COMPUTER SCIENCE AND ENGINEERING

FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

EINDHOVEN UNIVERSITY OF TECHNOLOGY

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REPORT ON THE BACHELOR'S PROGRAMME COMPUTER SCIENCE AND ENGINEERING AND THE MASTER'S PROGRAMME COMPUTER SCIENCE AND ENGINEERING OF EINDHOVEN UNIVERSITY OF TECHNOLOGY

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

Bachelor's programme Computer Science and Engineering

Name of the programme:	Computer Science and Engineering
CROHO number:	56964
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Specialisations or tracks:	None
Location:	Eindhoven
Mode of study:	full time
Language of instruction:	English
Programme specific details:	Minor in Education
Submission deadline NVAO:	01/05/2020

Master's programme Computer Science and Engineering

Name of the programme:	Computer Science and Engineering
CROHO number:	60438
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specialisations or tracks:	Computer Science and Engineering (CSE) Security Technology (IST) Data Science in Engineering (DSiE) EIT Digital Data Science (EIT) Erasmus Mundus Joint Master Degree Big Data Management and Analytics (BDMA)
Locations:	Eindhoven (CSE + DSiE) Eindhoven + Nijmegen (IST) Eindhoven + one EIT partner institution Eindhoven, Brussels, Barcelona (BDMA)
Mode of study:	full time
Language of instruction:	English
Programme specific details:	Minor in Education
Joint / Double degree programmes:	BDMA – triple degree EIT – double degree
Submission deadline NVAO:	01/05/2020

The visit of the assessment panel Computer Science to the faculty of Mathematics and Computer Science of Eindhoven University of Technology took place on 1 and 2 October 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 15 April 2019. The panel that assessed the bachelor's programme Computer Science and Engineering and the master's programme Computer Science and Engineering consisted of:

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) Van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- A. (Antonia) Wildvank, owner and manager of the company Wildvank Management en Advies;
- Prof. dr. ir. J. (Jan) Aerts, full professor Visual Data Analysis at the University of Hasselt and associate professor Visual Data Analysis at the faculty of Engineering Science at KU Leuven (Belgium);
- N. (Nienke) Wessel BSc, master's student Computing Science and bachelor's student Mathematics and Linguistics at Radboud University [student member].

The panel was supported by M. (Mark) Delmartino MA, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's and master's programme Computer Science and Engineering at the Faculty of Mathematics and Computer Science of Eindhoven University of Technology was part of the cluster assessment Computer Science. Between June and December 2019 the panel assessed 29 programmes at 10 universities. The following universities participated in this cluster assessment: Leiden University, Delft University of Technology, University of Utrecht, Eindhoven University of Technology, Open University, University of Amsterdam, Vrije Universiteit Amsterdam, Radboud University, University of Groningen and University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. P.A. (Peter) Hildering MSc. was project coordinator for QANU. P.A. (Peter) Hildering MSc. and M. (Mark) Delmartino MA acted as secretary in the cluster assessment.

During the site visit at Eindhoven University of Technology, the panel was supported by Mark Delmartino, who is a certified NVAO secretary.

Panel members

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

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) Van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- Prof. dr. J.J. (John-Jules) Meyer, full professor Computer Science and Artificial Intelligence at the University of Utrecht;
- Drs. L. (Lennart) Herlaar, owner/director at Redbits.nl, a company specialised in software development and IT consultancy, and assistant professor Computer Science at the Faculty of Science of Utrecht University;
- A. (Antonia) Wildvank, owner/CEO at Wildvank, Management en Advies, specialised in IT-management and -consultancy;
- Prof. dr. ir. J. (Jan) Aerts, full professor Visual Data Analysis at the University of Hasselt and associate professor Visual Data Analysis at the faculty of Engineering Science at KU Leuven (Belgium);
- Drs. H.C. (Jeroen) Borst, senior consultant Smart Cities at TNO;
- Prof. dr. P. (Petros) Koumoutsakos, full professor Computational Science at ETH Zürich (Switzerland);
- Prof. dr. ir. J.M.W. (Joost) Visser, Chief Product Officer at Software Improvement Group (SIG) Nederland and professor Large-scale Software Systems at Radboud University;
- Drs. E.A.P. (Ewine) Smits, Manager in Advanced Analytics & Big Data at KPMG Nederland;
- Prof. dr. D.P. (Danilo) Mandic, full professor Signal Processing at the department of Electrical and Electronic Engineering of Imperial College London (United Kingdom);
- Dr. ir. J.C. (Job) Oostveen, Research Manager at the Department Monitoring and Control Services at TNO;
- Prof. dr. B.A.M. (Ben) Schouten, full professor Playful Interactions at Eindhoven University of Technology;
- Dr. ir. N. (Nico) Plat, owner/CEO at Thanos IT-consultancy and architecture;
- N. (Nienke) Wessel BSc, master's student Computing Science and bachelor's student Mathematics and Linguistics at Radboud University [student member];
- E. (Evi) Sijben BSc, master's student Computing Science in the specialisation track Data Science at Radboud University [student member];
- B. (Baran) Erdogan, third-year bachelor's student Computer Science at University of Amsterdam [student member];
- M. (Martijn) Brehm, third-year bachelor's student Computer Science at University of Amsterdam [student member].

Preparation

On 21 March 2019, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on 9 May 2019. During this meeting, the panel members received instruction on the use of the assessment framework. The panel also discussed their working method and the planning of the site visits and reports.

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

Before the site visit to Eindhoven University of Technology, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair

and secretary. The selection consisted of final bachelor projects, master theses and their respective assessment forms, based on a provided list of graduates in the academic years 2016-2017, 2017-2018 and 2018-2019. A variety of topics and tracks and a diversity of examiners were included in the selection. The secretary and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available projects and theses. After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. The secretary collected all initial findings and questions and distributed these amongst all panel members.

At the start of the site visit, the panel discussed these initial findings, identified the key issues to be discussed during the sessions, and agreed on a division of tasks during the site visit.

Site visit
The site visit to Eindhoven University of Technology took place on 1 and 2 October 2019. Before and during the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme management, alumni and the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. Nobody made use of this opportunity.

The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations.

The visit was concluded with a development conversation, in which the panel and the programmes discussed various development routes for the programmes. The result of this conversation is summarised in a separate report.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, following measures were taken: the panel composition ensured regular attendance of (key) panel members, including the chair, and the project coordinator was present at the panel discussion leading to the preliminary findings of each programme at all site visits.

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

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

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

Meets the standard
The programme meets the generic quality standard.

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

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

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

Positive
The programme meets all the standards.

Conditionally positive
The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

Negative
In the following situations:
- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

SUMMARY JUDGEMENT

BSc Computer Science and Engineering

This evaluation concerns the bachelor's programme Computer Science and Engineering (BCS), a three-year full-time 180 EC programme offered by the Department of Mathematics and Computer Science at Eindhoven University of Technology.

The BCS programme aims to train and educate young professionals in order for them to progress onto an appropriate master programme or embark on a professional career in the field of computer science. According to the panel, the programme has a clear profile, which originates in the vision of the university and is implemented through the Bachelor College. The profile and ambitions of BCS are reflected properly in the intended learning outcomes, which in turn are grounded in the national 4TU criteria, the European-wide Dublin Descriptors and the international ACM curriculum. The panel considers that the formulation of the intended learning outcomes appropriately reflects the discipline, level and orientation of the programme. The panel thinks highly of the attention to professional skills and invites BCS to ensure that also the scientific dimension of academic skills be explicitly addressed in the learning outcomes.

The teaching-learning environment of the BCS programme is up to standard. The curriculum is coherent and its contents are in full alignment with the intended learning outcomes and the international disciplinary requirements. The final project constitutes a relevant exercise that fits the design-oriented profile of the programme. The educational concept is appropriate and implemented rigorously. Talented students attending the honours programme or enrolling for a second bachelor degree appreciate these additional opportunities. The programme is feasible; measures to enhance the BSA rate and to reduce the average study duration prove to be effective. Teaching staff is highly qualified and appreciated by students for their disciplinary know-how, didactic competencies and availability. Student services organised by the Department and through the study association GEWIS facilitate the study period of BCS students. The panel noticed that the programme recently underwent two significant changes: the gradual introduction of a new curriculum and the adoption of a selection procedure to counter growing student numbers. The panel understands that these changes are impacting on the teaching-learning environment but considers that the management is taking adequate measures to mitigate their effects. Furthermore, the panel thinks highly of the opportunities for educational experiments offered by the Department through the Education Innovation group. Notwithstanding the panel's overall appreciation, there is one element that requires further attention: the explicit and visible coverage in the curriculum of certain academic skills such as academic writing and research methodology.

Student assessment is well organised in the BCS programme. The policy and principles underlying the course assessments are up to standard. The educational concepts of design-based and active learning are applied in the day-to-day reality of teaching and assessment and are appreciated by students. The panel considers that course assessments are valid, reliable and transparent. It also welcomes the programme's explicit attention to fraud prevention. The Examination Committee has appropriate expertise and, together with the safeguarding committee, plays an important role in assuring the assessment quality of the BCS programme. Based on its sample review, the panel considers that both the process and the assessment of the final project are well documented. Nonetheless, it encourages the programme to reconsider certain aspects of the current assessment process insofar as individual grading is concerned. Hence, the panel invites the Examination Committee to monitor that all students verifiably achieve every learning goal of the final project and that their specific contributions to the bachelor project are motivated in the final grade.

Students who graduate from the BCS programme are adequately prepared for a follow-up study or a position on the labour market. Having established that all final bachelor projects meet at least the minimum requirements of what can be expected from a final project at bachelor level—and are often of much higher quality—it is fair to state that the intended learning outcomes of the BCS programme are achieved at the end of the curriculum. While most BCS graduates pursue a master's degree, a

significant minority decides to enter the labour market as employee or entrepreneur. The panel considers that the BCS programme constitutes a relevant preparation for these graduates as well. In this regard, the programme is clearly delivering on its double aim.

In sum, the panel concludes that the quality of the bachelor's programme BCS is up to standard on all accounts, hence its overall positive conclusion.

Bachelor's programme Computer Science and Engineering

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

MSc Computer Science and Engineering

This evaluation concerns the master's programme Computer Science and Engineering (CSE), a two-year full-time 120 EC programme offered by the Department of Mathematics and Computer Science at Eindhoven University of Technology.

The CSE programme aims to deliver T-shaped engineers: graduates with a solid scientific foundation in one or two areas, excellent professional skills and broad multidisciplinary knowledge and experience. According to the panel, the profile of the CSE programme originates in the vision of the university, is implemented through the Graduate College, and reflected in the intended learning outcomes. Moreover, the link of the programme with the professional field is particularly strong. The panel considers that the intended learning outcomes reflect the discipline, level and orientation of the programme. Nonetheless, the formulation of the domain-specific part of the ILOs can be more harmonised across the respective tracks, while the distinctiveness of the CSE track and its streams deserves further attention through refined learning outcomes. In this regard, the panel welcomes and supports the current efforts of the programme's curriculum committee.

The teaching-learning environment of the CSE programme is up to standard. The curriculum of the respective tracks is coherent and its contents are in alignment with the profile, the intended learning outcomes and the international disciplinary requirements. The final project constitutes a relevant exercise that fits the research-oriented profile of the programme. The educational concept is appropriate and implemented rigorously. Talented students attending the honours programme or enrolling for a second master degree appreciate these additional opportunities. The programme is feasible. Faculty is highly qualified and appreciated by students for their disciplinary know-how, didactic competencies and availability. Student services organised by the department and through the study association GEWIS facilitate the study period of CSE students. The panel noticed that the CSE programme underwent several curriculum adjustments over the past few years and that student numbers are growing much faster than the staff equivalents. The panel understands that these changes are impacting on the teaching-learning environment but considers that the management is taking adequate measures to mitigate their effects. In this regard, the panel thinks highly of the recent professionalisation opportunities for teaching staff to set up educational experiments through the Education Innovation group and of the online Skills Lab, where students can test and practice academic skills.

Student assessment is well organised in the CSE programme. The policy and principles underlying the course assessments are up to standard. The educational concepts of research-oriented and active learning are applied in the day-to-day reality of teaching and assessment. The panel considers that course assessments are valid, reliable and transparent. It also welcomes the programme's explicit attention to fraud (prevention). The Examination Committee has appropriate expertise and, together with the safeguarding committee, plays an important role in assuring the assessment quality of the

CSE programme. Based on its own review, the panel considers that both the process and the assessment of the final master projects is well documented; the assessment forms are transparent and informative, provided they are completed correctly. Nonetheless, the panel sees room for improvement in quality assuring the final thesis grades obtained outside TU/e, in calibrating the grades across tracks and assessment committees, and in completing all (not just most) thesis assessment forms in an insightful way. Hence it invites the programme to address these issues and the Examination Committee to monitor the final master thesis grades and their motivation systematically.

Students who graduate from the CSE programme are adequately prepared for—and successfully enter—both the labour market or a PhD trajectory. Having established that the master theses are of high quality, it is fair to state that the intended learning outcomes of the CSE programme are achieved at the end of the master curriculum. According to the panel, the programme is clearly delivering on its ambition to educate T-shaped engineers.

In sum, the panel concludes that the quality of the master's programme CSE is up to standard on all accounts, hence its overall positive conclusion.

Master's programme Computer Science and Engineering

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair, em. Prof. dr. T. (Theo) D'Hondt, and the secretary, M. (Mark) Delmartino MA, of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 23 January 2020

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

BSc Computer Science and Engineering

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

Findings

Profile
The bachelor's programme Computer Science and Engineering (BCS) is offered by the Department of Mathematics and Computer Science of Eindhoven University of Technology (TU/e). The programme is existing for quite some time already; since 2012, it is provided within the framework of the university-wide Bachelor College. At the time of the previous accreditation visit in 2013, the bachelor's programme consisted of two tracks—Software Science and Web Science. In the meantime a curriculum redesign took place: the current BCS programme is offered since 2017-2018 and consists of one major (computer science and engineering) which resembles the former Software Science track but continues to attract a diverse group of students. The panel visited Eindhoven in October 2019: BCS was entering its third year of implementation while students from cohorts 2016 and before were finishing their study according to the old curriculum.

BCS is a three-year programme that aims to train and educate young professionals in order for them to progress onto an appropriate master programme or embark on a professional career in the field of computer science. To reach this goal, students acquire cognitive skills in computer science and engineering, practical capabilities in software design, professional skills and general academic skills. The panel learned during the visit that BCS constitutes a challenging educational programme in computer science and engineering that rests on three pillars: (1) a solid background in computer science, (2) with an design orientation, and (3) allowing some degree of flexibility for students to design their own study programme through electives. Furthermore, as part of the Bachelor College, BCS offers a broad foundation that is common to all TU/e engineers and includes societal awareness and professional skills.

Intended learning outcomes
The programme aims are reflected in the intended learning outcomes (ILOs) of BCS, which are listed in Appendix 2 to this report. The panel noticed that the ILOs consist of 10 general learning outcomes, which are common to all TU/e bachelor programmes, and of 13 domain-specific learning outcomes. The latter outcomes have been formulated taking into account the so-called 'Meijers criteria' for academic bachelor's curricula in engineering, which were set by the four Technical Universities (4TU) in the Netherlands as a translation of the Dublin descriptors for higher education in engineering.

There is a common understanding among Dutch universities offering computer science programmes that the so-called ACM Computer Science Curricula 2013 serve as domain-specific framework of reference for undergraduate programmes. The panel gathered that this is also the case for the bachelor's programme BCS, whose ILOs cover the eleven characteristics of computer scientists as formulated by the Association for Computer Machinery. These characteristics, as well as a link to the reference document, are provided in Appendix 1 to this report.

Studying the extensive information in the self-evaluation report, the panel found that the programme ILOs have been formulated correctly and reflect the provisions of the Meijers criteria (and as a result also the Dublin Descriptors) and the domain-specific reference framework. Comparing the BCS programme to the domain-specific profile, the panel noticed that the differences are minor and reflect

the profile of the TU/e programme: BCS emphasises theoretical subjects such as discrete structures, mathematics and computational science, while paying somewhat less attention to programming languages, concurrency and system fundamentals.

While acknowledging the quality and relevance of the current ILOs, the panel did notice that the academic skills part of the ILOs mainly cover academic skills that also serve professional purposes, such as teamwork and communication. It encourages the programme to also include academic skills (e.g. research methodology or academic writing) in the learning outcomes to better reflect the research skills that students acquire in the programme.

Professional field
Further to the above-mentioned design orientation, the panel learned that the industry dimension is very much embedded in the programme. In fact, the entire TU/e including BCS is situated within and oriented towards Brainport Eindhoven, a technology region in which companies, governments and educational institutions work together. This involvement is formalised among others through the Professional Advisory Board. The panel learned during the visit that this Board consists of representatives of the professional field, including alumni of BCS, who meet three times per year and inform both the Department and programme management of domain-specific developments and of the expectations (potential) employers from industry have towards (bachelor) graduates in computer science and engineering.

Considerations
The panel considers that the bachelor's programme BCS has a clear profile, which originates in the vision of the university and is implemented through the educational model of the Bachelor College. The panel subscribes to the three pillars of the BCS programme, which are well motivated and fit the profile and educational model.

BCS has a double goal as it prepares students for both a master's programme and the labour market. According to the panel, these ambitions are reflected properly in the intended learning outcomes, which in turn are grounded in the national 4TU criteria, the European-wide Dublin Descriptors and the international ACM curriculum. Moreover, the panel thinks that the programme's involvement of, and orientation towards, the professional field is particularly strong.

The panel considers that the ILOs are appropriate: their formulation reflects adequately the domain (computer science and engineering), the level (bachelor) and the orientation (academic) of the BCS programme adequately. The panel thinks highly of the attention to professional skills. It invites the programme to ensure that also the scientific dimension of academic skills is explicitly addressed in the learning outcomes.

Conclusion
Bachelor's programme Computer Science and Engineering: the panel assesses Standard 1 as 'meets the standard'.

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

Findings

Curriculum
The bachelor's programme BCS amounts to 180 EC, which are spread equally over three years of four quarters each. Since 2012, the university-wide Bachelor College hosts all bachelor's programmes, including BCS. Every curriculum consists of four components: common courses for all TU/e students in the context of the Bachelor College; a major focusing on the programme-specific

courses; courses on the perspectives of Users, Society and Enterprise (USE); and elective courses. Appendix 3 provides an overview of the BCS curriculum as offered to cohorts 2017 and after.

The panel obtained extensive information on the BCS programme and its curriculum in the self-evaluation report and the annexes. The current BCS curriculum is relatively new: it was prepared by a dedicated curriculum committee between 2015 and 2017 and implemented gradually as of 2017-2018. Studying the materials, the panel found that the BCS curriculum has a relevant and coherent structure of common, discipline-specific and elective courses and projects. Together the curriculum courses and projects cover the intended learning outcomes, as well as the eleven characteristics of computer scientists and the fourteen knowledge areas defined by the ACM Curricula 2013. According to the panel, the BCS curriculum is in full alignment with the programme profile, the ILOs and the international domain-specific requirements.

Furthermore, the panel understood from the discussions that the curriculum format, which is imposed by the Bachelor College, contains several strong elements, such as the five common courses, the harmonised course size of 5 EC, the number of elective courses, and the attention to professional skills in the curriculum. The Bachelor College also made the explicit choice to schedule the first elective course already in the second quarter of all bachelor programmes and not to include a study period abroad in the curriculum.

A particular feature of the curriculum is its explicit attention to professional skills: communication, reflection, cooperation, planning and organising, and handling scientific information. These general academic skills are taught and practised in several courses, the design-based learning (DBL) projects and in the final project. Students use scrums as a way to organise team projects from the first year DBL-project onward. They also have a pitch assignment before a panel of recruiters. With the support of the study association GEWIS, students are trained on how to have effective meetings, on academic writing and on the art of convincing. Students indicated both in the report and during the discussions that they appreciate this attention to professional skills. According to the panel, the university's focus on professional skills constitutes a particular added value of the programme and sets it apart from other bachelor programmes in computer science.

An important item for discussion during the site visit was the final project, which consists of a software engineering project (SEP) and amounts to 10 EC. The SEP offers a setting that reflects a real-life project: a team of about 10 students develops a software system prototype for a real customer in a short period of time. Through the SEP various academic skills are practised and assessed. Students indicated to the panel that they very much appreciate the SEP although some students mentioned that individually they had not practised all skills because students focus on particular tasks within the project team. As the SEP constitutes the main deliverable to demonstrate that learning outcomes have been achieved, the panel has reviewed several projects before the site visit. Its findings on quality and assessment are described in the next sections. The panel understood from the extensive materials and the discussions that the final project is well-organised and documented. According to the panel, SEP constitutes a very relevant final exercise that fits the design-oriented profile of the programme. The panel learned during the visit that more research-oriented academic skills are not explicitly addressed in this final project but covered in other courses and projects. Moreover, (honours) students can opt to do an additional bachelor research project of 10 EC. Students who had taken this research project thought it provided complementary competencies and constituted a good preparation for the master programme. Without wanting to compromise the particular value of the SEP, the panel invites the programme to consider making the research project a more mainstream component for all students.

Students who desire more challenges can participate in one of the university-wide or departmental Honours tracks, which address major societal and scientific questions and challenges. The Department offers two 30 EC tracks on competitive programming and artificial intelligence. Alternatively, students can combine BCS with a bachelor's degree in Applied Mathematics and obtain two bachelor degrees in three years with a slightly higher study load. The panel understood from

current and former Honours students that they highly appreciate these opportunities because they broaden and deepen their knowledge, skills and contacts. Students mentioned that the honours tracks are well organised and publicised, include an evaluation after year one and require students to produce a personal development plan.

Language of instruction
As of 2011 the BCS programme is offered in English. The panel noticed that this change of language is properly motivated in the materials: the programme wants to optimally prepare students for a career in an international setting and the Brainport region expects graduates to have international skills. Moreover, offering an English language programme has led to a higher and more diverse intake. Currently, international students constitute 20-25% of the intake and the share of female students has increased from 5% (in 2012) to 13% (in 2018). The academic staff is also part of the international environment. In 2018, one-third of the lecturers on the CSE programmes were international, a rate that is likely to increase when the entire university switches to English as *lingua franca* in 2020.

Educational concept
The programme's educational concept is based on principles set by the Bachelor College: BCS is design-oriented, aimed at both cognitive and practical skills, and encourages students to actively engage in their own learning process. These features are operationalised in a curriculum structure with learning trajectories, dependencies between courses, and activating courses with extensive attention to feedback. Most courses consist of a combination of plenary lectures, small tutorial sessions, medium-sized instruction sessions and lab sessions where students work in pairs. Several courses in year one have weekly homework exercises on which students receive feedback. Moreover, each first-year course has at least two interim test moments with a summative and formative function as both homework and tests count towards the final grade. Later on, students apply the acquired knowledge and receive feedback through practical assignments, while each course has at least one formative interim test.

Furthermore, the design-based learning (DBL) projects offer testbeds for introducing scrumming as an agile software development method in which professional skills are addressed in a natural domain-relevant way. Since the start of the new BCS curriculum, the scrum learning trajectory has been extended from the final project to the DBL projects in year one and two. The panel gathered from the discussions with students and staff that the educational principles are upheld in the courses and projects, that students welcome this approach and that they particularly like the regular formative feedback. Several interviewees indicated moreover that working together is stimulated, while there is also proper attention to producing and assessing individual contributions in group work. The panel appreciates both the educational concept and the way in which it is implemented in the programme. The focus on DBL is not only a clear choice, according to the panel, but also an appropriate approach for an engineering programme.

Intake
Since the previous accreditation visit, the number of incoming students has increased substantially from 126 (in 2013) to 346 (in 2017). In order to maintain educational standards, the Executive Board and the Department Board decided to restrict the number of freshmen to 250 and 275 in 2018 and 2019, respectively. The panel obtained extensive information on the selection procedure and on the activities organised for potential students. Students indicated that the procedure is clear; they like the online test which reflects properly the key parts of the study. Students also appreciated the Open Day which was organised after the test as they had the opportunity to discuss the test questions and meet peer candidates and academic advisers. According to the panel, the selection is organised meticulously; moreover, potential points for improvement will be taken into account in the forthcoming selection rounds.

Feasibility
The panel learned that the Bachelor College originated among others to improve the success rates of TU/e programmes. The current BCS programme has a clear structure with a limited number of parallel courses. At the end of the first year, students receive a Binding Study Advice (BSA), which is set university-wide at 45 EC. BCS students are supported and monitored in different ways during the first year: those who fail courses after the first exam period are invited for a meeting with the academic advisors; after two quarters, they receive a pre-BSA advice. The panel gathered from the materials that about two-thirds of the students obtain a positive BSA, while one quarter drops out and the remainder switches to other programmes. Until now, neither the increase in student numbers nor the raise of the BSA threshold from 40 EC to 45 EC have affected this result. However, the number of students who obtain all 60 EC within one year has substantially increased over the years. Students reported both in the written materials and during the site visit that overall the courses are of an appropriate level and a reasonable study load. They appreciate the homework assignments and mid-term tests because they are a good indicator of the individual student's progress. Students confirmed to the panel that they are expected to be actively engaged with the study materials, which in turn increases their chances of passing the courses and obtaining a positive BSA. The panel thinks highly of the different components within the programme that help students during year one and notices that the resulting positive BSA figures are quite high. Taken all elements together, the panel found that both the BCS curriculum as a whole and its course components are feasible.

Of all students passing the BSA, almost 40% finishes the programme in the set time frame of three years, while another 25% does so in four years. These figures reflect the most recent situation and have been increasing over time. The panel learned that one reason for this positive trend is the programme's decision to organise the final project three times per year instead of once. This decision in turn has resulted in a decrease of the average study duration from 48 months (in 2013) tot 40 months (in 2017). Nonetheless, a consistent share of 20-25% of students continues to need five years or more to finish their study. Several interlocutors indicated that students have part-time jobs in the field of computer science that cause delay and distract them from finishing the degree programme. The panel compliments the programme for its successful efforts to reduce the average study duration. It is aware that very often reasons for completing the study with a considerable delay are outside the scope of the programme.

Staff
The self-evaluation report provides an overview of the permanent staff members in the sub-department Computer Science at TU/e since the previous accreditation. Currently there are 70 staff members, including 9 full professors and 5 lecturers. Two-thirds of the staff is Dutch; only 9% of the permanent staff is female. This share is somewhat lower than the slowly yet consistently growing share of female students. Most staff have a university teaching qualification (UTQ) or are in the process of obtaining one. The English language requirement for staff is set at CEFR level C1 and should be demonstrated through the English lecturer assessment by the university's language centre. While students indicated that almost all teachers speak adequate English, the panel noticed that only half of the staff have such English language certificate. It encourages the Department to pursue certification of its teaching staff more actively.

In terms of full-time equivalents (fte), staffing in the sub-department increased from 45 fte (in 2013) to 58 fte (in 2018). In that same period, the number of computer science students (on both programmes together) has increased much more rapidly, from 265 (in 2013) to 850 (in 2018). In order to accommodate the growing staff-student ratio, the Department has taken several measures, including the appointment of additional faculty, PhD teaching assistants, temporary lecturers with a 100% teaching load, and academic advisers. The panel gathered from the materials and the discussions that across the university, the number of students is growing (much) faster than the staff equivalents. Nonetheless, the panel noticed that both at central and at department level, the staffing issue is on the agenda of the management.

Students indicated to the panel that they think highly of the domain expertise, didactic qualities and availability of the staff. They are aware that the workload of staff has been growing and appreciate that teaching staff nonetheless go to lengths to be approachable and help students in their educational development.

In line with the university's educational vision for 2030, the Department recently installed the Educational Innovation group: it consists of academic and support staff and is led by the chair of Technology Enhanced Education of Mathematics and Science. Through this group, academic staff can propose educational experiments and ask for professional support in didactics, ICT, learning analytics, project management, and the dissemination of experiments. Because additional teaching capacity is available, teachers can invest time in these innovations. The panel learned that these innovation projects often serve to pilot didactical approaches that cater for growing student audiences. Moreover, the university-wide TEACH training programme for lecturers includes courses on topics such as developing and implementing teaching, testing and evaluation. The panel thinks highly of these initiatives and welcomes the initiative of the Department to have a dedicated teacher support officer who assists staff in the professionalisation of their courses.

Facilities
The Department of Mathematics and Computer Science is situated on four floors of the MetaForum building. This modern building also houses the university library and has many student workspaces. Students can book rooms for project work. In the last few years the rise in student numbers has led to a shortage of lecture rooms. The panel learned that several measures were introduced to mitigate this situation, including an adapted schedule with evening classes. In order to accommodate courses with more than 300 participants, live streaming is offered. Less interactive lectures are compensated by organising digital Q&As, discussion fora, and dedicated office hours. Students indicated that they do not like the evening classes but understand why these have been scheduled. They do appreciate, though, that the lectures are streamed and can also be watched afterwards.

The panel gathered from the materials that the programme features both academic advisers and mentors who guide students throughout their study. Students indicated in the report that they had not always been satisfied with the quality of the mentors and that the academic advisers did not have sufficient time to deal with students. During the visit, students confirmed that this had been the case before, but that the programme has taken effective measures in the meantime to raise the number and quality of the student mentors, to explain to students the task division between mentors and academic advisers, and to increase the availability of the academic advisers. Both mentors and academic advisers are now much more helpful and, within their respective roles, meet adequately the expectations of students.

Students play an important role in the quality system of the programme. They fill in course evaluation forms at the end of each quarter and participate in informal quarterly feedback meetings (*kringgesprekken*) with lecturers. These sessions are used to facilitate quick adjustments to the course. In addition to discussing course and curriculum evaluation results, students on the programme committee have a say in proposals concerning curriculum changes and can signal flaws and possible improvements. Students indicated that most teachers are open to their feedback and take the survey results seriously. An important development in this respect is the presentation by the academic advisors at the quarterly kick-off sessions on the attention points that were raised in the past and how these will be addressed in the future.

Furthermore, the study association for students of the Department of Mathematics and Computer Science, GEWIS, plays an important role in building a community with and providing services to students. Its education officer is strongly involved in the quality assurance cycle, organising the quarterly feedback sessions with every cohort. Moreover, the study association connects students to staff through monthly receptions in the GEWIS home in the MetaForum building and organises career orientation activities such as lunch lectures and company visits. In addition to GEWIS, international students can also join Cosmos, the international student association of TU/e.

Considerations
The panel considers that the teaching-learning environment of the BCS programme is up to standard. The curriculum is coherent and its contents are in full alignment with the programme profile, the intended learning outcomes and the international disciplinary requirements. The final project constitutes a relevant exercise that fits the design-oriented profile of the programme. The educational concept is appropriate and implemented rigorously. Talented students attending the honours programme or enrolling for a second bachelor degree appreciate these additional opportunities. The programme is feasible; measures to enhance the BSA rate and reduce the average study duration prove effective. Faculty is highly qualified in terms of both disciplinary know-how and didactics. Student services organised by the Department and through the study association GEWIS facilitate the study period of BCS students.

The panel noticed that the BCS programme recently underwent two significant changes: the gradual introduction of a new curriculum and the adoption of a selection procedure to counter growing student numbers. The panel understands that these changes are impacting on the teaching-learning environment but considers that the management is taking adequate measures to mitigate these effects. Furthermore, the panel thinks highly of the professionalisation opportunities for teaching staff to set up educational experiments through the Education Innovation group in the department.

While the quality of the teaching-learning environment is definitely appropriate, there is one element which requires further attention: the explicit and visible coverage in the curriculum of certain academic skills such as academic writing and research methodology. In this regard, the programme may want to consider making the research project a more mainstream component for all students.

Conclusion
Bachelor's programme Computer Science and Engineering: the panel assesses Standard 2 as ' meets the standard

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

Findings

Assessment system
The panel obtained extensive information in the self-evaluation report and the annexes on the principles that underpin student assessment in the BCS programme. It gathered from the written materials that the bachelor's programme adheres to the university's Exam Framework and is implementing the principles set by the Bachelor College and the Department's Assessment Policy. The panel also looked into the BCS Assessment Plan, which provides a comprehensive overview of the assessment methods that are used in the courses and projects to demonstrate that graduates achieve the intended learning outcomes at the end of the BCS curriculum. Formal arrangements concerning assessments are laid out in Education and Examination Regulations and in the Examination Committee's rules and regulations.

Throughout the programme students are confronted with various test formats: learning goals related to knowledge and comprehension are mostly tested by open and multiple-choice questions; learning goals aimed at application and problem-solving are often assessed through (homework) assignments. In line with the educational concept that students take an active attitude towards their own learning process, the Bachelor College has stipulated that students who sign up for a course will also participate in its assessment. The panel learned that most courses include some form of formative assessment. These assignments are increasingly organised and assessed in a digital way, which in turn allows students to get fast feedback on their progress and performance.

Students indicated in the written materials and during the discussion that they appreciate the assignments, the formative feedback and the mid-term exams because these tests help them staying on track during the course and prevent them from postponing their study work. In this respect, the assessment principles are well aligned with the educational principle of active learning.

Course and thesis assessments
The panel noticed that the assessment principles underlying the programme are sound and have been rigorously implemented in all courses. On site the panel looked into course materials and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that assessment is transparent: all provisions and documents are available in the digital education guide. Moreover, students know well in advance what they need to know for the exam and how they will be assessed. Each quarter ends with a two-week exam period; once grades are registered, students can inspect and discuss their exam and its grading.

As part of its thesis review, the panel studied a sample of five Software Engineering Projects (SEP), group projects with an individual assessment. In order to pass SEP, students need to fulfil all individual skill assignments. Their individual grade is based on the group grade and adjusted by at most one point. This adjustment is calculated following reviews by peers, the project management and the supervisor. The group grade relates to the quality of the product, the process, the code, and the satisfaction of the customer. The panel learned that further to comments from students, the assessment method was adjusted taking into account also the quality of coding. Asked whether the limited adjustment margin for the individual grade did not promote free-riding or put off the particularly talented or ambitious students, the programme indicated that the process entails intermediate peer reviews and discussions with project management in order to identify free-riders or other problematic behaviour at an early stage. Students can be—and have effectively been—taken out of teams if they do not participate properly. Moreover, students usually compose their own teams, which allows them to select colleagues with similar ambitions.

Based on its own sample review, the panel noticed that overall, both the process and the assessment of these final projects are documented adequately. Grading sheets are very elaborate and in all cases the group grade had been sufficiently motivated. According to the panel, the approach is a valid way to evaluate both a collective work and the performance of many individuals. In this regard, the panel is convinced that individual students can demonstrate through SEP that they have achieved all individual learning outcomes. Nonetheless, and in line with the students' remark that there is a division of tasks within each SEP team, the panel advises the programme to look for ways in which each student is exposed explicitly to each learning goal of the final project. Furthermore, the panel sees room for improvement in establishing the individual grade of the team members: until now, the adjustment of the group grade seems based more on a collective and comparative rather than an individual appreciation of the contributions of the respective team members. Moreover, the panel found that the way in which the individual assessment forms were completed did not give sufficient insight in how the individual grade had been obtained. In fact, the reviewed assessment forms contained hardly any motivation why the individual grade had been adjusted.

Examination Committee
The Examination Committee is responsible for safeguarding the quality of assessment and the realisation of the intended learning outcomes in the BCS programme. The panel noticed from the discussion that the individual members of the committee have adequate expertise to fulfil their quality assurance tasks. It appreciates the committee's decision to create within its own small structure a safeguarding committee that executes ad hoc specific in-depth tasks such as monitoring the quality of course assessments or investigating the reliability of final project grades. Moreover, the Examination Committee insisted with the programme management to uphold individual grade variations. According to the Examination Committee, there have been no official complaints from students regarding the assessment and (individual) grading of the final project.

The departmental Exam Policy includes a section on fraud, describing how students and lecturers are informed about fraud prevention and how it is detected and sanctioned. The Examination Committee plays an active role in maintaining this policy. The panel learned that because the number of fraud cases in the first year had increased, teachers were encouraged to explicitly state in the course guide what is considered to be fraud. Plagiarism is by far the most commonly occurring type of fraud. In order to make students aware of academic integrity and the consequences of committing fraud, a reflection assignment on the Code of Scientific Conduct was introduced in the first year as of September 2018. During the discussions on site, students indicated to the panel that they are aware of these preventative measures and confirmed that the programme in general and its course teachers in particular are taking fraud seriously. The panel appreciates the way in which the programme pays explicit attention to fraud.

Considerations
The panel considers that student assessment is well organised in the BCS programme. The policy and principles underlying the course assessments are up to standard. The educational concepts of design-based and active learning are applied in the day-to-day reality of teaching and assessment. Based on the discussions on site and the limited sample of individual assessments it reviewed, the panel considers that BCS course assessments are valid, reliable and transparent. Moreover, the panel appreciates that the programme is taking fraud seriously.

Based on its own sample review, the panel considers that overall, both the process and the assessment of the final projects are documented adequately. Grading sheets are elaborate and the group grade is sufficiently motivated. While it appreciates SEP as a relevant and valid graduation product, the panel does encourage the programme to strengthen the individual assessment component of the final project by formulating criteria that assess the student's individual performance on each learning goal of the final project and by having assessors motivate the (adjusted) individual grade.

According to the panel, the Examination Committee has appropriate expertise and, together with the safeguarding committee, plays an important role in assuring the assessment quality of the BCS programme. Further to its considerations on the individual component of the final project, the panel invites the Examination Committee to continue monitoring in the SEP assessment forms that students verifiably achieve all learning goals and that individual contributions to the final project are motivated in the final grade.

Conclusion
Bachelor's programme Computer Science and Engineering: the panel assesses Standard 3 as ' meets the standard'.

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

Findings

Thesis quality
In order to establish whether students achieve the intended learning outcomes, the panel has reviewed a sample of 5 final bachelor projects that were accepted in the academic years 2016-2017, 2017-2018 and 2018-2019. Given that these Software Engineering Projects consisted of teamwork with an individual component, the panel has reviewed inputs from 48 students. The panel found that each of the five group projects were of a quality that can be expected of a final project at bachelor level. In fact, in almost all cases the technical quality of the work was very high. In this respect, the panel agreed to the often high final grades assessors gave to each project and its individual contributors.

In a previous section, the panel found that through the individual courses and projects, the BCS curriculum allows students to acquire the programme's intended learning outcomes. Having reviewed a selection of final projects, the panel considers that students who successfully pass SEP have indeed achieved all intended learning outcomes. Furthermore, the panel considers the Software Engineering Project to fit particularly well with the profile of the BCS programme and its attention to professional skills.

While students do acquire the necessary academic skills on a basic bachelor's level throughout the curriculum and in the final project, the panel does encourage the programme to pay more explicit attention to the scientific dimension of academic skills and to have students demonstrate such research methodology and academic writing skills at end level.

Alumni
In addition to verifying the quality of the final deliverables, the labour market performance of graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. The panel gathered from the written materials and the discussions on site that in general BCS students do not only have a positive opinion about their ability to pursue a follow-up study or professional career, but are also effective in their education or employment career. Most BCS graduates continue with a master programme and very often (66%) enrol in the Computer Science and Engineering programme at TU/e. About 16% of BCS graduates move to another university or switch domains. According to data from 2017 and 2018, an increasing number of bachelor graduates (about 15%) choose to enter the labour market directly. Graduates easily find a job and are mainly appointed as software engineers, which is in line with the programme profile and learning objectives on software development. Moreover, quite a few graduates enter the labour market as entrepreneur. The panel understood from the discussions that the market pull has always been strong and that anyway many students already work part-time in the ICT domain during their studies.

Considerations
Based on its review of final projects and the discussions on site, the panel considers that students who graduate from the BCS programme are adequately prepared for a follow-up study or a position on the labour market.

Having established that all final bachelor projects meet at least the minimum requirements of what can be expected from a final project at bachelor level—and are often of much higher quality—it is fair to state that the intended learning outcomes of the BCS programme are eventually achieved at the end of the bachelor curriculum. Moreover, while most BCS graduates pursue a master's degree, a significant minority decides to enter the labour market as employee or entrepreneur. The panel considers that the BCS programme constitutes a relevant preparation for these graduates, as well. In this regard, the programme is clearly delivering on its double ambition.

Conclusion
Bachelor's programme Computer Science and Engineering: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION
In the previous sections, the panel has come to the conclusion that the BCS programme fulfils the quality requirements with regard to each of the four standards set by the NVAO's Assessment Framework for the Higher Education Accreditation System of The Netherlands for limited programme assessments: intended learning outcomes, teaching-learning environment, student assessment, and achieved learning outcomes. Hence, the panel's overall assessment of the *bachelor's programme Computer Science and Engineering* is 'positive'.

MSc Computer Science and Engineering

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

Findings

Profile
The master's programme Computer Science and Engineering (CSE) is offered by the Department of Mathematics and Computer Science at Eindhoven University of Technology (TU/e). The programme exists for quite some time already; since 2014 it is provided within the framework of the university-wide Graduate School. Like all master programmes at TU/e, CSE is built on three pillars: it provides a foundation in disciplinary knowledge, emphasises the application of research in education, and offers students a large freedom of choice. In this way, it aligns with the vision of the university / Graduate College that its education should deliver T-shaped engineers: graduates with a solid scientific foundation in one or two areas, excellent professional skills and broad multidisciplinary knowledge and experience.

The CSE programme consists of five separate tracks. Each track consists of two years of full-time study, amounts to 120 EC and includes a final project of 30 EC. Students should indicate when registering / applying for the programme which of the following tracks they intend to follow:

- Computer Science and Engineering (CSE) offers a broad basis in the field of computer science offering extensive freedom for students to compose their study programme along three specialisation streams: Software Science, Web Science and System Science;
- Data Science in Engineering (DSiE) focuses on the collection and analysis of data and is offered together with the Mathematics sub-department;
- Information Security Technology (IST) focuses on digital communication in general and cybersecurity in particular. It contains computer science and mathematics courses and is offered together with Radboud University in Nijmegen;
- EIT Digital Data Science (EIT) is a collaboration between several European universities focusing on data science, entrepreneurship and innovation. Students study one year in Eindhoven and one year and another partner university leading to a double degree. Students follow either the first or the second year at TU/e;
- Big Data Management and Analytics (BDMA) is an Erasmus Mundus Joint Master Degree where students follow the first year in Brussels and Barcelona and the second year in Eindhoven.

Furthermore, the CSE and DSiE tracks offer students with an interest in education the opportunity to follow a double degree programme in which they combine Computer Science with Science Education and Communication and which provides the master graduate with a teaching degree in computer science. In line with the arrangement in the bachelor programme, talented master students can combine the CSE track with a master's degree in Mathematics.

Intended learning outcomes
The programme aims are reflected in the intended learning outcomes (ILOs) of CSE, which are listed in Appendix 2 to this report. The panel noticed that the ILOs consist of 10 learning outcomes, which were formulated by the Graduate College and are applicable to all master programmes at TU/e. Furthermore, most tracks feature additional learning outcomes covering expertise in the area of specialisation. The panel noticed that the ILOs have been formulated taking into account the academically oriented Meijers criteria that were developed by the four Dutch Universities of Technology (4TU) as a translation of the Dublin descriptors for higher education in engineering.

There is a common understanding among Dutch universities offering computer science programmes that the so-called ACM Computer Science Curricula 2013 serve as domain-specific framework of

reference for both bachelor's and master's programmes. As the ACM framework was formulated for undergraduate programmes, it only forms a source of inspiration for master's programmes. This is also the case for CSE, whose intended learning outcomes cover the eleven characteristics of computer scientists as formulated by the Association for Computing Machinery but are deepened and extended to a graduate level. For the IST track, there is another domain-specific reference framework: the curriculum Guidelines for Post-Secondary Degree Programmes in Cybersecurity by ACM & IEEE. The panel noticed in the materials that the mandatory courses for IST cover all knowledge areas of the ACM & IEEE curriculum guidelines. A link to both reference frameworks is provided in Appendix 1 to this report.

During the site visit, the panel spoke with the programme about the structure of the degree programme and the relative importance and individual position of its respective tracks. Although the Computer Science Graduate programme guide contained relevant and detailed information on the different tracks, it was difficult for the panel to grasp the rationale behind the inclusion of the international tracks EIT and BDMA in the degree programme CSE. Looking at the ILOs of the CSE track, which are common to all master programmes within the Graduate School, the panel wondered about the distinctiveness of this track and its streams compared to other engineering degrees at TU/e. During the visit, the panel learned that the CSE track is under revision; a dedicated curriculum committee is looking into its redesign, which includes a refinement of the current ILOs. Furthermore, the panel was informed that a separate master's programme in Data Science is being considered; if materialised, this programme will most likely include the DSiE, EIT and BDMA tracks. Both developments should become effective in 2020-2021. The panel welcomes these plans and encourages the programme in particular to refine the ILOs and make these more track-specific.

Professional field
Further to the above-mentioned orientation on application, the panel learned that the industry dimension is very much embedded in the programme. In fact, the entire TU/e including CSE is situated within and oriented towards Brainport Eindhoven, a technology region in which companies, governments and educational institutions work together. This involvement is formalised among others through the Professional Advisory Board. The panel learned during the visit that this Board consists of representatives of the professional field, including alumni of CSE, who meet three times per year and inform both the Department and programme management of domain-specific developments and of the expectations (potential) employers from industry have of (master) graduates in computer science and engineering.

Considerations
The panel considers that the profile of the master's programme CSE originates in the vision of the university and is implemented in line with the provisions of the Graduate College. The panel subscribes to the three pillars of CSE—disciplinary foundation, research application, and individual / flexible study plans—that fit both the profile of the programme and the educational model of the university.

CSE aims to deliver T-shaped engineers: according to the panel, this ambition is reflected properly in the intended learning outcomes, which in turn take into account the national 4TU criteria, the European-wide Dublin Descriptors and the international reference frameworks. Moreover, the panel thinks that the programme's involvement of, and orientation towards, the professional field is particularly strong.

The panel considers that the ILOs are appropriate: their formulation reflects the domain (computer science and engineering), the level (master) and the orientation (academic) of the CSE programme. Nonetheless, there is room for improvement: according to the panel, the formulation of the domain-specific part of the ILOs can be more harmonised across the respective tracks, while the distinctiveness of the CSE track and its streams deserves further attention through refined learning outcomes. In this regard, the panel welcomes and supports the current efforts of the programme's curriculum committee.

Conclusion
Master's programme Computer Science and Engineering: the panel assesses Standard 1 as ' meets the standard'.

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

Findings

Curriculum
The master's programme CSE amounts to 120 EC, which are spread equally over two years of four quarters each. Since 2014, the university-wide Graduate College hosts all master programmes, including CSE. It sets guidelines to ensure the organisational alignment of all master programmes thereby enabling students to choose electives from other disciplines. Every curriculum consists of maximum 30 EC mandatory courses, minimum 15 EC electives and a final project between 30 EC and 60 EC. Moreover, all courses have a study load of 5 EC. Appendix 3 to this report provides an overview of the curricula offered by the respective tracks of the CSE programme.

The panel obtained extensive information on the CSE programme and its curriculum in the self-evaluation report and the annexes. Since the previous accreditation visit in 2013, the CSE programme has undergone several changes: the curricula of both CSE and IST tracks have been revised while the DSiE, EIT and BDMA tracks were added. Studying the materials, the panel found that each track within the CSE programme has its own relevant and coherent structure of mandatory and elective courses. Together, the courses cover the ILOs of the respective tracks. Furthermore the panel understood that the curriculum set-up, which is prescribed by the Graduate College, opens up all TU/e courses to students from all tracks and programmes, provided they have the necessary prior knowledge. This entails that in practice CSE students follow many courses together and that the differences between tracks are smaller than might be expected based on the formal arrangements. At the start of the year, students have to compose a study plan, a list of courses they intend to follow. Students on the IST track should ensure that their course schedule in Eindhoven is compatible with the courses they intend to follow in Nijmegen. The curriculum of the EIT and BDMA tracks is more prescriptive as students spend only one year at TU/e. The final master project is organised in a similar way across all tracks.

A particular feature of the curriculum is its explicit attention to professional skills: oral presentation, academic writing, collaboration, critical reflection. Most courses contain assignments in which students have to produce written reports. In the research seminars, this report is presented orally. The final project incorporates and tests all professional skills. The Graduate College offers several courses on academic writing, taught by a writing expert. In the university-wide SkillsLab—an online environment with tests, theoretical materials, exercises and a support platform—master students test their presentation, reflection, teamwork, academic writing, planning and organising skills. Based on the test results, students receive a personal development plan. Moreover, the programme encourages students to do an internship (15 EC) or the final project in a company. The panel learned that about two-thirds of the CSE students spend some time outside TU/e as part of their curriculum. While most students look for opportunities in the Brainport region, some students also spend a period abroad. Students indicated both in the report and during the site visit discussions that they are satisfied with the professional skills education at CSE.

The final master project of 30 EC requires students to individually design and implement a computer science artefact (which can be theory, software or an empirical study), to describe its design or theory in a written report, to present it in public and to defend it in a question and answer session following the presentation. As the master project constitutes the main deliverable to demonstrate that learning outcomes have been achieved, the panel has reviewed several theses before the site

visit. Its findings on quality and assessment are described in the next sections. The panel understood that the final project is well organised and documented across the tracks. It can be completed in any of the research groups in the Computer Science sub-department and starts when students hand in an approved project description. Students who stay at TU/e are offered a workplace near the research group; those who do a final project outside, have a daily supervisor and a CSE supervisor. Students indicated that they are satisfied with the supervision and that they value the frequent in-depth feedback. Several alumni indicated that the master project constituted a particularly valuable contribution to their development as an engineer.

Talented students who desire more challenges have different options, which are presented every semester at the kick-off meeting: the Graduate School Honours Academy offers personalised tracks on (a combination of) research, design, entrepreneurship, teaching or management. Students can also apply for the Honours programme of the Computer Science sub-department which focuses on research or design projects and allows students to participate in national research schools. Alternatively students can join a multidisciplinary product development student team or follow a second master's degree, combining CSE with for instance mathematics. The panel understood from current and former Honours students that they highly appreciate these opportunities because it broadens and deepens their knowledge, skills and contacts. Students indicated moreover that the honours tracks are well organised and publicised internally.

Language of instruction
For more than ten years, the CSE programme is offered in English. The panel noticed that the choice for an English language programme is properly motivated in the materials: the programme wants to optimally prepare students for a career in an international setting and the Brainport region expects graduates to have international skills. Moreover, offering an English language programme increases the intake and its diversity. Currently, international students constitute 40% of the CSE programme intake and the share of female students has increased from 10% (in 2013) to 19% (in 2018). The academic staff is also part of the international environment. In 2018, one-third of the lecturers on the CSE programmes were international, a rate that is likely to increase when the entire university switches to English as *lingua franca* in 2020.

Educational concept
The programme's educational concept is based on principles set by the Graduate College. Compared to the design-oriented bachelor's programme, the CSE programme focuses on research. The panel learned that the educational approach is similar across the tracks: it focuses on the hands-on application of theory and encourages students to be active learners. The emphasis on application is the result of the university' embedding in the Brainport region. Moreover, it improves students' understanding of theoretical knowledge and helps them draw connections between various concepts. During courses, students apply the acquired knowledge and receive feedback through practical assignments. The feedback loop is shortened by the use of social media channels. Feedback is particularly important during the final project, when an appeal is made to the independent, disciplined and active attitude of students. Students meet frequently with their supervisor, who also becomes their mentor, thereby creating a master-apprentice relationship. The panel appreciates both the educational concept and the way in which it is implemented in the programme. The combined focus on research orientation, hands-on application of theory and active learning is not only a clear choice, according to the panel, but also constitutes an appropriate approach for an engineering programme.

Student intake
Since the previous accreditation visit, the number of students in the CSE programme has increased substantially from 162 (in 2013) to 373 (in 2018). The total intake in 2018 was 183 students, with DSiE being the most popular track with 66 students. The number of students on the CSE track has almost doubled since the previous visit. It is likely to grow for some more time and then decrease or stabilise due to the recent intake restriction in the bachelor programme.

The panel obtained detailed information on the admission criteria for the CSE programme tracks. Bachelor graduates in computer science from a Dutch university have direct access to CSE, IST and DSiE tracks. Other students follow either a homologation programme of maximum 15 EC or a pre-master of maximum 30 EC. The size and contents of the deficiency package is decided by the Departmental Admissions Committee for Computer Science and depends also on the track envisaged. Candidates for the EIT and BDMA tracks apply to the EIT Digital Master School and the Erasmus Programme, respectively.

The panel noticed that the student population is quite heterogeneous across tracks: EIT and BDMA tracks for instance attract more than 75% of non-Dutch students. About 40% of the students in the CSE programme have a bachelor degree from TU/e, while 14% hold a bachelor's degree from a university of applied science. Students indicated in the report that the information on the programme's website regarding the admission criteria and application procedures can be improved, notably for prospective students outside TU/e. During the discussions on site, both staff and students mentioned that the communication has improved. All student interviewees moreover indicated that the CSE programme is matching their expectations: the information that was made available beforehand drew a correct picture of the programme and its respective tracks.

Feasibility
Students reported both in the report and during the visit that overall the courses are of an appropriate level and that the study load is reasonable. The panel learned from the data in the self-evaluation report that on average 30% of students in the CSE programme graduate in two years, while 78% do so within three years. The drop-out rate is minimal: around 95% of the students graduate eventually. Several interlocutors indicated that students often have part-time jobs in the field of computer science that cause delay and distract them from finishing the degree programme. Furthermore, the panel noticed that over the years, the average length of study has decreased from 31 months (in 2013) to 28 months (in 2018). The latter result is better than the TU/e average of 31 months. Taken all elements together, the panel found that both the CSE curriculum as a whole and its course components are feasible. It is aware that very often reasons for completing the study with a considerable delay are outside the scope of the programme.

Staff
The self-evaluation report provides an overview of the permanent staff members in the sub-department Computer Science at TU/e since the previous accreditation. Currently there are 70 staff members, including 9 full professors and 5 lecturers. Two-thirds of the staff is Dutch; only 9% of the permanent staff is female. Most staff have a university teaching qualification (UTQ) or are in the process of obtaining one. The English language requirement for staff is set at CEFR level C1 and should be demonstrated through the English lecturer assessment by the university's language centre. While students indicated that almost all teachers speak well enough English, the panel noticed that only half of the staff have such English language certificate. It encourages the Department to pursue certification of its teaching staff more actively.

In terms of full-time equivalents (fte), staffing in the sub-department increased from 45 fte (in 2013) to 58 fte (in 2018). In that same period, the number of computer science students (from both programmes together) has increased much more rapidly, from 265 (in 2013) to 850 (in 2018). In order to accommodate the growing staff-student ratio, the department has taken several measures, including the appointment of additional faculty, PhD teaching assistants, temporary lecturers with a 100% teaching load, and academic advisers. The panel gathered from the materials and the discussions that across the university, the number of students is growing (much) faster than the staff equivalents. Nonetheless, the panel noticed that both at central and at department level, the staffing issue is on the agenda of the management.

Students indicated to the panel that they think highly of the domain expertise, didactic qualities and availability of the staff. They are aware that the workload of staff has been growing and appreciate

that teaching staff nonetheless go at lengths to be approachable and help students in their educational development.

In line with the university's educational vision for 2030, the department recently installed the Educational Innovation group: it consists of academic and support staff and is led by the chair of Technology Enhanced Education of Mathematics and Science. Through this group, academic staff can propose educational experiments and ask for professional support in didactics, ICT, learning analytics, project management, and the dissemination of experiments. Because additional teaching capacity is available, teachers can invest time in these innovations. The panel learned that these innovation projects often serve to pilot didactical approaches that cater for growing student audiences. Moreover, the university-wide TEACH training programme for lecturers includes courses on topics such as developing and implementing teaching, testing and evaluation. The panel thinks highly of these initiatives and welcomes the initiative of the department to have a dedicated teacher support officer who assists staff in the professionalisation of their courses.

Facilities
The Department of Mathematics and Computer Science is situated on four floors of the MetaForum building. This modern building also houses the university library and has many student work spaces. Students can book rooms for project work. In the last few years the rise in student numbers has led to a shortage of lecture rooms. The panel learned that several measures were introduced to mitigate this situation, including an adapted schedule with evening classes. In order to accommodate courses with more than 300 participants, live streaming is offered. Less interactive lectures are compensated by organising digital Q&As, discussion fora, and dedicated office hours. Students indicated that they do not like the evening classes but understand why these have been scheduled. They do appreciate, though, that the lectures are streamed and can also be watched afterwards.

The panel gathered from the materials that the CSE programme features both academic advisers and mentors who guide students throughout their study. During the first months of the programme, every master student is assigned a mentor, a lecturer whose research is closely related to the stream/track chosen by the student. Mentors help students in composing a coherent study plan and introduce them to people in research departments and companies. When preparing for the final master project, the graduation supervisor takes over the role of the mentor. For study-related issues, the CSE academic advisers play an important role in study-related issues concerning planning, policies and procedures. Academic advisers monitor study progress, can provide confidential advice or refer students to specialised services. Students indicated in the report that they had not always been satisfied with the quality of the mentors and that the academic advisers did not have sufficient time to deal with students. During the visit, students confirmed that this had been the case before, but that the programme has taken effective measures in the meantime to prepare all mentors for their tasks, to explain to students the task division between mentors and academic advisers, and to increase the availability of the academic advisers. Both mentors and academic advisers are now much more helpful and, within their respective roles, meet adequately the expectations of students. All students indicated furthermore that they appreciate the mentoring role of the graduation supervisors.

Students play an important role in the quality system of the programme. They fill in course evaluation forms at the end of each quarter. In addition to discussing course and curriculum evaluation results, students on the programme committee have a say in proposals concerning curriculum changes and can signal flaws and possible improvements. Students indicated that most teachers are open to their feedback and take the survey results seriously. An important development in this respect is the presentation by the academic advisors at the quarterly kick-off sessions on the attention points that were raised in the past and how these will be addressed in the future.

Furthermore, the study association for students of the Department of Mathematics and Computer Science, GEWIS, plays an important role in building a community with and providing services to students. Its education officer is strongly involved in the quality assurance cycle, organising the

quarterly feedback sessions with every cohort. Moreover, the study association connects students to staff through monthly receptions in the GEWIS home in the MetaForum building and organises career orientation activities such as lunch lectures and company visits. In addition to GEWIS, international students can also join Cosmos, the international student association of TU/e.

Considerations
The panel considers that the teaching-learning environment of the CSE programme is up to standard. The curriculum of the respective tracks is coherent and its contents are in alignment with the programme profile, the intended learning outcomes and the international disciplinary requirements. The final project constitutes a relevant exercise that fits the research-oriented profile of the programme. The educational concept is appropriate and implemented rigorously. Talented students attending the honours programme or enrolling for a second master degree appreciate these additional opportunities. The programme is feasible. Faculty is highly qualified and appreciated by students for their disciplinary know-how, didactic competencies and availability. Student services organised by the department and through the study association GEWIS facilitate the study period of CSE students.

The panel noticed that the CSE programme underwent several curriculum adjustments over the past few years to arrive at its current form, which is likely to change again as of 2020-2021. Moreover, student numbers are growing much faster than the staff equivalents. The panel understands that these changes are impacting on the teaching-learning environment but considers that the management is taking adequate measures to mitigate their effects. In this regard, the panel thinks highly of the recent professionalisation opportunities for teaching staff to set up educational experiments through the Education Innovation group and of the online Skills Lab, where students can test and practice academic skills.

Conclusion
Master's programme Computer Science and Engineering: the panel assesses Standard 2 as 'meets the standard'.

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

Findings

Assessment system
The panel obtained extensive information in the self-evaluation report and the annexes on the principles that underpin student assessment in the CSE programme. It gathered from the written materials that the master's programme adheres to the university's Exam Framework and is implementing the principles set by the Department's Assessment Policy. The panel also looked into the CSE Assessment Plan, which provides a comprehensive overview of the assessment methods that are used in the courses to demonstrate that graduates achieve the intended learning outcomes at the end of the CSE curriculum. Most courses are assessed through written exams and/or project assignments. In the seminar and the final project, the achievement of all ILOs are assessed. Performing research independently is an important aspect of the final assessment, which also encompasses the ability to think critically and form a scientific opinion. Formal arrangements concerning assessments are laid out in Education and Examination Regulations and in the Examination Committee's rules and regulations.

Course and thesis assessments
The panel noticed that the assessment principles underlying the programme are sound and have been rigorously implemented in the individual courses. On site the panel looked into CSE course materials and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that assessment is transparent: all

provisions and documents are available in the digital education guide. Moreover, students know well in advance what they need to know for the exam and how they will be assessed. Each quarter ends with a two-week exam period; once grades are registered, students can inspect and discuss their exam and its grading.

As part of its thesis review, the panel studied a sample of fifteen final master projects. CSE students in all tracks write their master thesis in Eindhoven, except for those students who follow the EIT entry programme. In the latter case, arrangements were made among partners with regard to the (automatic) mutual recognition of scores and grades. Each graduation project is reviewed by an assessment committee, which consists of at least three examiners and needs to be approved by the Examination Committee. The master thesis is assessed on results, report, presentation, defence and project execution. Detailed regulations are in place to ensure the quality of projects and the standardisation of their assessment. Students indicated to the panel that they are satisfied with the way in which the final project is assessed.

Based on its own sample review, the panel noticed that both the master thesis process and its assessment are well documented. The assessment forms are transparent and very informative, provided they are completed correctly. The panel agreed to most of the final grades and found that a majority of forms contained sufficient qualitative information to motivate the assessment committees' sub-scores and final grade. In one case, however, the panel endorsed the genuinely sufficient quality of the thesis but disagreed completely with the near-perfect score, which it considered too high. This thesis belonged to the EIT track, had been written and assessed at a partner university, and its final grade had been validated—in line with the EIT partner agreements—by the track coordinator at TU/e. While the panel understands the necessity and relevance of partners arrangements on mutual recognition, it nonetheless advises the CSE programme to perform some explicit quality check prior to accepting the final grade. In another case, the panel reviewed three theses which it thought to be of very similar quality. However, the projects were scored differently without a proper motivation of the respective grades. According to the panel, the CSE programme could increase its calibration efforts among (master thesis) examiners and encourage all assessors to motivate their sub-scores and final grades.

Examination committee
The Examination Committee is responsible for safeguarding the quality of assessment and the realisation of the intended learning outcomes in the CSE programme. The panel noticed from the discussion that the individual members of the committee have adequate expertise to fulfil their quality assurance tasks. It appreciates the committee's decision to create within its own small structure a safeguarding committee that executes ad hoc specific in-depth tasks such as monitoring the quality of course assessments or investigating the reliability of the final master thesis grades.

Furthermore, the panel learned that the courses of the Science Education and Communication programme are evaluated by the Eindhoven School of Education and quality assured by a separate Examination Committee. The EIT and BDMA track courses taught at partner institutions are quality ensured by these partners, established European universities subject to their own accreditation regulations. Further to its findings on the master thesis assessment, the panel invites the Examination Committee to perform a quality check on all master theses that have been produced and assessed outside TU/e.

The departmental Exam Policy includes a section on fraud, describing how students and lecturers are informed about fraud prevention and how it is detected and sanctioned. The Examination Committee plays an active role in maintaining this policy. The panel learned that because the number of fraud cases had increased, teachers were encouraged to explicitly state in the course guide what is considered to be fraud. Plagiarism is by far the most commonly occurring type of fraud. In order to make students aware of academic integrity and the consequences of committing fraud, students sign a Code of Conduct for Scientific Integrity. During the discussions on site, students indicated to the panel that they are aware of these preventative measures, that they had signed the code of conduct,

and that the programme in general and its course teachers in particular are taking fraud seriously. The panel appreciates the way in which the programme pays explicit attention to fraud.

Considerations
The panel considers that student assessment is well organised in the CSE programme. The policy and principles underlying the course assessments are up to standard. The educational concepts of research-oriented and active learning are applied in the day-to-day reality of teaching and assessment. Based on the discussions on site and the limited sample of individual assessments it reviewed, the panel considers that CSE course assessments are valid, reliable and transparent. Moreover, it appreciates that the programme is taking fraud seriously.

Further to its own review, the panel considers that both the process and the assessment of the final master projects are well documented. The assessment forms are transparent and informative, provided they are completed correctly. Notwithstanding its positive appreciation, there is room for improvement in quality assuring the final thesis grades obtained outside TU/e, in calibrating the master thesis grades across tracks and assessment committees, and in completing all—not just most—thesis assessment forms in an insightful way.

According to the panel, the Examination Committee has appropriate expertise and, together with the safeguarding committee, plays an important role in assuring the assessment quality of the CSE programme. It invites the Examination Committee to monitor systematically the final master thesis grades and their motivation.

Conclusion
Master's programme Computer Science and Engineering: the panel assesses Standard 3 as 'meets the standard'.

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

Findings

Thesis quality
In order to establish whether students achieve the intended learning outcomes, the panel has reviewed a sample of 15 master thesis projects that were accepted in the academic years 2016-2017, 2017-2018 and 2018-2019 across all of the five tracks. Such final project represents a full-time study load of six months (30 EC) and requires students to design and implement individually a computer science artefact, which can be theory, software or an empirical study. Students can choose to do the graduation project at one of the research groups of the department or with a company, research institute, university or public organisation outside TU/e.

The panel found that each of the fifteen theses was of the quality that can be expected from a final project of academic orientation at master level. Moreover, the panel thought that several theses were of very good quality. In this regard, the panel findings confirm the programme's relatively high average grade (8.1) for master theses. The topics covered were relevant for the domain of computer science and reflected the variation in research themes across the tracks. In the theses, students adequately formulate a research question, describe the state of the art, elaborate on the methodology, report on the results, and discuss their findings. Across the fifteen theses, the panel thought students did particularly well in terms of theoretical models, design and solutions, and reflection. It therefore comes as no surprise to the panel that several of the graduation projects eventually led to publications. Based on the sample it reviewed, the panel found that students who successfully pass the master thesis have indeed achieved all intended learning outcomes.

Alumni
In addition to verifying the quality of the final deliverables, the labour market performance of graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. The panel gathered from the written materials and the discussions on site that CSE students are effective in pursuing a career in industry or academia. According to data from 2017 and 2018, graduates easily find employment in their field and at an academic level within two months upon graduation. Many alumni work in software technology (42%) or data science (22%). About 13% start a PhD programme. A very small group (3%) starts their own company after the master programme. Roughly one-third of the alumni of the CSE programme stayed in the Brainport region, while 20% is employed abroad.

Alumni and employers indicated both in surveys and during the site visit that they benefit mostly from the theoretical foundation and the analytical problem-solving skills offered by the CSE programme. If anything, they would like the programme to pay more attention to practical and soft skills, notably communication. The panel understood from the discussions that the market pull for computer scientists is very strong, which results in students working part-time in the ICT domain during their studies. However, the panel also noted with satisfaction that the programme manages to motivate students for a scientific career in academia.

Considerations
Based on its review of final projects and the discussions on site, the panel considers that students who graduate from the CSE programme are adequately prepared for—and successfully enter—both the labour market and a PhD trajectory. Having established that the master theses are of high quality, it is fair to state that the intended learning outcomes of the CSE programme are achieved at the end of the master curriculum. According to the panel, the programme clearly delivers on its ambition to educate T-shaped engineers.

Conclusion
Master's programme Computer Science and Engineering: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

In the previous sections, the panel has come to the conclusion that the CSE programme fulfils the quality requirements with regard to each of the four standards set by the NVAO's Assessment Framework for the Higher Education Accreditation System of The Netherlands for limited programme assessments: intended learning outcomes, teaching-learning environment, student assessment, and achieved learning outcomes. Hence, the panel's overall assessment of the *master's programme Computer Science and Engineering* is 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Both the bachelor's and the master's programme Computer Science and Engineering uses the ACM Computer Science Curricula 2013 as domain-specific framework of reference. This curriculum framework is used by many programmes across the world and the Dutch computer science programmes have agreed to use it for bachelor's as well as master's programmes. The ACM framework is formulated for undergraduate programmes. Its characteristics are deepened and extended to post-graduate academic level for the master's programme. The document is available at: https://www.acm.org/binaries/content/assets/education/cs2013_web_final.pdf

The Association for Computing Machinery (ACM) is an internationally recognised institute that produces resources with the intention of helping computer science and similar fields advance scientifically as well as professionally. Besides giving detailed lists of subject matter to be covered in an undergraduate programme, it describes a computer science graduate in 11 characteristics.

At a broad level, the expected characteristics of computer science graduates include the following:

1. Technical understanding of computer science
2. Familiarity with common themes and principles
3. Appreciation of the interplay between theory and practice
4. System-level perspective
5. Problem solving skills
6. Project experience
7. Commitment to life-long learning
8. Commitment to professional responsibility
9. Communication and organisational skills
10. Awareness of the broad applicability of computing
11. Appreciation of domain-specific knowledge

For a more detailed coverage, please refer to chapter 3, page 23 on the above link.

The IST track of the master's programme uses another domain-specific reference framework: the Curriculum Guidelines 2017 for Post-Secondary Degree Programs in Cybersecurity, issued amongst others by ACM and IEEE Computer Society. The document is available at: https://www.acm.org/binaries/content/assets/education/curricula-recommendations/csec2017.pdf

APPENDIX 2: INTENDED LEARNING OUTCOMES

Bachelor's programme Computer Science and Engineering

All TU/e Bachelor of Science graduates:

- are qualified to a degree level within the domain of engineering science and technology;
- are competent in the relevant domain-specific discipline(s) to the level of a Bachelor of Science;
- are able to conduct research and design under supervision;
- are aware of the significance of other disciplines;
- take a scientific approach to non-complex problems and ideas, based on current knowledge;
- possess intellectual skills that enable them to reflect critically, reason and form opinions under supervision;
- are good at communicating the results of their learning, thinking, acts and decision-making processes;
- can plan and implement their activities;
- are aware of the temporal and societal contexts of science and technology (comprehension and analysis);
- in addition to a recognizable domain-specific profile, possess a sufficiently broad basis to be able to work or collaborate in an interdisciplinary and multidisciplinary context. Here, multidisciplinary means focusing on other relevant disciplines needed to solve the design or research problem in question.

Moreover, all CSE bachelor graduates should reach following domain-specific learning outcomes:

Basic knowledge and skills in computer science and engineering:
b1. familiarity with basic concepts related to Software Science/Web Science and a sub-set of other computer science domains: Theory and Algorithms, Software Development, Information Systems, System Architecture and Networks, Data Mining and Web Technology;
b2. the skill to prove theorems with respect to these basic concepts;
b3. a thorough technical and scientific understanding of software and software systems;
b4. the ability to rapidly deduce the essence of such systems, to acquaint oneself with those systems and to judge their merits.

Software design:
s1. the ability to develop programs or software systems in an effective and structured manner, whereby those systems will perform the tasks expected of them accurately and efficiently;
s2. the ability to analyze any software system in terms of its behavioral aspects;
s3. further to this analysis, the ability to adapt and improve the system where necessary;
s4. the ability to document all findings and activities for future reference.

General academic skills:
g1. the ability to acquire further knowledge in the field of computer science and to do so independently;
g2. an awareness of the position and importance of computer science within society, an awareness of the rapid changes—both positive and negative—which information technology can bring about and the ability to reflect on such changes;
g3. the ability to work effectively within a team;
g4. the ability to impart information, ideas and solutions to either fellow specialists or a lay public;
g5. the ability to plan and organise one's own work, as well as a software development project.

Master's programme Computer Science and Engineering

The intended learning outcomes that have been formulated for all master's programmes within TU/e's Graduate school are also applicable to the CSE programme, across tracks and streams. All CSE master's programme graduates:

- are qualified to degree level within the domain of science engineering & technology;
- are competent in the relevant domain-specific discipline(s), namely computer science and engineering;
- are able to conduct research and design independently;
- have the ability and attitude to include other disciplines in their research, where necessary;
- have a scientific approach to complex problems and ideas;
- possess intellectual skills that enable them to reflect critically, reason and form opinions;
- have the ability to communicate the results of their learning, thinking and decision-making processes at an international level;
- are aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work;
- 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;
- have the ability and attitude to seek new potential applications, taking the social context into consideration.

In addition to these general learning outcomes, graduates in the **CSE track** should also be experts in the subarea of computer science they specialise in.

In addition to these general learning outcomes, graduates on the **IST track**:

- Should have a broad view of information security;
- Should be able to evaluate existing and newly designed security systems;
- Should be able to list relevant security requirements in an application and to select the right techniques to address these issues;
- Are expert in at least one subarea of information security;
- Can contribute to discussions about the role of information security in our society;
- Have experience in the process of specifying, designing and realisation of an application in which security plays an important role.

In addition to these general learning outcomes, graduates on the **DSiE and BDMA track**:

- Should have a broad view of data science
- Should be able to understand and develop technology for handling structured and semi-structured and possibly distributed big data;
- Should be able to analyse data and draw meaningful conclusions from data, effectively turning data into value;
- Should understand the role of data in organisations, enabling the shift towards data-driven decision-making in industry;
- Should understand the legal and social aspects of collecting, owning and manipulating data.

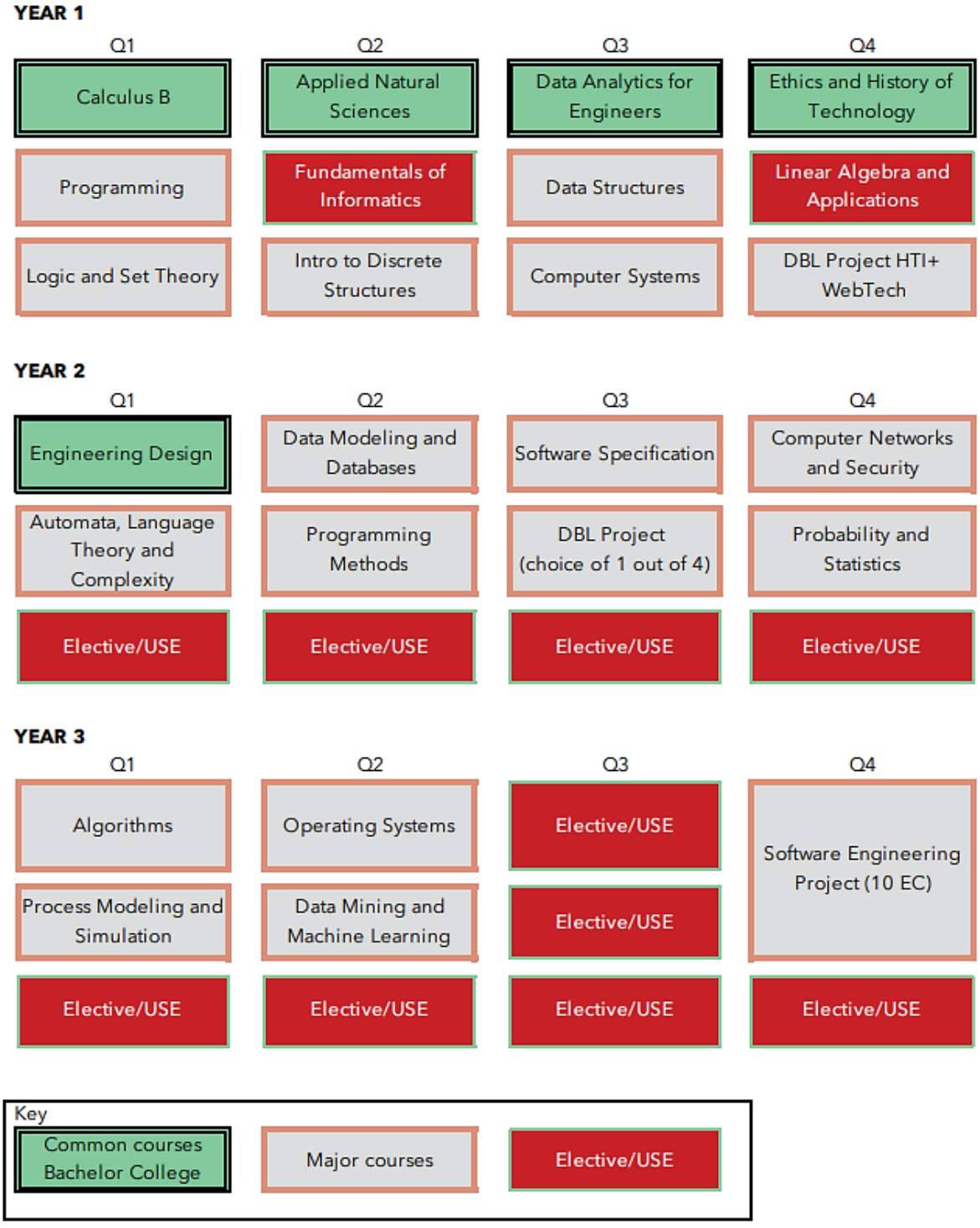
According to the general learning outcomes of the **EIT track**, graduates:

- Have a broad view of data science as a specialisation of computer science, engineering and technology;
- Should be able to understand and develop technology for handling structured and semi-structured and possibly distributed big data;
- Should be able to analyse data and draw meaningful conclusions from data, effectively turning data into value;
- Should understand the role of data in organisations, enabling the shift towards data-driven decision-making in industry;
- Should understand the legal and social aspects of collecting, owning and manipulating data.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's programme Computer Science and Engineering

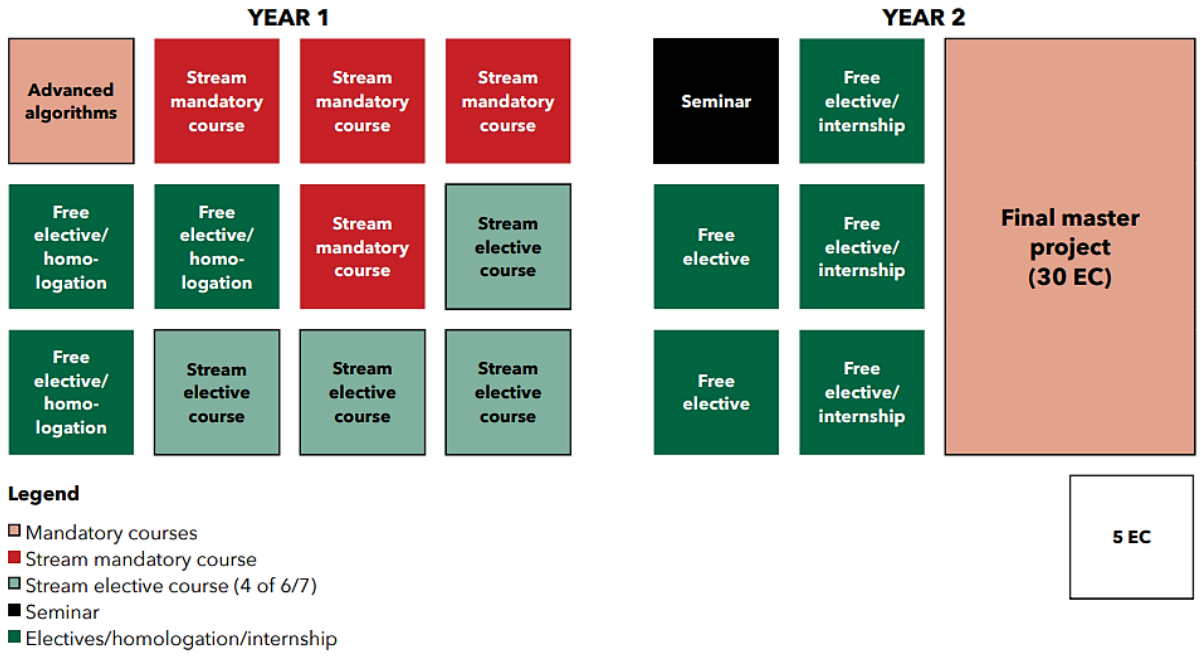
The BSc CSE is one of the bachelor's programmes offered at TU/e within the framework of the Bachelor College. Each TU/e bachelor's programme rests on four pillars: 5 common courses for every TU/e student (25 EC); a major (95 EC, including 5 EC for professional skills) focusing on a specialisation; 3 courses (15 EC) on the perspectives of Users, Society and Enterprise (USE); and 9 elective courses (45 EC). Below follows a schematic overview of the BSc CSE programme.



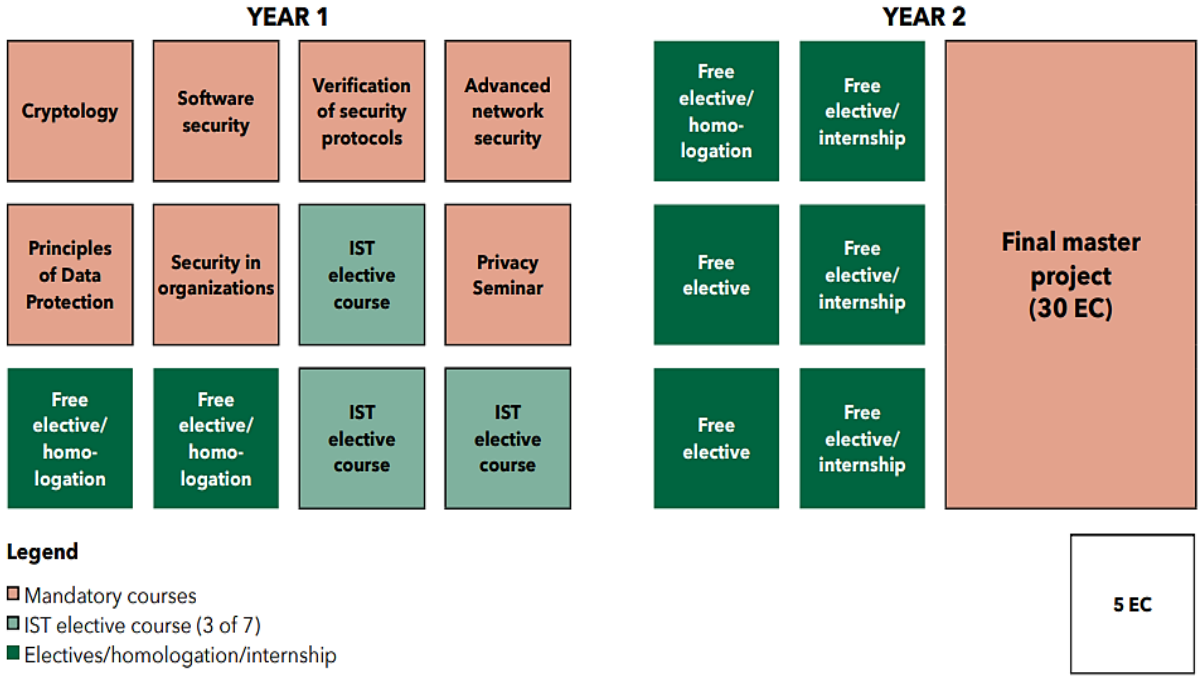
Master's programme Computer Science and Engineering

The MSc CSE is offered within the framework of the TU/e Graduate School. Each track has its own curriculum but all tracks consist of 120 EC, including a final master project of 30 EC. The EIT and BDMA tracks are followed partly (60 EC) at TU/e and partly at one or more other institutions.

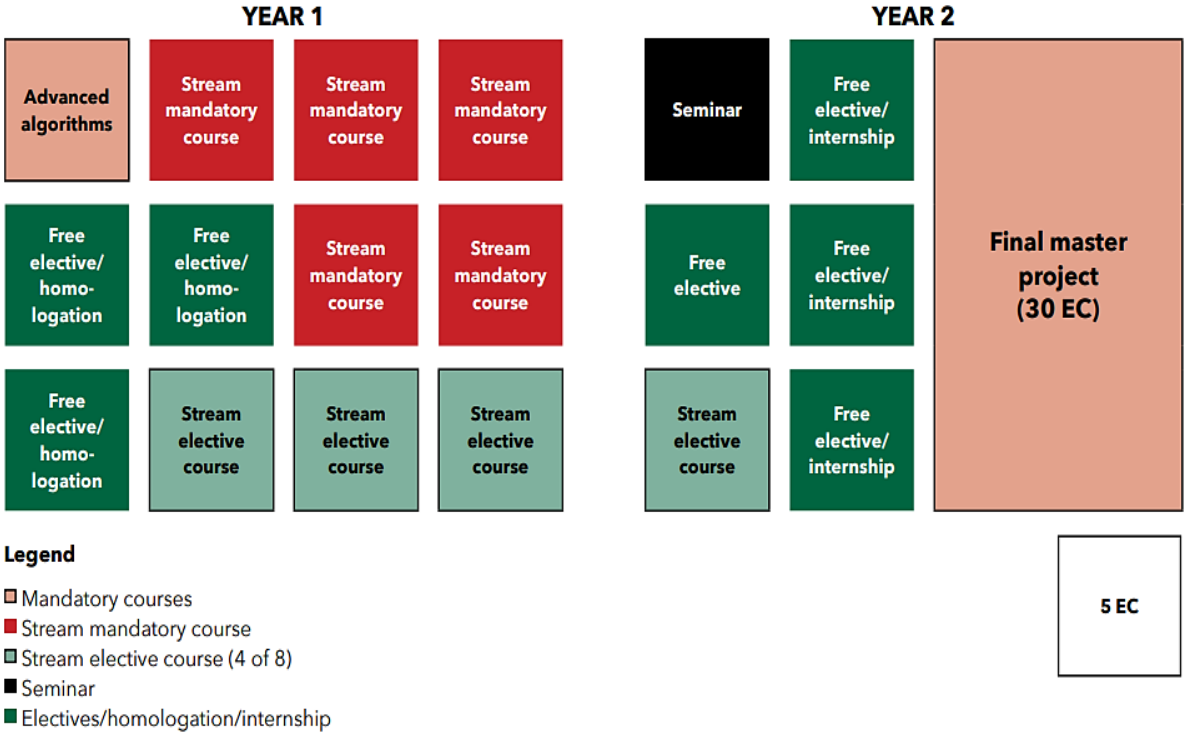
Overview of the track Computer Science and Engineering



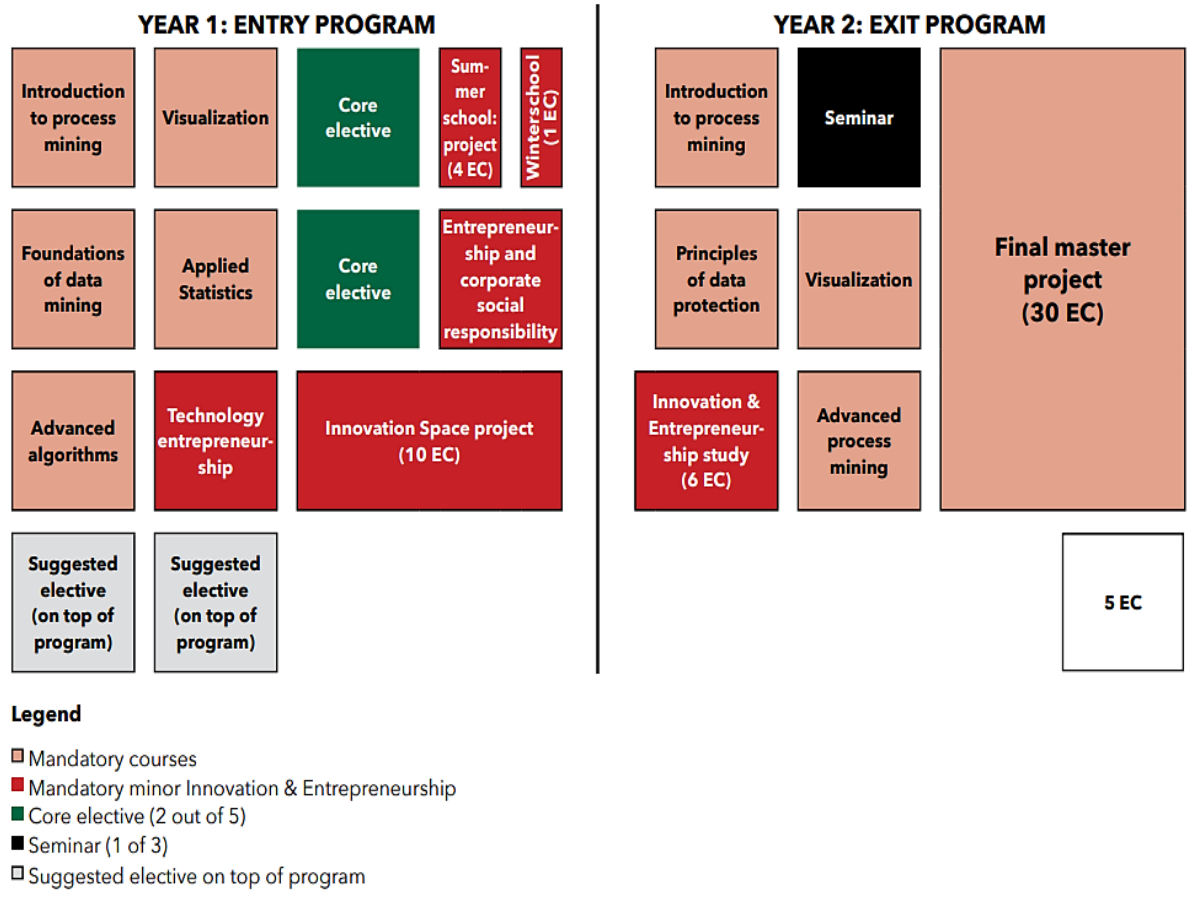
Overview of the track Security Technology



Overview of the track Data Science in Engineering



Overview of the track EIT Digital Data Science



Overview of the track Big Data Management and Analytics (Erasmus Mundus Joint Master Degree)

TU/e is involved in the second year of the Erasmus Mundus programme offering the specialisation Business Process Analytics. The curriculum at TU/e consists of 5 courses (25 EC), one seminar (5 EC) and one master project (30 EC):

- Introduction to process mining
- Process modelling and simulation
- Ethics and Technology
- Applied statistics
- Visualisation
- Seminar Analytics for Information System
- Master project

APPENDIX 4: PROGRAMME OF THE SITE VISIT

Venue: TU Eindhoven campus, MetaForum building, room 3.119 and 3.122

Tuesday 1 October 2019

10.30 Arrival panel and welcome
10.45 Internal panel meeting (and lunch)
12.30 Session with management
13.45 Session with lecturers of the bachelor's programme
14.45 Session with bachelor students
15.30 Guided tour in MetaForum
16.15 Session with lecturers of the master's programme
17.30 Session with master students
18.30 Internal panel meeting
19.00 End of day one

Wednesday 2 October 2019

09.00 Internal panel meeting
09.45 Session with alumni and professional field
10.45 Session with Examination Committee
11.45 Internal panel meeting
12.15 Final session with management
12.45 Internal panel meeting (and lunch)
15.00 Development dialogue
16.15 Plenary presentation of preliminary findings
16.30 End of site visit

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Self-evaluation report BSc Computer Science and Engineering, July 2019.
Self-evaluation report MSc Computer Science and Engineering, July 2019.

Prior to the site visit, the panel studied 5 group works of the bachelor's programme CSE and 15 theses of the master's programme CSE. Information on the selected works/theses is available from QANU upon request.

Following materials were made available by the Department of Mathematics and Computer Science before or during the site visit, either as hard copy or in digital format through the QANU document site or the faculty's electronic learning environment:

- Program and Examination Regulations 2018-2019
- Departmental Evaluation Plan
- Departmental Exam Policy
- Staff Overview
- Rankings
- Report NVAO Assessment 2013
- Projects of the Educational Innovation Group in 2019
- TU/E Bachelor College guidelines
- TU/E Graduate School guidelines
- Organisational structure
- Domain-specific framework of reference
- CSE program guide 2018-2019
- The requested reports and assessment forms from the Final Projects
- Students' publications
- Assessment plan CSE Bachelor's programme
- Assessment plan CSE Master's programme
- Professional skills in the new curriculum
- Presentation of CSE bachelor's and master's programmes
- Annual Reports Programme Committee
- Annual Reports Examination Committee
- Annual Reports Education
- CSE curriculum review (proposal)
- Course materials, including assessments:
    - Computer Systems (Bachelor)
    - Data modelling and databases (B)
    - Algorithms (B)
    - DBL HTI+webtech (B)
    - Software/web engineering project (B)
    - Introduction to discrete structures (B)
    - Research project (B)
    - Web information retrieval and data mining (Master)
    - Advanced Algorithms (M)
- Digital learning environment:
    - Advanced Algorithms (M)
    - Data Structures (B)
    - Process Theory (M)
    - Skills Lab (B+M)