdepartmental teams.

Possible components of the CBL active learning environment:

- Introductory lectures to give structure and coherence
- Online materials:
  - Online lectures
  - Many examples (application notes)
  - Assignments on topic detail level with solutions and explanation.
  - Remote labs
- 'Walk-in' lab training sessions
- Expert sessions
- Flipping the classroom
- Facilitate live interaction with teaching staff
- Training sessions on non-technical skills

- Additional CBL learning goals

Apart from the planned curriculum renewal the following experiments are being conducted at the department of Electrical Engineering.

## 5.1 Experimental education formats

***Electromagnetics II***

The second-year course in the bachelor program Electromagnetics II (5EPB0) experienced demotivation with students and quite a low passing rate.

Therefore, the teachers implemented the so-called student-led tutorials, which require a mandatory active participation of 60% of all the exercises during the tutorials. This is done in smaller groups (in total 17) of about 20 students, coached by a trained teaching assistant.

Another change to give students more responsibility is to make the mid-term an optional one. Students decided to make the mid-term exam (or not) in the first week of the course. In the end, after completing the course, the teachers and the Teacher Support/Quality assurance officer investigated the effects of these innovative changes.

The passing rate of the course increased from 20 to 30% (based on all enrolled students). When we only include the 'serious' enrolled students, who actually made the exam for example, the passing rate is almost 46%. Furthermore, the exam analysis showed that the students who chose to do the optional mid-term, did make their final exam better. So making the mid-term helped the students (in general) in understanding and completing the course successfully.

***Serious game: learning electricity markets***

Teachers can start to develop their innovative educational projects with financial support from program plan BOOST. A competitive game is designed to teach students at Electrical Engineering everything they need to know about how the electricity markets operate.

The game is a so-called *serious game*, which means that it will be developed for other purposes than merely the gamer's entertainment. This game is about the interaction between companies that produce electricity, and the markets on which they trade that electricity.

***Scalable Blended Teaching of Systems & Control***

The teachers are developing appropriate e-learning material such that students can gain insight in the fundamental theory outside the lecture hours, by watching videos or online tutorials. This will allow the actual classroom lectures to focus on further explaining theory in the context of relevant, easy to understand real-life applications and using a problem-solving approach.

The blended lectures will feature video bytes presenting practical problems and challenges to the students related to the Laboratory sessions and live scripts showing completed e-assignments related to Seminars. This type of rotational teaching will enhance the interconnection between Lectures, Seminars and Laboratory sessions and thus encourage students to focus on all activities with equal priority and interest. Also, it will facilitate in-course remediation of teaching material of activities as reflected by the data analytics provided by the Matlab Grader.

The wanted outcome: Using graded e-assignments for each seminar session will increase the motivation of students to solve problems, especially because the analysis of how many students have

solved which problem will be visible to all students. Furthermore, the graded e-assignments will replace the classical written mid-term.

Additionally, this platform will provide continuous feedback to students and lecturers regarding the students' understanding of the material and success of teaching, respectively. According to the teachers, the e-assignments will better assess the understanding of the taught material compared to a mid-term exam, because they will feature exercises from all seminars which will prepare the students better for the final exam.

# Appendix 1: Roles and powers

| Pre-conditions | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | University Council/JPC | Examiner | Manager ESA department | CM Exam planning- and fraud[2] | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Composition of and appointment to Examination Committee | | a / r | c | c | i | i | | i | i | | i | i | | | | WHW, Section 7.12, 7.12a and 7.12b, and OER, Article 2.10B and 2.11B |
| Examination Committee annual report | | a | c | r | | | | i | i | | | | | | | WHW, Section 7.12c paragraph 1 |
| Examination Committee annual report | | a | i | r | i | i | | i | i | | | i | | | | WHW, Section 7.12b paragraph 5, and model departmental regulations[3], Article 2.13B |
| Model OER | a / r | c | c | | c[4] | c[5] | c | | c[6] | | | | | | | TU/e Guideline BC+GS |
| Program and Examination Regulations program | | a | r | c | c | c | | i | r | | | i | | | | WHW, Section 7.13 and Section 7.14 |
| University-wide assessment policy | a / r | c | c | c | c | c | c | i | c[7] | i | i | | | | | TU/e Exam framework |
| Program assessment policy (content) | i | a | r | c | c | i | | i | c | | | i | | | | TU/e Exam framework |
| Examination regulations | i | | i | a / r | i | i | | i | i | | | i | i | i | i | OER + WHW Article 7.12b paragraph 1b |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | | |

2 CM ESA Chain Manager Exam planning and fraud

3 As guideline for the departmental regulations

4 Via JPC

5 Via UR

6 Also central ESA manager

7 Idem

| Pre-conditions | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | University Council/JPC | Examiner | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quality of examiners | | a | r | c | i | i | | r | | | | | | | | TU/e Exam framework |
| Safeguarding the quality of testing | i | i | c / i | a / r | c / i | | | c / i | i | | | | | | | Examination Regulations (WHW, Article 7.12b) |

| Teaching and Examination processes | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Program goals/ descriptors | i | a | r | c | c | | i | | | | i | | | | WHW, Section 5a.8, 5a.10a, 5a.13f and 5a.13g<br>WHW, Section 7.13 par 2c, OER |
| Program exam plan | i | c | a / r | c | c | | i | | | | i | | | | TU/e Exam Framework |
| Course exam plan | | | c | i | i | | a / r | i | | | i | | | | BC regulations/ OER |
| Learning objectives for each course | i | | a | c | c | | r | i | | | i | | | | Curriculum |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | |

| Teaching and Examination processes | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Making sample exams available | | | | i | | | a/r | | | | i | | | | BC regulations/ OER |
| Exam matrix/ exam schedule | | | | i | | | a/r | | | | i | | | | Assessment policy and program exam plan |
| Exam + exam quality | | | i | i | | | a/r | | | | i | | | | Examination regulations |
| Assessment procedures and model | | | | i | | | a/r | | | | i | | | | OER, and Examination |
| Determining the pass mark/ guess correction | | | | i | | | a/r | | | | i | | | | OER, and Examination[8] |
| Assessment | | | | i | | | a/r | | | | i | | | | Examination regulations |
| Exam analysis and evaluation | | | i | a | i | | r | r | | | | | | | Examination regulations |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | |

[8] at the least: make clear in advance how pass mark is determined ; opportunities for modifications later are clear; how to deal with borderline cases

| Organization of testing | | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | Examiner | Manager ESA department | Manager ESA central | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | Requirements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Registering for scheduled exams | | | | | | | | i | i | | | a | r | i | i | | OER |
| Holding an exam | Deliver exam for holding | | | a | | | | r | i | | | | | | | i | OER, TU/e central examination |
| | The actual holding itself | | | | i | | | r | | a | | | r | r | | r | OER, TU/e central examination |
| | Organiza-tion/ mange-ment in order to hold the exams | | | c/i | c/i | | | i | | a | c/i | | | i | | r | TU/e Exam Framework/ TU/e policy concerning studying with a functional impairment |
| Scheduling of exams | | | | c | c | | | c | r | a | c/i | i | i | i | r | c/i | Examination regulations |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | | | |

| Exemptions and degree certificates | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | Examiner | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | CBE[9] | Requirements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exemptions | | | i | a/r/ | | | c | i | | | r[10]/ i | | | | | WHW Section 7.12b lid 1d |
| Degree certificate | | | i | a/r/ | | | | r | | | r[11]/ i | | | | | WHW Section 7.11 |
| Double degree | | | | a/r/ i | | | | i | | | R/ i | | | | | Directive Executive Board TU/e with regard to internal double diplomas |

| Fraud and complaints | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | Examiner | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | CBE | Requirements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prevention of and information about fraud | | | a/ r | r | | | r | r | | | r | i | | r | i | Assessment policy CE&C, and TU/e wide agreements regarding fraud prevention |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | | |

[9] CBE: Examinations Appeals Board

[10] At the request of the student

[11] Idem

| Fraud and complaints | CvB (via Dean) | Department Dean | Director of Education | Examination Committee | Program Committee | Department council | Examiner | Manager ESA department | CM Exam planning- and fraud | CM Study progress | Student | invigilator | Exam planner | Exam coordinator | CBE | Requirements |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Detection of cases of suspicion of fraud | | | | i | | | a/ r | | i | | c/i | r | | | | OER, Student statute and Examination Regulations |
| Dealing with cases of suspicion of fraud | | i | i | a/r | | | c/ i | | | | c/i | c / i | | | | WHW, Section 7.12b paragraph 2, procedure for cases of fraud that affect more than one department |
| Dealing with complaints in relation to exams | | | | r[12] / c | | | | | i | | c/i | | | | a / r | WHW, Section 7.12b paragraph 3 and 4 Program and Examination Regulations |
| a=accountable, r= responsible c= to be consulted, i= to be informed | | | | | | | | | | | | | | | | |

[12] Amicable settlement

# Appendix 2: Core subjects and curriculum trajectories

| Core subject | Trajectory |
|---|---|
| The theory of electromagnetic phenomena, their generation and analysis. | Electromagnetics |
| The combination of materials with different conductivity properties and their modeling. | Physics |
| The manipulation of charge movements. | Networks & Electronics |
| The acquisition of physical quantities and their transformation into useful measurements or control signals to achieve desired actuation. | Signals & Systems |
| The processing of information (acquisition, storage, organization, transformation, retrieval, presentation and broadcasting) as electromagnetic (including optical) signals, and the organization of components with such functions in so-called information systems. | Computer Engineering |
| The systems and techniques for signal transmission over large distances Telecommunication<br>Energy conversion, where at least one form is of electrical or magnetic kind. | Electrical Energy |
| The methodology which is the basis of the design procedures for artifacts and the adequate management of their complexity with a keen eye for trade-offs between all performance characteristics. | Design projects |
| A solid background in mathematics and an understanding of the methods of physics. | Mathematics / Physics |
| This learning trajectory contains basic courses which provide the foundation for moulding the 'Eindhoven Engineer' and develops a student's transversal knowledge. | Generic Engineering |

The Automotive core essentially consists of the same topics, but with a focus shift because of the Automotive perspective. Specifically, there is substantial attention for the interaction between technology and society in the area of mobility, from a user perspective and from a societal perspective. There is also more attention for the mechanical aspects in the physics core. Both focus shifts are implemented at the cost of depth in other topics.

## Additional core subject and trajectory for the Automotive Technology track

| Core subject | Trajectory |
|---|---|
| The interaction between technology and society in the area of mobility | *Mobility* |

Our learning trajectories meet the standards on the international ASIIN and ABET standards. The generic engineering learning trajectory forms a basis for the entire bachelor. Furthermore, the design projects in the field of Electrical Engineering are very important.

# Appendix 2a. Elaboration of the learning outcomes of the BSc program in Electrical Engineering

The general program objectives, the content requirements and choices based on the DSFR and the academic criteria (*Meijers criteria*) have been merged into a set of intended learning outcomes for the bachelor and master programs in Electrical Engineering. This has resulted in the following set of intended learning outcomes.

| Learning outcomes of the BSc program | Study components where the learning outcome is elaborated |
|---|---|
| BSc graduates are qualified to degree level within the domain of engineering science and technology. | All study components |
| BSc graduates understand and are capable of interpreting the basic knowledge (theories, methods, techniques) of electrical engineering or automotive. | Calculus, Applied Natural Sciences, Data Analytics, USE basic, Engineering Design, USE |
| BSc graduates have a solid background in mathematics and an understanding of the methods of physics | Calculus, Applied Natural Sciences |
| BSc graduates are competent in the relevant domain-specific discipline(s) of Electrical Engineering at the level of a Bachelor of Science, in particular:<br>*a. the theory of electromagnetic phenomena, their generation and analysis*<br>*b. the combination of materials with different conductivity properties and their modeling*<br>*c. the manipulation of charge movements*<br>*d. the acquisition of physical quantities and their transformation into useful measurements or control signals to achieve desired actuation*<br>*e. the processing of information, being acquisition, storage, organization, transformation, retrieval, presentation and broadcasting of information as electromagnetic (including optical) signals, and the organization of components with such functions in so-called information systems*<br>*f. the systems and techniques for signal transmission over large distances*<br>*g. energy conversion, where at least one form is of electrical or magnetic kind*<br>*h. the methodology which is the basis of the design procedures for artifacts and the adequate management of their complexity with a keen eye for trade-offs between all performance characteristics*<br>Additionally, Automotive Technology bachelors have knowledge of and understand…<br>*i. the societal and individual interaction with mobility technology*<br>*j. mechanics, static as well as dynamic (vibrations)*<br>*k. energy conversion to and from mechanical energy* | All study components except USE Basic, Data Analytics, Engineering Design, USE |
| BSc graduates are able to conduct research and design under supervision. | Engineering Design, all DBL's, Bachelor Final Project |

| | |
|---|---|
| BSc graduates are aware of the significance of other disciplines (interdisciplinary work). | Calculus, Applied Natural Sciences, USE basic, Data Analytics, Engineering Design, USE, Elective program |
| BSc graduates take a scientific approach to non-complex problems and ideas, based on current knowledge. | Data Analytics, all DBL's, USE, Bachelor Final Project |
| BSc graduates possess intellectual skills that enable them to reflect critically, reason and form opinions under supervision. | All study components |
| BSc graduates are good at communicating the results of their learning, thinking, acts and decision-making processes. | USE Basic, all DBL's, USE, Bachelor final Project |
| BSc graduates can plan and implement their activities. | Engineering Design, all DBL's, USE, Bachelor Final Project |
| BSc graduates are aware of the temporal and societal contexts of science and technology (comprehension and analysis). | USE |
| In addition to a recognizable domain-specific profile, possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. Here, multidisciplinary means focusing on other relevant disciplines needed to solve the design or research problem in question. | Engineering Design, USE, elective program |

# Appendix 2b. Elaboration of the learning outcomes of the MSc program in Electrical Engineering

| Learning outcomes of the MSc program | Study components where the learning outcome is elaborated |
|---|---|
| MSc graduates are qualified to degree level within the domain of 'science engineering & technology'. | All program components |
| MSc graduates command the discipline touching on the forefront of the knowledge (latest theories, methods, techniques). | All program components |
| MSc graduates are competent in the relevant domain-specific discipline of Electrical Engineering. | All program components |
| MSc graduates are able to conduct research and design independently. | Internship, graduation project |
| MSc graduates have the ability and attitude to include other disciplines in their research, where necessary. | Internship, graduation project |
| MSc graduates have a scientific approach to complex problems and ideas. | All program components |
| MSc graduates possess intellectual skills that enable them to reflect critically, reason and form opinions. | All program components |
| MSc graduates have the ability to communicate the results of their learning, thinking and decision-making processes at an international level. | All program components |
| MSc graduates are aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work. | Internship, graduation project |
| In addition to a recognizable domain-specific profile, possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being focused on other relevant disciplines needed to solve the design or research problem in question. | Internship, specialization path, elective program |
| MSc graduates have the ability and attitude to seek new potential applications, taking the social context into consideration. | Internship, graduation project |

## Appendix 3a. Learning outcomes BSc related to Meijers criteria

At Eindhoven University of Technology, academic criteria for the bachelor and master programs (the so-called *Meijers criteria*) were formulated by a special committee at university level, the *Platform for Academic Education at Eindhoven University of Technology*. There are seven criteria classes:

| | Meijers criteria |
|---|---|
| **1** | Disciplinary baggage |
| **2** | Research |
| **3** | Design |
| **4** | Science (scientific approach) |
| **5** | Reasoning and reflecting (intellectual skills) |
| **6** | Cooperating and communicating |
| **7** | Interpreting and anticipating (temporal & social context) |

each of which has been specified into more detail, for a bachelor level as well as for a master level. The criteria roughly align with the *Dublin descriptors* for first and second cycle degree program, and provide a basis for the development, analysis and evaluation of academic education. The criteria are approved by the NVAO. They align closely to the learning outcomes for the bachelor and master programs in Electrical Engineering.

| | Learning outcomes of the BSc program Electrical Engineering |
|---|---|
| **A** | BSc graduates are qualified to degree level within the domain of engineering science and technology. |
| **B** | BSc graduates understand and are capable of interpreting the basic knowledge (theories, methods, techniques) of electrical engineering or automotive. |
| **C** | BSc graduates have a solid background in mathematics and an understanding of the methods of physics |
| **D** | BSc graduates are competent in the relevant domain-specific discipline(s) of Electrical Engineering at the level of a Bachelor of Science, in particular:<br>*a. the theory of electromagnetic phenomena, their generation and analysis*<br>*b. the combination of materials with different conductivity properties and their modeling*<br>*c. the manipulation of charge movements*<br>*d. the acquisition of physical quantities and their transformation into useful measurements or control signals to achieve desired actuation*<br>*e. the processing of information, being acquisition, storage, organization, transformation, retrieval, presentation and broadcasting of information as electromagnetic (including optical) signals, and the organization of components with such functions in so-called information systems*<br>*f. the systems and techniques for signal transmission over large distances*<br>*g. energy conversion, where at least one form is of electrical or magnetic kind*<br>*h. the methodology which is the basis of the design procedures for artifacts and the adequate management of their complexity with a keen eye for trade-offs between all performance characteristics*<br>Additionally, Automotive Technology bachelors have knowledge of and understand…<br>*i. the societal and individual interaction with mobility technology*<br>*j. mechanics, static as well as dynamic (vibrations)*<br>*k. energy conversion to and from mechanical energy* |
| **E** | BSc graduates are able to conduct research and design under supervision. |
| **F** | BSc graduates are aware of the significance of other disciplines (interdisciplinary work). |
| **G** | BSc graduates take a scientific approach to non-complex problems and ideas, based on current knowledge. |

| | |
|---|---|
| **H** | BSc graduates possess intellectual skills that enable them to reflect critically, reason and form opinions under supervision. |
| **I** | BSc graduates are good at communicating the results of their learning, thinking, acts and decision-making processes. |
| **J** | BSc graduates can plan and implement their activities. |
| **K** | BSc graduates are aware of the temporal and societal contexts of science and technology (comprehension and analysis). |
| **L** | In addition to a recognizable domain-specific profile, possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. Here, multidisciplinary means focusing on other relevant disciplines needed to solve the design or research problem in question. |

In the matrix below, the relationship between the learning outcomes of the BSc program in Electrical Engineering offered by TU/e and the Meijers criteria are shown:

| Meijers criteria for BSc programs | Meijers criteria xx is covered in learning Outcome xx of the BSc program in Electrical Engineering |
|---|---|
| **1** | A, B, C, D |
| **2** | E, F, L |
| **3** | E, F, L |
| **4** | A, B, G, I |
| **5** | G, H, I, J |
| **6** | F, I, J, K, L |
| **7** | K |

## Appendix 3b. Learning outcomes MSc related to Meijers criteria

At Eindhoven University of Technology, academic criteria for the bachelor and master programs (the so-called *Meijers criteria*) were formulated by a special committee at university level, the *Platform for Academic Education at Eindhoven University of Technology*. There are seven criteria classes:

| | Meijers criteria |
|---|---|
| **1** | Disciplinary baggage |
| **2** | Research |
| **3** | Design |
| **4** | Science (scientific approach) |
| **5** | Reasoning and reflecting (intellectual skills) |
| **6** | Cooperating and communicating |
| **7** | Interpreting and anticipating (temporal & social context) |

each of which has been specified into more detail, for a bachelor level as well as for a master level. The criteria roughly align with the *Dublin descriptors* for first and second cycle degree program, and provide a basis for the development, analysis and evaluation of academic education. The criteria are approved by the NVAO. They align closely to the learning outcomes for the bachelor and master programs in Electrical Engineering.

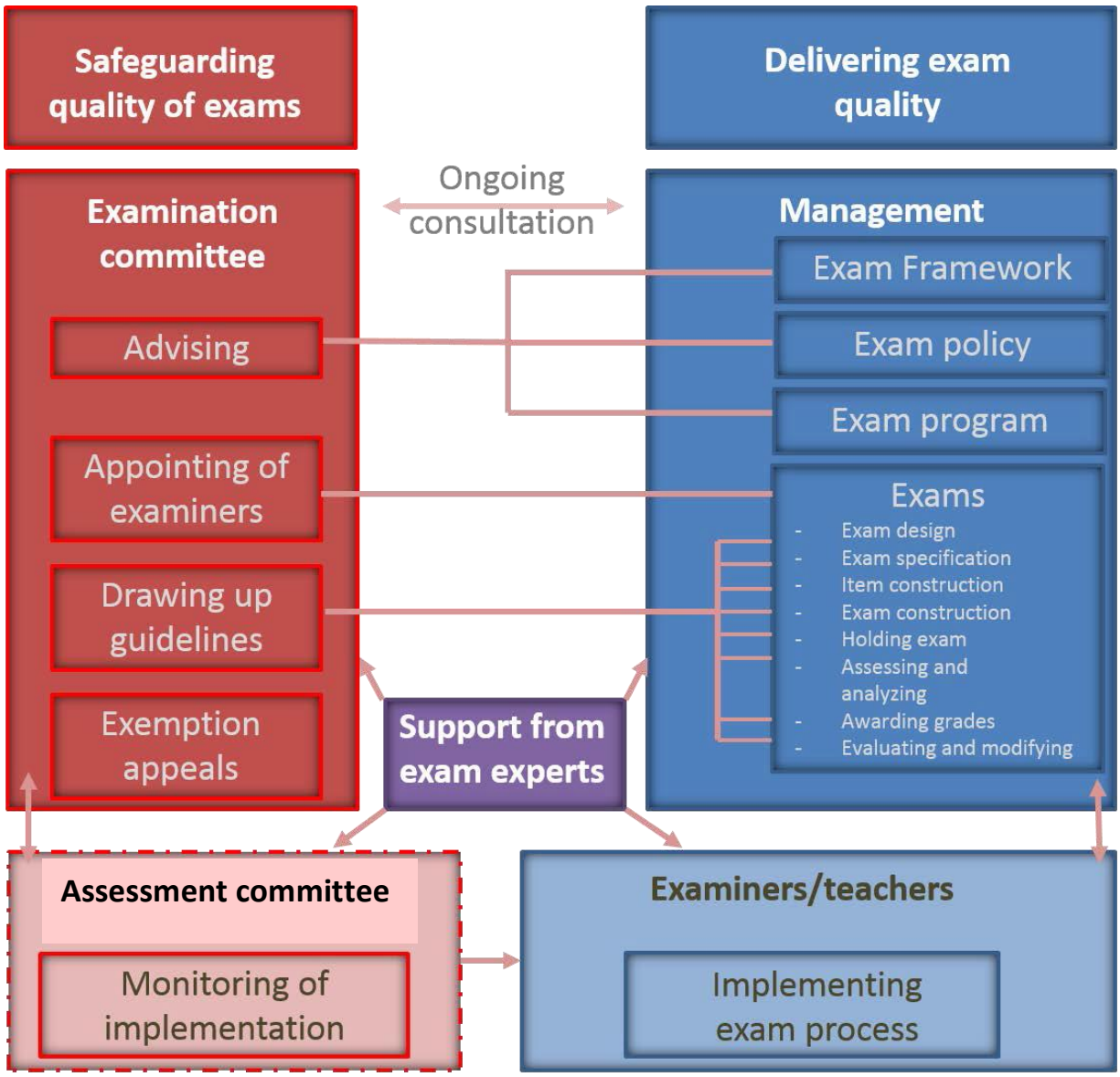
| | Learning outcomes of the MSc program |
|---|---|
| **A** | MSc graduates are qualified to degree level within the domain of 'science engineering & technology'. |
| **B** | MSc graduates command the discipline touching on the forefront of the knowledge (latest theories, methods, techniques). |
| **C** | MSc graduates are competent in the relevant domain-specific discipline of Electrical Engineering. |
| **D** | MSc graduates are able to conduct research and design independently. |
| **E** | MSc graduates have the ability and attitude to include other disciplines in their research, where necessary. |
| **F** | MSc graduates have a scientific approach to complex problems and ideas. |
| **G** | MSc graduates possess intellectual skills that enable them to reflect critically, reason and form opinions. |
| **H** | MSc graduates have the ability to communicate the results of their learning, thinking and decision-making processes at an international level. |
| **I** | MSc graduates are aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work. |
| **J** | In addition to a recognizable domain-specific profile, possess a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being focused on other relevant disciplines needed to solve the design or research problem in question. |
| **K** | MSc graduates have the ability and attitude to seek new potential applications, taking the social context into consideration. |

In the matrix below, the relationship between the learning outcomes of the MSc program in Electrical Engineering offered by TU/e and the Meijers criteria are shown:

| Meijers criteria for BSc programs | Meijers criteria xx is covered in learning Outcome xx of the BSc program in Electrical Engineering |
|---|---|
| **1** | A, B, C |
| **2** | D, E, J |
| **3** | D, E, J |
| **4** | A, B, F, H |
| **5** | F, G, H |
| **6** | F, I, J, K |
| **7** | I, K |

# Appendix 4: Ensuring versus safeguarding

The division of the responsibilities of the Examination Committee and management at TU/e.




*Based on Van Zijl & Jaspers (2012), Joosten-ten Brinke & Van der Linen-Straatman (2012). Reviewers can assess the quality of an exam before it is held; a test committee may be appointed by the Examination Committee, whether or not with specific points of attention concerning the safeguarding of the quality of exams.*