BACHELOR'S PROGRAMME INFORMATICA

MASTER'S PROGRAMME COMPUTING SCIENCE

FACULTY OF SCIENCE AND ENGINEERING

UNIVERSITY OF GRONINGEN

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REPORT ON THE BACHELOR'S PROGRAMME INFORMATICA AND THE MASTER'S PROGRAMME COMPUTING SCIENCE OF THE UNIVERSITY OF GRONINGEN

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 Computing Science

Name of the programme:	Informatica (international name: Computing Science)
CROHO number:	56978
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Location:	Groningen
Mode of study:	full time
Minor in education:	applicable (second degree qualification)
Language of instruction:	English
Submission deadline NVAO:	01/05/2020

In this report, the international name of the bachelor's programme (Computing Science) will be used instead of its formal CROHO name (Informatica) for reasons of readability.

Master's programme Computing Science

Name of the programme:	Computing Science
CROHO number:	60364
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Specialisations or tracks:	- Intelligent Systems and Visual Computing - Data Science and Systems Complexity - Software Engineering and Distributed Systems - Science, Business and Policy
Location:	Groningen
Mode of study:	full time
Language of instruction:	English
Submission deadline NVAO:	01/05/2020

The visit of the assessment panel Computer Science to the Faculty of Science and Engineering of the University of Groningen took place on 28 and 29 November 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

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

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 15 April 2019. The panel that assessed the bachelor's and master's programme Computing Science 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);
- 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;
- 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 P.A. (Peter) Hildering MSc, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's and master's programme Computing Science at the Faculty of Science and Engineering of the University of Groningen 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 the University of Groningen, the panel was supported by P.A. (Peter) Hildering MSc, 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 the University of Groningen, 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 15 final bachelor projects, 15 master theses and their respective assessment forms, based on a provided list of graduates in the academic years 2017-2018 and 2018-2019. A variety of topics 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, and that all four specialisations in the master's programme were covered in the selection. For the Science Business & Policy specialisation, a thesis from 2014 was added to the selection, as no recent graduates had chosen this specialisation. 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 the University of Groningen took place on 28 and 29 November 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.

Minor in Education
The Minor in Education leading to a second degree teaching qualification will be covered in-depth in the assessment of the academic teaching programmes in 2020.

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

Bachelor's programme Computing Science

The bachelor's programme Computing Science convincingly profiles itself as a theoretical and research-oriented programme in computing science. The intended learning outcomes meet the expectations of the academic and professional field through alignment with the international ACM benchmark curriculum, and are in line with an academic bachelor's programme in terms of level and orientation. The ILOs could be made more distinctive through a stronger emphasis on the theoretical and research focus of the programme. The programme has an active and well-functioning External Advisory Council which provides advice that keeps the programme aligned with the expectations of the professional field.

The programme has adequately translated its intended learning outcomes into a coherent curriculum. It offers a solid core curriculum in computing science, structured along a clear set of learning lines. The panel recommends the programme to ensure that the learning lines are fully aligned with the programme's ILOs. The panel thinks that, if fully aligned and described, the learning lines have the potential to be the main instrument to describe the curriculum, both in terms of design as in communication to students about the curriculum content. The academic skills learning line is clear and comprehensive, but the specific skill training within the courses could be made more visible for students. The use of English as the language of instruction in the programmes fits the international character of the programme and its teaching staff, and prepares students for the international job market.

The programme is feasible, although some students take longer to finish due to jobs and/or prolonged research projects. The programme has a high percentage of drop-outs in the first year. The panel endorses the measures taken to reduce this through better matching, better support for international students and early warning systems. The panel recommends to investigate the alignment of content between courses, and to better communicate to students how course evaluations are being used to improve course quality. The panel is positive about the teaching staff of the programme, and the professionalisation of teachers through UTQs. The quantity of the teaching staff is just enough for the current student numbers, but the programme needs to pay continuous attention to staff quantity with regard to the rapid growth in student numbers, both for teaching staff and teaching assistants. The programme offers adequate facilities, although their availability can be limited due to high student numbers.

The assessment system of the programme is adequate, and guarantees that students are assessed on all intended learning outcomes. According to the panel, the second examiner that is assigned for each course adds to the transparency and validity of assessment, and the automatic feedback system for programming assessments is very interesting. The assessment per course is clearly described in the Course Unit Assessment Overviews, but could be better described on a curriculum level. The panel recommends to improve the assessment plans by adding a more in-depth description of the individual exams and assessment methods associated with each learning outcome.. The thesis assessment of the programme is good. The starting form and mid-term evaluations add to the reliability of the assessment. The assessment form is well-designed and well-implemented, and provides a transparent motivation of the final grades. The Board of Examiners adequately fulfils its role in the quality assurance of assessment, but could take a more proactive role with regard to initiating improvements and checks with regard to the quality of assessment in the programmes.

The panel concludes that the theses of the programmes are of high quality, and convincingly show that the intended learning outcomes are achieved. The panel agrees with the grading, and praises the programme for the high number of scientific publications resulting from the theses. The bachelor's students usually continue in a master's programme, fitting the goals of the programme, and those that enter the master's programme at Groningen do very well.

Master's programme Computing Science

The master's programme Computing Science convincingly profiles itself as a theoretical and research-oriented programme in computing science that is well-aligned with the research interests of the computing science departments. Students can choose to specialise either in the direction of academic research, industry or policy making through the four specialisations. The intended learning outcomes meet the expectations of the academic and professional field by expanding on the international ACM benchmark curriculum, and are in line with an academic master's programme in terms of level and orientation. The ILOs could be made more distinctive through a stronger emphasis of the theoretical and research focus of the programme. The programme has an active and well-functioning External Advisory Council which provides advice that keeps the programme aligned with the expectations of the professional field.

The programme has adequately translated its intended learning outcomes into a coherent curriculum. The curriculum allows students to obtain an advanced understanding of computing science, and specialise in one of four directions to fit to their preferences. Students obtain a very thorough training in research skills in the research internship and the student colloquium. The teaching methods in the programme are appropriate, and the close relation between education and research is a strong point. The panel recommends the programme to investigate whether and how the students can interact more with the professional field. The use of English as the language of instruction fits the international character of the programme and its teaching staff, and prepares students for the international job market.

The programmes is feasible, although some students take longer to finish due to jobs and/or prolonged research projects. For the latter, the programme introduced an adapted thesis trajectory with extra deadlines, which the panel strongly supports. The panel recommends to investigate the perceived imbalance in workload in the first semester of the curriculum, and the alignment of content between courses. Further, the programme should better communicate to students how course evaluations are being used to improve course quality. The panel is positive about the teaching staff of the programme, and the professionalisation of teachers through UTQs. The quantity of the teaching staff is just enough for the current student numbers, but the programme needs to pay continuous attention to staff quantity with regard to the rapid growth in student numbers, both for teaching staff and teaching assistants. The programme offers adequate facilities, although their availability can be limited due to high student numbers.

The assessment system of the programme is adequate, and guarantees that students are assessed on all intended learning outcomes. According to the panel, the second examiner that is assigned for each course adds to the transparency and validity of assessment. The assessment per course is clearly described in the Course Unit Assessment Overviews, but could be better described on a curriculum level. The panel recommends to improve the assessment plans by adding a more in-depth description of the individual exams and assessment methods associated with each learning outcome. The thesis assessment of the programme is good. The starting form and mid-term evaluations add to the reliability of the assessment. The assessment form is well-designed and well-implemented, and provides a transparent motivation of the final grades. The Board of Examiners adequately fulfils its role in the quality assurance of assessment, but could take a more proactive role with regard to initiating improvements and checks with regard to the quality of assessment in the programmes.

The panel concludes that the theses of the programme are of high quality, and convincingly show that the intended learning outcomes are achieved. The panel agrees with the grading, and praises in the programme for the excellent level of the master's theses, as well as the high number of scientific publications resulting from the theses. Graduates are in high demand on the labour market, both as PhD researcher as well as in industry.

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

Bachelor's programme Computing Science

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

Master's programme Computing Science

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, P.A. (Peter) Hildering MSc, 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 March 2020

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

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 Informatica (hereafter called by its international name Computing Science) and master's programme Computing Science at the University of Groningen are offered by the Faculty of Science and Engineering. The programmes aim to train students in the fundamental knowledge and skills to improve existing and develop new computer systems and software, in order to contribute to technological developments in a broad sense. The bachelor's programme aims to qualify students for an academic master's programme in Computing Science or a related discipline. The master's programme graduates should be able to become independent professionals in Computing Science, either as academic researcher or in the professional field.

In comparison to other computing science programmes in the Netherlands, the programmes profile themselves with a long tradition of emphasis on theory and research. For instance, theoretical topics such as complexity, advanced algorithmic and programme correctness are offered as early as the first bachelor's year. The content of the courses and individual research projects are closely associated with the research interests of the research groups involved, especially in the master's programme. This allows for research-based programmes that incorporate the latest research developments and literature.

The bachelor's programme offers a broad basis of knowledge and skills for Computing Science and gradually shifts towards more specialised topics in the third year. The master's programme is more focused, and allows students to specialise in one of four directions:

- Intelligent Systems and Visual Computing (ISVC)
- Data Science and Systems Complexity (DSSC)
- Software Engineering and Distributed Systems (SEDS)
- Science, Business and Policy (SBP)

ISVC and DSSC are closely aligned with the research interests of the Computing Science department, and are mainly focused on preparing students for a career as an academic researcher. SEDS is primarily aimed towards delivering software and systems engineers for the professional field. SBP is a faculty-wide specialisation in which students learn to combine the knowledge and skills from their specific discipline with insights from business and policy studies in order to prepare for a societal career. This specialisation is offered by the faculty's department of Science & Society.

The panel has studied the profile of the bachelor's and master's programme and concludes that both programmes have a clear and distinctive profile. They are strongly founded in theory and research, and combine theoretical foundations with a vision on a role of computing science in technological innovations. The bachelor's programme is specifically aimed at preparing for a master's programme in Computing Science and less at direct outflow to the professional field, which the panel considers a clear choice fitting the profile of the programme. The specialisations of the master's programme are well-balanced and in line with the career options for graduates as well as the research interests of the department. Through the specialisations, students have the choice to prepare themselves for a career in either academic research, industry or policy making, depending on their interests.

Intended learning outcomes
The intended learning outcomes (ILOs) of the *bachelor's programme* are grouped in three sets detailing the knowledge, skills and attitudes that students are required to achieve during the programme. The panel studied the ILOs to determine the level, orientation and relation to the expectations of the field. It was shown an overview in which the ILOs are linked to the Dublin's descriptors for academic bachelor's programmes. The panel concludes that all Dublin Descriptors are adequately included, reflecting the bachelor's level of the programme's ILOs. According to the panel, the academic orientation of the programme is clearly visible in the attention to academic skills and attitudes in the ILOs. The panel thinks that the formulation of the ILOs could emphasise the research focus of the programme more. This is a strong point of the programme that could be better reflected in the ILOs in order to make them more distinctive. Finally, the panel compared the ILOs to the expectations of the field through the ACM Computer Science Curriculum 2013, which the universities involved in this accreditation process defined as the domain-specific framework of reference for all bachelor's programmes. The panel noted that the ILOs and the corresponding course units cover the eleven characteristics of computer scientists as formulated by ACM. These characteristics, as well as a link to the reference document, are provided in Appendix 1 to this report.

The ILOs of the *master's programme* are divided in a set of general ILOs, and two sets of specific ILOs for the SEDS and SBP specialisations. The general ILOs describe the generic knowledge, skills and attitudes that all student should achieve. They build upon the foundations laid in the ILOs of the bachelor's programme and add master level learning outcomes such as critically reading literature, acquiring specialised knowledge and contributing to the enhancement of scientific understanding in a specific field. The additional learning outcomes for the SEDS and SBP specialisation describe the additional skills associated with these specialisations, notably professional skills and knowledge and skills related to software engineering and distributed systems for SEDS, and ILOs related to business & policy for SBP. According to an overview presented to the panel, all master's level Dublin Descriptors are covered in the ILOs. As in the bachelor's programme, the academic level is clearly visible in the research focus as well as the academic skills and attitudes described in the ILOs, but it could be more elaborated in this aspect to emphasise the strong theoretical and research focus of the programme to make them more distinctive. The ACM Framework that serves as domain-specific framework of reference was formulated for undergraduate programmes, but serves as a source of inspiration for master's programmes. The panel concludes that the ILOs and the associated course units cover the eleven characteristics of ACM Framework, and are deepened and extended to a graduate level. The panel considers this in line with a master's programme in the field of computing science.

To further align the ILOs of the programme with the expectations of the professional field, the programmes have a (shared) External Advisory Council consisting of representatives of Dutch and international universities and of various local companies that often hire graduates from the programme. They meet annually with programme representatives to discuss developments in the professional field and possible implications of these for the ILOs and curricula of the programmes. In addition, the Council members assist in creating contacts and opportunities for students, promoting collaborations between the programme and local businesses and serving as external project and thesis supervisors. The panel has had the opportunity to meet representatives of the External Advisory Council during the site visit, and was impressed by its involvement in the programme and the dedication with which the Council supports the programme and provides suggestions for improvement. The panel praises the programme for its involvement of the professional field into the fine-tuning of the ILOs and the curriculum.

Considerations
The *bachelor's programme Computing Science* convincingly profiles itself as a theoretical and research-oriented programme in computing science. The intended learning outcomes meet the expectations of the academic and professional field through alignment with the international ACM benchmark curriculum, and are in line with an academic bachelor's programme in terms of level and orientation. The ILOs could be made more distinctive through a stronger emphasis on the theoretical

and research focus of the programme. The programme has an active and well-functioning External Advisory Council which provides advice that keeps the programme aligned with the expectations of the professional field.

The *master's programme Computing Science* convincingly profiles itself as a theoretical and research-oriented programme in computing science that is well-aligned with the research interests of the computing science departments. Students can choose to specialise either in the direction of academic research, industry or policy making through the four specialisations. The intended learning outcomes meet the expectations of the academic and professional field by expanding on the international ACM benchmark curriculum, and are in line with an academic master's programme in terms of level and orientation. The ILOs could be made more distinctive through a stronger emphasis of the theoretical and research focus of the programme. The programme has an active and well-functioning External Advisory Council which provides advice that keeps the programme aligned with the expectations of the professional field.

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

Master's programme Computing Science: 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.

Curriculum
The curriculum of the *bachelor's programme Computing Science* consists of a compulsory core (135 EC), a one-semester elective part (30 EC) and an individual bachelor's project (15 EC) at the end. The curriculum has been aligned with the programme's intended learning outcomes alongside seven axes (learning lines) that describe the main type of knowledge, skills and attitudes central to the programme: 1) orientation in the field, 2) fundamentals of computing science, 3) formal methods, 4) computer systems, 5) software engineering, 6) mathematical modelling and 7) academic skills.

The compulsory part starts with foundational courses in the first year, which introduce the fundamentals of programming, algorithms, computer data representation and numerical modelling. These courses function as the basis upon which the other courses are built. In the second year, these topics are further elaborated upon by broadening courses in several subfields of computing science, such as software systems engineering, advanced algorithms and data structures, and parallel computing. The third year offers more specialisation, partly in compulsory courses on topics such as computer graphics and operating systems, and partly in the fifth minor semester which is fully elective. Students can choose to follow in-depth Computing Science courses or courses from other disciplines at the university or abroad, or follow an educational minor leading to a second-degree teaching qualification. Before the start of the semester, the student's minor programmes have to be approved by the Board of Examiners to ensure their alignment with the programme's intended learning outcomes. The bachelor's project is an individual research project conducted either within one of the faculty's research groups or in industry, and consists of a literature study, algorithm development, software development, and reporting and presenting of the results.

The panel has studied the curriculum of the programme, as well as the content of a number of courses. It concludes that the ILOs are adequately translated into a coherent curriculum offering a solid core in computing science. This core covers all elements of the ACM model curriculum for computing science. The programme also showed the panel overviews in which the courses are mapped against both the learning lines and the intended learning outcomes. The panel concludes that the learning lines are a coherent set that describes the main elements of the curriculum. It did note that some elements from the intended learning outcomes are not explicitly visible in the learning

lines, for instance learning outcome 3d on preparedness to life-long learning. The panel recommends the programme to ensure that the learning lines are fully aligned with the programme's ILOs. The panel thinks that, if fully aligned and described, the learning lines have the potential to be the main instrument to describe the curriculum, both in terms of design as in communication to students about the curriculum content.

The programme has fully redesigned the academic skills learning line based on the recommendations by the previous accreditation panel. It consists of a clear learning line that shows what skills are offered at what level throughout the curriculum. The panel concludes that this learning line is clear and comprehensive. With regard to the implementation in individual courses, the panel notes that the academic skills content is not always visible at first glance, but can be hidden in the course content. The panel understood from the programme management that a full overview of specific assignments related to academic skills per course is still being implemented. The panel supports this, and thinks that such an overview can be helpful to students to make visible which skills training they can expect per course.

The curriculum of the *master's programme Computing Science* consists of a 30 EC compulsory part, 35 EC specialisation-related courses and 25 EC electives. The remaining 30 EC is for the master's thesis. Students choose a specialisation at the start of the programme, and start with specialisation-specific courses as early as the first semester. They can customise their curriculum with 10 EC electives chosen within the specialisation, and 15 EC from any master's courses taught at the university, as long as the full set is approved of by the Board of Examiners. The compulsory courses include courses on data science (5 EC) and web and cloud computing (5 EC), a student colloquium (5 EC), and an internship (15 EC). The topics of the two compulsory courses are considered by the programme to be essential to all four specialisations. The student colloquium trains students in academic skills. Students organise an emulated scientific conference and subsequently publish academic proceedings. During the process they fulfil the roles of contributors, peer reviewers, programme committee and session chairs. In the internship, students are placed in one of the research groups of the department, and are trained to conduct scientific research. In the SEDS specialisation, students can also opt for an in-company internship, where they can experience the process of software development in the professional field. Using the skills obtained in the colloquium and internship, students work on their master's thesis in the final semester of the curriculum. This is an independent research project, sometimes leading to a software product, that is finished with a written and oral report.

The panel has studied the curriculum of the programme, as well as the content of a number of courses. It concludes that students obtain an advanced understanding of computing science, and have the opportunity to specialise in one of four directions to fit their preferences. Each specialisation offers a coherent curriculum on its specific topic, aligned with the research interests of the associated research groups. Students obtain a very thorough training in research skills in the research internship and the student colloquium, which the panel considers strong points of the programme. The student colloquium in particular is a very original initiative, that was reported by students to be interesting and very valuable for the development of their research skills. The option to replace the research internship with an in-company placement for the SEDS specialisation is fitting with regard to the focus of this specialisation towards a professional career.

Teaching methods
Both Computing Science programmes aim for a close relation between education and research. All teaching staff are active researchers and frequently incorporate recent research developments and literature in the courses. The teaching methods used in the courses include active learning in practicals, tutorials and project assignments, supported by knowledge obtained in lectures. The panel concludes that these teaching methods are appropriate, and thinks that the close relation between education and research is a strong point of the programme.

The panel understood during the site visit that the rise in student numbers challenges the programme to keep students engaged during lectures and tutorials. To solve this, the programme is increasing its efforts to use interactive teaching methods, such as quizzing, live coding and code visualisation. Students indicated to the panel that they appreciate this, and would like to see more of such initiatives. The panel supports this, and recommends the programme to continue these efforts.

Furthermore, the master's students stated that, while they very much appreciated the relation of the courses with recent developments in the academic field, they would like to have a similar interaction with the professional field. This was most prominently the case for students in the ISVC and DSSC specialisations. Although these specialisations are tailored towards an academic career, many graduates ultimately find employment in the professional field. More contact with industry, for instance through extra internship possibilities or guest lecturers would be appreciated. The panel recommends the master's programme to investigate whether this request can be fulfilled.

Language and internationalisation
Both the bachelor's and the master's programme are offered in English, as are nearly all programmes at the Faculty of Science and Engineering. According to the programmes, education in English opens up international career possibilities for graduates, including the opportunity for acquiring intercultural training in an international classroom. It also allows for the inclusion of the most recent developments in the field, which are predominantly available in English. As the staff of the Computing Science department is very international (75 percent non-Dutch), the use of English means that all staff can participate in education. In recent years, more than half of the student intake has been non-Dutch, reflecting the international nature of the programme. To maintain the quality of the education in English, language proficiency is a selection criterion for new staff. Additionally, the university offers courses to improve language proficiency to all staff.

The panel considers the choice for the use of English to be very well motivated. The programmes are offered in a very international environment, both with regard to the field of computing science as to the staff of the computer science department. An English language programme prepares students for an internationally oriented field in which they can expect to often work interculturally. Students are generally positive on the quality of the education in English, and there is sufficient attention to the language skills of the teaching staff. The theses that the panel read demonstrated that the students have a good command of English. One point of attention for the programme might be the integration of a specific group of international students in the master's programme. International students that did not originate from the faculty's own bachelor's programme indicated that they sometimes felt isolated in their first months in the programme, as most students already seem to know each other from the bachelor education. The panel recommends the programme to identify and address the needs of this group.

Feasibility
The panel has studied an overview of the study success for both programmes, and discussed the feasibility of the programmes with students, teaching staff and programme management. This overview shows that approximately half of the students in the bachelor's programme that register after the first year finish the programme within three years, and two-thirds within four years. With regard to the feasibility of the bachelor's curriculum, the panel concludes, based on the student interviews, that courses are generally feasible within the allocated time and that there are no major stumbling blocks in the curriculum.

The bachelor's programme has a high drop-out rate (40 percent) in the first year. The programme management indicates that the first year has a highly selective character, and it often reveals students that are not a good match with the programme. The programme is currently adjusting its matching procedure to try to decrease the number of mismatches, and to step up support for students in the first year. The matching procedure includes a mathematics test and a test in which students receive some material on Storage and Data Compression that they have to study and are

assessed on. Additionally, the programme participates in a faculty-wide project to improve the study success of international students and in an early warning system that identifies underperforming students as soon as possible so they can get help. The panel is positive on these measures, and encourages the programme to continue with them in order to minimise drop-outs.

Most master's students (around 80 percent) eventually graduate, but they usually take quite long to get there. Approximately 15 percent finishes in two years and 40 percent in three years. According to the programme this study delay, and to a lesser extent also that in the bachelor's programme, is mainly caused by students taking jobs while studying due to the high demand for IT personnel in the professional field. The programme actively discourages students to leave the programme before graduating, and as a result, some students continue their studies at a slower pace. Part of the delay in the master's programme is also caused during the research internships and master's thesis, where students until recently had no strict deadlines to adhere to. To remedy this, the programme has recently launched a new protocol for the master's thesis with stricter deadlines and a timeline to support students and supervisors. The panel supports these measures, and thinks that mid-term evaluations stimulate students to finish their projects in time. With regard to the feasibility of the curriculum, master's students indicated that the workload is usually adequate, but that the first semester is experienced by some as having a higher workload than subsequent semesters. The panel recommends the programme to look into this and, if possible, readjust the workload.

Both bachelor's and master's students noted that there could be incidental issues with regard to alignment between courses, leading to either overlap in course content, or gaps in pre-required (mathematical) knowledge. The teaching staff recognised some of these issues and indicated that, although course content is periodically aligned, inconsistencies can creep back in over time, especially when the coordinating teacher is replaced, which was the case for some courses. The panel recommends the programmes to keep attention to avoid overlap between courses, and if necessary, increase the frequency with which course content is aligned.

To improve the educational quality, course units are being evaluated by students through the programme committee. The committee uses the outcomes of a digital survey among students as well as the written feedback provided by the teacher to compile an evaluation report, and the resulting advice to the programme management for further improvement. During the site visit and in the student chapter of the self-evaluation report, students mentioned that they had the impression that recommendations from course evaluations were not always taken into account. The panel discussed this issue with students and teaching staff (including programme committee members) and programme management during the site visit. It found out that the student evaluations through digital forms tend to have low response rates, making it hard for the teaching staff to draw reliable conclusions from this feedback. To improve the quality of feedback, the programme has recently introduced group discussions with students after courses in which future improvements to the course are discussed. The panel is positive on this development, and concludes that the programmes make the effort to use student feedback to improve course quality. However, the programmes could improve the way in which changes in courses are communicated. The panel has the impression that the perceived lack of response to student feedback stems from the fact that improvements to courses based on evaluations are not communicated to students that contributed to those evaluations. The panel recommends the programmes to improve this, so students can clearly see the positive effect that the course evaluations have.

Teaching staff

The teaching staff of both programmes is for a large majority affiliated with the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence. Most are active researchers in computing science or related disciplines, and have a non-Dutch background (75 percent). The core staff consists of approximately 20 lecturers, who take care of most of the teaching and supervision. Obtaining a University Teaching Qualification (UTQ) is a prerequisite for every new teacher, and 90 percent of these teachers currently have a UTQ or are in the process of obtaining one. Students indicated to the panel that they are enthusiastic about their teachers, and feel that the staff is very

approachable, even though the number of students is high. The panel is positive about the teaching staff of the programmes, and praises the professionalisation of teachers through UTQs. The teaching staff is able to connect the courses to their own research, providing students with the opportunity to stay up-to-date on current research.

Both the bachelor's and master's programme have experienced a substantial increase in student numbers, with the associated increase in workload for the teaching staff, with almost triple the numbers in 2019 (187 to 74 for the bachelor, 110 to 23 for the master) compared to 2014. The Faculty Board and the programmes aim to counter this by a growth in the core teaching staff from 20 to 25 lecturers. The hiring was underway at the time of the site visit. The teaching staff considers the workload high, but still feasible with the current student numbers. The programmes are also investing in hiring more teaching assistants to relieve the workload of the teaching staff. In the interviews with staff and students, the panel learned that the programme struggles to fill these positions, as there are not enough suitable master's and PhD students available to fill in all vacancies. The programmes try to remedy this by training interested students up to the required level. In general, the panel supports the measures the formal management takes to match growing student numbers with an increase in staff. It stresses that, even with the expected expansion of the teaching staff, the staff quantity is still on the low side. It recommends the Faculty and the programmes to anticipate even higher student numbers, as the end of the growth does not seem to be in sight yet, and to continue taking additional measures to keep staff quantity in line with student numbers. This applies to teaching staff as well as teaching assistants, for which the programmes might consider looking beyond their own master's and PhD students to fill in the vacancies.

Another change in the programme's teaching staff has resulted from replacements due to retirement. Some students expressed their concerns to the panel that these changes in staff could endanger the theoretical character of the programmes, as the new staff is perceived to have a more application-oriented approach towards computing science. The panel recommends the Faculty Board and the programmes to take these concerns into consideration, and to keep paying attention to the match between the research interests of the staff and the profile of the educational programmes.

Programme-specific facilities
The Computing Science programmes are located in the Bernoulliborg building on the Zernike Campus. Programme-specific facilities include computer rooms with dual boot Linux/Windows PCs, project rooms for group work and specialised software packages for specific courses. Furthermore, students can, for some courses and for their research projects, use the university's advanced facilities for high-performance computing and visualisation. The panel thinks that these facilities are fitting with a computing science programme. From interviews with students, the panel understood that the growth in student numbers puts pressure on the availability of these resources. Labs, study places, project rooms and wall plugs are sometimes in short supply during busy hours. The panel recommends to keep matching the growth of resources with the increase in student numbers as much as possible.

Another remark by students concerned one specific master's course on cloud computing. Here, students indicated that the cloud services offered by the programme were not sufficient for them to do the practical work properly. Most students then decided to purchase additional cloud computing resources themselves. The panel considers this undesirable, and recommends the master's programme to guarantee sufficient facilities for all students.

Considerations
Both the bachelor's and master's programme Computing Science have adequately translated their intended learning outcomes into a coherent curriculum. The bachelor's programme offers a solid core curriculum in computing science, structured along a clear set of learning lines. The panel recommends the programme to ensure that the learning lines are fully aligned with the programme's ILOs. The panel thinks that, if fully aligned and described, the learning lines have the potential to be the main instrument to describe the curriculum, both in terms of design as in communication to

students about the curriculum content. The academic skills learning line is clear and comprehensive, but the specific skill training within the courses could be made more visible for students. The master's curriculum allows students to obtain an advanced understanding of computing science, and specialise in one of four directions to fit to their preferences. Students obtain a very thorough training in research skills in the research internship and the student colloquium. The teaching methods in both programmes are appropriate, and the close relation between education and research is a strong point of the programmes. The panel recommends the master's programme to investigate whether and how the students can interact more with the professional field. The use of English as the language of instruction in the programmes fits the international character of the programme and its teaching staff, and prepares students for the international job market.

The programmes are feasible, although some students take longer to finish due to jobs and/or prolonged research projects. For the latter, the master's programme introduced an adapted thesis trajectory with extra deadlines, which the panel strongly supports. The bachelor's programme has a high percentage of drop-outs in the first year. The panel endorses the measures taken by the programme to reduce this through better matching, better support for international students and early warning systems. The panel recommends to investigate the perceived imbalance in workload in the first semester of the master's curriculum, and the alignment of content between courses in both programmes. Further, the programmes should better communicate to students how course evaluations are being used to improve course quality. The panel is positive about the teaching staff of the Computing Science programmes, and the professionalisation of teachers through UTQs. The quantity of the teaching staff is just enough for the current student numbers, but the programmes need to pay continuous attention to staff quantity with regard to the rapid growth in student numbers, both for teaching staff and teaching assistants. The programmes offer adequate facilities, although their availability can be limited due to high student numbers.

Conclusion
Bachelor's programme Computing Science: the panel assesses Standard 2 as 'meets the standard'

Master's programme Computing Science: 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
Both programmes adhere to the assessment system and exam regulations decided upon at the faculty level. The assessment policy prescribes for each programme an assessment plan that contains an overview of the learning outcomes for the entire curriculum, coupled in a matrix to the various courses, methods of assessment within the courses and the associated examiners. For the validation of course units and their examination, the programmes use Course Unit Assessment Overviews (CUAOs), systematic descriptions per course unit detailing the learning outcomes, teaching methods, assessment methods and grading, and the place of the course in the entire curriculum. These CUAOs are updated annually by the lecturers of each course. Assessment methods within the programmes include written exams with open questions for assessment of knowledge, and skills through programming, presentations and reports. To improve transparency and consistency of assessment, a second examiner is appointed to each course unit, who checks the assessment material and grading scheme drafted by the first examiner. For programming assignments, the programmes use an in-house developed system called Themis. This system provides automatic feedback on programming work, checking whether computer programs submitted by students work, and points out all kinds of automatically traceable errors. It is used both for formative feedback as for assessment of student assignments.

The panel studied the assessment system of the programmes, a sample of CUAOs, and some examples of exams used within the programmes. It is positive about the variety of assessment methods and the clear description of course assessment within the CUAOs. The second examiner for each of the courses adds to the validity and transparency of exams. According to the panel, the assessment plans on the curriculum level could be improved. These plans are currently more a description of the assessment in the curricula rather than an instrument used to design the assessment on a programme level. This has resulted in an uneven document that shows which course contributes to the assessment of what intended learning outcomes, without specifying how or to what extent. The panel recommends to improve the assessment plans by adding a more in-depth description of the individual exams and assessment methods associated with each learning outcome. The panel notes that the programmes are already well-equipped for this, as this information is readily available in the individual CUAOs. This improvement will allows these documents to be used as instruments in the design and fine-tuning of the assessment on a curriculum level for both programmes.

The Themis system for automatic assessment of programming assignments is considered by the panel to be very interesting. Students were very positive about this software, as it provided them with instant feedback on their work whenever they desired. The panel praises the programme for this.

Thesis assessment
In both programmes, students conclude their curriculum with an individual research project, which results in a written thesis and an oral presentation. The project is assessed by two examiners: the supervisor and a second examiner. For the master's thesis, both examiners are always scientific staff members of the faculty; for the bachelor's thesis the second examiner can be a postdoc or PhD student. The research internship in the master's programme follows the same procedure. In the case of an externally conducted project, such as the In-Company Placement in the SEDS specialisation, the local supervisor acts as advisor to the two examiners. Each project is documented in three forms: a starting form detailing the project goals and description, as well as the grading that will be used at the end, a mid-term evaluation and a final evaluation. The final evaluation focuses on four criteria: scientific quality, project management and skills, oral presentation and the report. The final grade is a weighted average of the four criteria, with the weights being described in the starting form. Additionally, each criterion should at least receive a satisfactory score for successful completion of the thesis. The two examiners decide collectively on a grade on all four criteria, and substantiate and register this on a standardised assessment form. The second examiner is required to fill an additional text box detailing his or her remarks on the assessment.

The panel has studied the assessment form and the use thereof in the bachelor's and master's programme Computing Science. It considers that the assessment procedure for research projects is good. The second examiner increases the validity of the grading, which is visible in the separate comments this second examiner gives on the form. The starting forms and mid-term evaluation provide a unique and transparent insight into the grading process, especially with regard to the assessment of skills and project management. The assessment forms in most cases include extensive qualitative feedback which provides a clear motivation of the grade, and adds to the transparency of the grading. The panel praises both programmes for the very good and transparent procedures surrounding the thesis assessment, and the clear documentation of this in the assessment forms.

Board of Examiners
The bachelor's and master's programme Computing Science share a Board of Examiners. It consists of three staff members and an external member who also serves as didactical expert, and is supported by a formal secretary from within the faculty. The Board appoints the programmes' examiners and monitors the quality of assessment within the programmes. It monitors the quality of assessment through an annual check of the programmes' assessment plans and CUAOs against the ILOs of each programme. Additionally, it performs systematic checks of the exams within the programmes in terms of clarity, completeness and level of difficulty in a three-year cycle. A sample

of bachelor's and master's projects is checked annually for both programmes in terms of adequate grading with regard to thesis quality, as well as the correct use of the assessment form. In recent samples, the Board was satisfied with the quality of the assessment.

The panel spoke with the Board of Examiners and studied a number of its annual reports. It judged that the Board adequately fulfils its role in the quality assurance of assessment within the programme. The quality assurance measures the Board has in place are fitting and contribute to the validity of the assessment within the programmes. According to the panel, the Board could have been more proactive with regard to some of the observations that the panel made during the site visit. Examples are the limited usefulness of the assessment plans in the programmes, which require the individual CUAOs of all courses to provide a full picture of coverage of ILOs in exams (see discussion above), and the high average thesis grades in the master's programme (see Standard 4). Even though the panel eventually found these grades to be justified, it thinks that the fact alone that a programme has an average thesis grade of 8.5 could have triggered the Board to issue an extra check, for instance through an external reviewer from outside the university. The panel recommends the Board to step up its proactive role in order to improve the quality of assessment wherever it thinks this is necessary.

Considerations
Both programmes have an adequate assessment system that assesses students on all intended learning outcomes. According to the panel, a second examiner for each course adds to the transparency and validity of assessment, and the automatic feedback system for programming assessments is very interesting. The assessment per course is clearly described in the Course Unit Assessment Overviews, but could be better described on a curriculum level. The panel recommends to develop a full assessment plan per programme with all individual exams. The thesis assessment of both programmes is good. The starting form and mid-term evaluations add to the reliability of the assessment. The assessment form is well-designed and well-implemented, and provides a transparent motivation of the final grades. The Board of Examiners adequately fulfils its role in the quality assurance of assessment, but could take a more proactive role with regard to initiating improvements and checks with regard to the quality of assessment in the programmes.

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

Master's programme Computing Science: 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

Bachelor's programme Computing Science
Prior to the site visit, the panel studied 15 theses of the bachelor's programme Computing Science. The panel is positive about the very high quality of the projects. The theses all correspond to the requirements for a bachelor's thesis in computing science. They show appropriate research skills and in some cases a high level of theoretical knowledge and insight, fitting the profile of the programme. In the past six years, 16 bachelor's theses led to a scientific publication, which the panel considers to be very high.

Most graduates of the programme continue with a master's programme in Computing Science, often the master's programme within Groningen. This is in line with the profile of the programme, which aims to prepare students for a master's programme rather than the professional field. Alumni of the bachelor's programme report no obstacles in their respective master's programmes. The high level of the master's students (see below), almost half of which originate from this bachelor's programme,

strengthens the impression of the panel that the intended learning outcomes of the programme are achieved and often exceeded.

Master's programme Computing science
Prior to the site visit, the panel studied 15 master's theses of the master's programme Computing Science, divided over all four specialisations. The panel is positive about the quality of all projects, which they consider very high. The theses all correspond to the requirements for a master's thesis in computing science. They show appropriate research skills and in some cases a high level of theoretical knowledge and insight, fitting the profile of the programme. The average grade of the master's theses has gradually grown from 7.8 in 2015/16 to 8.5 in 2018/19. The panel considers this a very high average and has carefully studied the thesis selection and discussed this topic during the site visit to ensure that there was no inflation of thesis grades. In the end, it concluded that the thesis grades as well as the grading process are appropriate and that the level of the programme's graduates is indeed excellent and improving.

This is further demonstrated by the high number (31) of peer-reviewed publications resulting from master's theses from the past year, which is roughly 30-40 percent of all theses. Also, 14 percent of graduates continue in academia, which is high compared to similar master's programmes. This fits the research-oriented character of the programme. The other graduates mainly end up either in ICT engineering (75 percent) or as IT consultant (8 percent). The graduates of the programme are very much in demand, as previously stated, many students already find or even start a job before graduation. The panel considers this to be an indicator of the successful realisation of the intended learning outcomes of the programme.

Considerations
The panel concludes that the theses of both programmes are of high quality, and convincingly show that the intended learning outcomes are achieved. The panel agrees with the grading, and praises in particular the master's programme Computing Science for the excellent level of the master's theses. It praises both programmes for the high number of scientific publications resulting from the theses. The bachelor's students usually continue in a master's programme, fitting the goals of the programme, and those that enter the master's programme at Groningen do very well. The graduates of the master's programme are in high demand on the labour market, both as PhD researcher as well as in industry.

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

Master's programme Computing Science: the panel assesses Standard 4 as 'meets the standard'.

GENERAL CONCLUSION

The panel assesses all standards of the NVAO's Framework for a limited programme assessment 2018 for both programmes as 'meets the standard'. According to the decision rules of the framework, the panel assesses positively on all programmes.

Conclusion
The panel assesses the *bachelor's programme Computing Science* as 'positive'.

The panel assesses the *master's programme Computing Science* as 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

The Computing Science programmes use 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 programmes, and as starting point for the master's programmes. This extensive 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.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Bachelor's Programme Computing Science

Graduates of the Bachelor's degree programme Computing Science:

1. Have the following knowledge, understanding and insights on an academic level:
   a. knowledge of the main topics of the Computing Science discipline;
   b. understanding of common themes and principles of Computing Science on different levels of abstraction;
   c. insight in the applicability of Computing Science and the interplay between its theory and practice components;
   d. either d1: in-depth knowledge of certain topics in the field of Computing Science, or d2: broad-based knowledge of topics in a different discipline at the bachelor level.
2. Have the following skills and competences, on an academic level:
   a. technical skills associated with Computing Science, including relevant mathematical, analytic, and logical skills;
   b. relevant soft skills, including communication, presentation (oral and in writing), intercultural team-working, and self-managed learning;
   c. academic skills, including conceptual thinking, critical questioning and argumentation, judgement forming, scientific research, and writing and presenting in English;
   d. the competence to analyze, structure, and (re)define and solve problems, using computational methods and tools;
   e. the competence to design, develop and evaluate (test) computer systems;
   f. the competence to apply their knowledge and understanding of Computing Science in a globalised professional and entrepreneurial context.
3. Have the following attitudes:
   a. appreciation of the role and importance of mathematics, related disciplines, and domain-specific knowledge;
   b. commitment to professional responsibility, including ethical, societal and intercultural issues, with a (self-) critical attitude;
   c. critical and academic attitude towards information and knowledge;
   d. preparedness to life-long learning, based on the awareness of the highly dynamical character of Computing Science.

Master's Programme Computing Science

The Master graduate in Computing Science:

LO 1. Is fully acquainted with the basic terms and techniques used in Computing Science, and is familiar with a number of classical problems and their solutions;
LO 2. Is experienced in the effective use of the tools available in solving Computing Science problems, such as compilers, theorem proofs, visualisation software, case-tools and domain specific software and hardware;
LO 3. Is familiar with Computing Science applications in several other scientific fields of study;
LO 4. Is capable of clear communication (both oral and in writing) on the subject of Computing Science and its applications;
LO 5. Is capable of working in a team and in various projects;
LO 6. Is sensitive to the social aspects of Computing Science applications and his/her own responsibilities therein;
LO 7. Has specialised knowledge of theories, methods and techniques in one of the following subfields of Computing Science:

- Intelligent Systems and Visual Computing
- Software Engineering and Distributed Systems
- Data Science and Systems Complexity
- Science, Business & Policy

LO 8. Is able, by using scientific data and assessments, to analyse problems in Computing Science or a related scientific field of study, to provide specified solutions to the problem, and – if possible – to materialise these solutions (in the shape of an algorithm or program or an implementation in software or hardware);
LO 9. Is able to critically read professional literature and to assess its correctness, usability and relevance;
LO 10. Is able to contribute to the enhancement of scientific understanding in a subfield of Computing Science;
LO 11. Has a proper understanding of the scientific relevance of problem definitions and results, and of the validity of the scientific method used.

The first six learning outcomes are similar to those of the Bachelor programme in Computing Science. Some subfields in the Computing Science master degree have the following additional learning outcomes:

The Master in Computing Science graduated in the subfield of Software Engineering and Distributed Systems:

P1. Is capable of systematically designing and implementing software systems in cooperation with interested parties;
P2. Is capable of integrating existing and new software components into a system that meets the quality criteria that were agreed upon.

The Master in Computing Science graduated in the subfield of Science, Business & Policy (SBP):

M1. Has a full understanding of the way in which businesses and policy organisations are functioning (governments and nongovernmental organisations, NGO's);
M2. Understands the connections between natural science research, trade and industry and governmental policies;
M3. Is able to integrate aspects of natural science, business and management;
M4. Is able to translate a concrete problem definition in business or management into a natural science problem definition;
M5. Is able to connect problem aspects of natural sciences to other relevant subject fields;
M6. Is able to put research data and conclusions into a business or policy context;
M7. Has developed his/her social and communicative skills:
M8. Is able to write texts that are effective and to the point;
M9. Is able to draw up an innovation plan or management plan for either a business or a government organisation;
M10. Is able to give convincing oral presentation;
M11. Is able to deliver an active contribution to plenary discussions;
M12. Familiar with techniques used in business meetings and is capable of chairing a meeting;
M13. Is able to work on a project as part of a team;
M14. Is able to give and receive feedback concerning his/her way of functioning in a team;
M15. Can work in a project;
M16. Is able to fully consider the interests or objectives of the ordering customer;
M17. Is able to plan a project independently;
M18. Is able to cooperate with the relevant parties involved in the project;
M19. Is able to adequately deal with limitations in time, information and means;
M20. Is able to prepare the implementation of a project result;
M21. Is capable of taking professional responsibility;
M22. Is able to take responsibility on behalf of the organisation;
M23. Is able to recognise the strategic aspects of his/her own project;
M24. Is able to provide practical solutions in matters concerning the ethical and professional codes of his/her own field of expertise and of the professional organisation.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

Bachelor's Programme Computing Science

Quarter	Year 1	Year 2	Year 3*
1a	Imperative Programming	Advanced Object-Oriented Programming	*Information Security*
	Introduction to Computing Science	Functional Programming	*Introduction to Intelligent Systems*
	Introduction to Logic	Statistics	*Requirements Engineering and Software Startups*
1b	Calculus	Advanced Algorithms and Data Structures	*Software Language Engineering*
	Discrete Structures	Signals and Systems	*Short programming project*
	Computer Architecture	Problem Analysis and Software Design	*(minor course unit chosen by student)*
2a	Algorithms and Data structures in C	Introduction to Scientific Computing	Operating Systems
	Introduction to Information Systems	CS: Ethical and Professional Issues	Computer Graphics
	Program Correctness	Software Engineering (10 ECTS)	Web Engineering
2b	Artificial Intelligence 1		Bachelor project (15 ECTS)
	Linear Algebra & Multivariable Calculus	Languages and Machines	
	Object-Oriented Programming	Parallel Computing	

*Course units in semester 1 of year 3 (printed in *italics*) are part of the Specializing minor Computing Science.

Master's Programme Computing Science

Year 1	Ia	Introduction to Data Science (5 ECTS)	Web and Cloud Computing (5 ECTS)	
	Ib			
	IIa	Student Colloquium (5 ECTS)		
	IIb	In-company or Research Internship (15 ECTS)		
Year 2	Ia			
	Ib			
	IIa	Master Thesis (30 ECTS)		
	IIb			

*Grey cells are allocated to specialisation-specific compulsory course units and/or elective courses.

APPENDIX 4: PROGRAMME OF THE SITE VISIT

DAY 1		**28 NOVEMBER 2019**
10.30	10.45	Ontvangst
10.45	13.00	Intern overleg (incl. lunch)
13.00	13.45	**Interview opleidingsmanagement**
13.45	14.00	Pauze / intern overleg
14.00	14.45	**Interview studenten bachelor**
14.45	15.00	Pauze / intern overleg
15.00	15.45	**Interview docenten bachelor**
15.45	16.15	**Showcases**
16.15	16.30	Pauze / intern overleg
16.30	17.15	**Interview examencommissie**
17.15	17.30	Pauze / intern overleg
17.30	18.00	**Interview alumni / werkveld**
18.00	18.30	Intern overleg

DAY 2		**29 NOVEMBER 2019**
09.00	10.00	Aankomst, intern overleg
10.00	10.45	**Interview studenten master**
10.45	11.00	Pauze / intern overleg
11.00	11.45	**Interview docenten master**
11.45	13.00	Intern overleg (incl. lunch)
13.00	13.45	**Eindgesprek met formeel verantwoordelijken**
13.45	15.15	Opstellen oordelen
15.15	15.30	**Mondelinge rapportage voorlopig oordeel**
15.30	15.45	Uitloop
15.45	16.30	**Ontwikkelgesprek**
16.30	16.45	Afronding en vertrek

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Prior to the site visit, the panel studied 15 theses of the bachelor's programme Computing Science, and 15 theses of the master's programme Computing Science. Information on the selected theses is available from QANU upon request.

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

- Overview programme content for each programme (study guide, electronic learning environment and a selection of course materials, including Course Unit Assessment Overviews)
- Selection of exam questions and answer models for each programme
- Education and Exam Regulation
- Teaching staff overview
- Annual reports 2017 and 2018 Boards of Examiners
- Annual reports 2017 and 2018 Assessment Committee
- Annual reports 2017 and 2018 Programme Committee
- FSE protocol board of examiners
- Quality Assurance Guide Boards of Examiners
- Rules and Regulations by the Boards of Examiners
- Programme committee handbook UG
- FSE Quality Assurance Manual
- FSE Quality Assurance Manual for teaching staff
- Instellingstoets kwaliteitszorg RUG
- Assessment plans for both programme
- Education monitor faculty and programme 2017 and 2018
- Report 'heidagen CS'
- Report External Board of Advice
- Results NSE
- Results 'Keuzegids Master'
- Selection of peer reviewed BSc and MSc student articles
- Panel reports of the 2013 Programme Assessments