# COMPUTER SCIENCE

FACULTY OF SCIENCE

**UNIVERSITY OF AMSTERDAM**

QANU
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
E-mail: support@qanu.nl
Internet: www.qanu.nl

Project number: Q0745

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# REPORT ON THE BACHELOR'S PROGRAMME INFORMATICA AND THE MASTER'S PROGRAMME SOFTWARE ENGINEERING OF THE UNIVERSITY OF AMSTERDAM

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 Informatica**

| | |
|---|---|
| Name of the programme: | Informatica |
| International name of the programme: | Computing Science |
| CROHO number: | 56978 |
| Level of the programme: | bachelor's |
| Orientation of the programme: | academic |
| Number of credits: | 180 EC |
| Location(s): | Amsterdam |
| Mode(s) of study: | full time |
| Educational minor: | applicable (second degree qualification) |
| Language of instruction: | Dutch |
| Submission deadline NVAO: | 01/05/2020 |

**Master's programme Software Engineering**

| | |
|---|---|
| Name of the programme: | Software Engineering |
| CROHO number: | 60228 |
| Level of the programme: | master's |
| Orientation of the programme: | academic |
| Number of credits: | 60 EC |
| Specialisations or tracks: | - |
| Location(s): | Amsterdam |
| Mode(s) of study: | full time, part time |
| Language of instruction: | English |
| Submission deadline NVAO: | 01/05/2020 |

The visit of the assessment panel Computer Science to the Faculty of Science of the University of Amsterdam took place on 4 and 5 November 2019 .

## ADMINISTRATIVE DATA REGARDING THE INSTITUTION

| | |
|---|---|
| Name of the institution: | University of Amsterdam |
| 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 Computing Science and the master's programme Software 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);
- Drs. H.C. (Jeroen) Borst, senior consultant Smart Cities at TNO;
- E. (Evi) Sijben BSc, Master's student Computing Science in the specialisation track Data Science 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 programme Computing Science and the master's programme Software Engineering at the Faculty of Science of University of Amsterdam 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 University of Amsterdam the panel was supported by M. (Mark) Delmartino MA, a certified NVAO secretary.

*Panel members of the cluster assessment Computer Science:*
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;
- T.A. (Tonny) Wildvank, owner/CEO at Wildvank, Management en Advies, specialised in IT-management and -consultancy;

- Prof. dr. 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 the Radboud University Nijmegen;
- Ir. E.A.P. (Ewine) Smits, Senior 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 Computing Science at University of Amsterdam [student member];
- M. (Martijn) Brehm, third-year bachelor's student Computing Science at University of Amsterdam [student member].

*Preparation*
On March 21st, 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 May 9th, 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. Part of the visit was dedicated to the joint Master's programme Computational Science, which the University of Amsterdam is organising together with the Vrije Universiteit Amsterdam. The panel's findings on this joint programme are reported in a separate document. 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 University of Amsterdam, 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 bachelor's theses and 15 master's 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 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, and that all tracks of the programmes were covered in the selection. 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.

*Site visit*
The site visit to University of Amsterdam took place on 4 and 5 November, 2019. At the start of the site visit, the panel discussed its initial findings, identified the key issues to be discussed during the sessions, and agreed on a division of tasks during the site visit. During the site visit, the panel studied the additional documents provided by the programmes. An overview of these materials can be found

in Appendix 5. The panel conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. One person 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 NVAO assessment framework includes a so-called development dialogue in which panel members and programmes representatives discussed various development routes for the programmes under review. During the preparation of the visit, it was agreed that this development conversation would be organised jointly by VU and UvA and take place at the end of the panel's site visit to the Vrije Universiteit Amsterdam, on 7 November 2020. 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 during the assessment of the academic teaching programmes (admission deadline: 1 November 2021).

*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 *(Bacheloropleiding Informatica)***
This evaluation concerns the bachelor's programme Computing Science, a three-year full-time 180 EC programme offered by the College of Science at the University of Amsterdam.

The programme aims to offer a broad basis in all domains of computer science preparing students for both an academic master's programme and a relevant position on the labour market. These ambitions are translated adequately in the intended learning outcomes, which in turn reflect properly the domain, level and orientation of the programme. According to the panel, the learning outcomes relate clearly to the European-wide Dublin Descriptors and cover the provisions of the international ACM curriculum. The professional field is involved in keeping the bachelor's programme up to date. Nonetheless, the panel thinks that the functioning of the Professional Advisory Board can be enhanced by extending its membership to cover the entire domain of computer science and by meeting more regularly.

Overall, the teaching-learning environment of the bachelor programme is up to standard. The panel thinks highly of the coherent curriculum structure with six learning lines. Students are very well trained in the dedicated learning line on academic skills. The didactic concept underlying the programme is clear and befits the profile, the ambitions and the intended learning outcomes of the programme. The curriculum is feasible. Students are actively involved in quality assurance, among others through sounding board groups. The Science Park campus constitutes an important asset for the programme and for (potential) students. In addition to these strengths, a few issues can be improved and are on the radar of the programme management. The panel suggests to revitalise the honours programme, to adjust the length of some courses within the existing block structure, to increase the number of staff and to involve more research staff and (full) professors in the bachelor courses.

Student assessment is well organised in the Computing Science programme. The policy and principles underlying course assessments are up to standard and applied in the day-to-day reality of teaching and assessment. The programme is taking fraud seriously. The course assessments are valid, reliable and transparent. Based on its own sample review, the panel considers that overall the assessment process of the theses is adequate. If used properly, the evaluation form is relevant. While several assessors complete the evaluation form in an insightful way, the panel encourages the programme to impose that all assessors provide qualitative feedback to motivate their scores. The members on the Examinations Board and its subcommittee for the bachelor's programme, its assessment committee and its fraud and plagiarism committee have good expertise to deal with their respective tasks. The panel suggests that the assessment committee verifies in its thesis review sample that the scores on the three elements (research, thesis, presentation) are always motivated in an insightful way.

Bachelor students who graduate from the Computing Science programme are adequately prepared for a follow-up study or a position on the labour market. Having established that all bachelor theses meet at least the minimum requirements of what can be expected of a final project at bachelor level—and are often of higher quality—it is fair to state that the intended learning outcomes of the programme are eventually achieved at the end of the bachelor curriculum. Because there is only limited information on the whereabouts of the bachelor graduates, the panel recommends the programme to follow-up more systematically the academic/professional careers of its alumni.

Across all standards, the panel noticed that there have been many small developments in the programme and that the programme has done an impressive job in addressing the recommendations of the previous accreditation committee. Hence the panel's overall positive appreciation of the programme quality. Nonetheless, one major change—a merger with the VU—did not come about: this means that two universities in the same city continue to offer separate bachelor's programmes in computer science. Given this situation, the bachelor's programme at UvA would benefit from a

strategic vision on its own future according to the panel, taking into account the needs and interests of the programme, the staff and the research groups. Furthermore, the management may consider whether and how it wants to increase the number/share of bachelor graduates who stay with UvA for a master's programme.

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 Software Engineering**

This evaluation concerns the master's programme Software Engineering, a 60 EC programme offered in a full-time and a part-time variant by the Graduate School of Informatics at the University of Amsterdam.

The programme has an almost unique position in the Dutch higher education landscape with a specific profile balancing technical and human aspects of software engineering. The profile is reflected in the intended learning outcomes, which are formulated adequately in terms of domain, level and orientation of the programme. Moreover, the exit qualifications cover both the European-wide Dublin Descriptors and the domain-specific Body of Knowledge. The professional field is involved in keeping the programme up to date. Nonetheless, the panel thinks that the functioning of the Professional Advisory Board can be enhanced by extending its membership to cover the entire domain of software engineering and by meeting more regularly.

Overall, the teaching-learning environment of the programme is up to standard. The panel thinks highly about the curriculum, the current staff, and the facilities: the programme contents are relevant and well elaborated; the curriculum is in full alignment with the programme profile, the intended learning outcomes and the international domain-specific body of knowledge; the part-time variant is well embedded in the programme structure; the international student and staff body is clearly an asset and contributes to the overall atmosphere and a safe programme environment; the educational concept is well thought through and aligns with the ambition to challenge students and motivate them to excel; the admission process is thorough; the pre-master programme offers a very good preparation and attracts motivated students with high potential; students appreciate the structured approach of the programme, as well as the guidance they receive from the teaching staff and the programme coordination and management, which in turn contributes to making this intensive programme feasible; the core staff is dedicated and has adequate domain specific expertise and didactical skills; students are actively involved both formally and informally in quality assuring the courses and the programme. Nonetheless, the panel also noticed that the backbone of the programme is critically depending on a few enthusiastic and pro-active individuals. The panel therefore supports the management in its efforts to ensure the long-term viability of this programme by hiring more staff and embedding the teaching staff in the appropriate research structure of the faculty.

Student assessment is well organised in the Master Software Engineering. The policy and principles underlying course assessments are up to standard and applied in the day-to-day reality of teaching and assessment. The programme is taking fraud seriously. The course assessments are valid, reliable and in most cases transparent. Based on its own sample review, the panel considers that overall the assessment process of the thesis is adequate. If used properly, the evaluation form is relevant. While

several defence committees complete the form in an insightful way, many others did not: the panel therefore encourages the programme to impose that all committees provide qualitative feedback to motivate their scores. The members of the Examinations Board and its subcommittee for the Master Software Engineering, its assessment committee and its fraud and plagiarism committee have good expertise to deal with their respective tasks. The panel encourages the assessment committee to verify in its course review sample that the different assessment components and their respective grading schemes are communicated and implemented properly.

Students who graduate from the Master Software Engineering are adequately prepared for a position in both industry and academia. Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at master level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are eventually achieved at the end of the master's curriculum. It goes to the credit of the programme that most graduates find an attractive position with companies or in public service soon after graduation. The panel welcomes the efforts of the programme to also motivate students for an academic career: several theses demonstrate that graduates from the Master Software Engineering possess the competences to pursue a PhD.

Across all standards, the panel noticed that there have been many developments to the programme and that the programme has done a great job in accommodating these changes: hence the panel's overall positive appreciation of the Master Software Engineering as a stand-alone programme of adequate quality. Nonetheless, one major change—a merger with the VU—did not come about: this means that two universities in the same city continue to offer similar programmes in computer science. According to the panel, the Master Software Engineering would benefit from a strategic vision on its future, taking into account the needs and interests of the programme, the staff and the research groups.

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

*Master's programme Software Engineering (both full-time and part-time)*

| | |
|---|---|
| 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: 17 April 2020

# DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – BACHELOR'S PROGRAMME COMPUTING SCIENCE

*De bacheloropleiding Informatica aan de Universiteit van Amsterdam wordt aangeboden in het Nederlands. Omdat beide andere opleidingen die het panel heeft beoordeeld in het Engels worden aangeboden en de meeste gesprekken tijdens het bezoek in het Engels zijn gevoerd, is met de opleiding afgesproken om ook het visitatierapport over deze bacheloropleiding in het Engels op te stellen.*

**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**
The bachelor's programme Computing Science (*bacheloropleiding Informatica*) is one of nine bachelor's programmes governed by the College of Science in the Faculty of Science (*Faculteit der Natuurwetenschappen, Wiskunde en Informatica*). It belongs, together with the bachelor's programmes Information Science (*Informatiekunde*) and Artificial Intelligence (*Kunstmatige Intelligentie*), to the domain Information Science (*Informatiewetenschappen*). The staff teaching in the bachelor's programme belongs mainly to the Research Institute for Computer Science (*Instituut voor Informatica*).

The previous accreditation visit took place in October 2013. At that time, there was the intention to merge the research institute of the University of Amsterdam (UvA) with the department Computer Science at Vrije Universiteit Amsterdam (VU). These intentions developed into very concrete plans until the co-decision bodies (*medezeggenschap*) at university level did not approve the envisaged merger in April 2017.

The current bachelor's programme Computing Science at UvA aims to offer a broad and balanced programme with the intention for students to become versatile computer science professionals. Given that students learn about all components of computer science and acquire both academic and professional skills, the programme prepares bachelor students for both a master's programme in computer science and for a position on the labour market. The language of instruction is Dutch; nonetheless the programme makes pragmatic use of the English language in those cases where the teaching staff does not speak Dutch. The panel gathered from the self-evaluation report and the discussions on site that the combination of these features—broad content, focus on both academic and professional continuation, Dutch language (with some English)—gives the programme a specific profile within the Dutch higher education landscape.

The panel noticed that the programme objectives are reflected in the intended learning outcomes (ILOs), which are listed in Appendix 2 to this report. The panel noticed that the formulation of the ILOs is quite concise—five end terms in total—and that each learning outcome is clearly related to one or more Dublin Descriptors. The panel appreciates the explicit reference in the fifth ILO to the meaning of computer science for society and the responsibilities of computer science experts *("de afgestudeerde heeft inzicht in de maatschappelijke betekenis van de Informatica en de verantwoordelijkheden van deskundigen op dit gebied binnen de wetenschap en in de samenleving.")*

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 from the extensive and good quality analysis in the self-evaluation that this is also the case for the bachelor's programme Computing

Science at UvA, whose ILOs cover the eleven characteristics of a computer scientist 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.

It is an explicit aim of the programme to offer its bachelor's students a decent preparation for a position on the labour market, as reflected in the ILOs. The programme monitors the developments in the professional field in different ways, informally via staff contacts with industry and formally through meetings of the Professional Advisory Board (PAB), which serves all degree programmes in Information Sciences. While it acknowledges both the contacts with the professional field and the relevant expertise of the individual PAB members, the panel thinks that more and better use can be made of such PAB by extending the membership to cover the entire domain of computer science and by having more regular meetings to discuss strategic developments in the respective programme domains.

The panel noticed during the discussions that the envisaged but discontinued merger with VU has been an important issue for the management of both faculties, for the respective UvA, VU and joint UVA-VU programmes, and for the staff in the computer science institute and department at the two institutions. Several interviewees indicated that it did not only require a lot of effort to prepare for the merger, but once the plans were dismissed it also took time to refocus the profile and strategy of the institutions and programmes. The panel recognises this, and thinks that the situation—with two universities in the same city offering separate programmes in computer science—requires a strategic vision on the future for the programme, the staff and the research groups at UvA. Concerning the bachelor's programme, this vision could start from the current strengths of the programme, consider the analysis in the self-evaluation on the points for development, and reflect the situation where two universities in the same city offer separate computer science programmes. Further to what will be discussed in the next sections, the vision should also address the development of research groups and the opportunities for bachelor graduates Computing Science to pursue a relevant master's programme at UvA.

**Considerations**
The panel considers that the bachelor's programme Computing Science constitutes a 'traditional' programme in the positive sense of the word: it aims to offer a broad basis in all domains preparing students for an academic master's programme or a relevant position on the labour market. According to the panel, these ambitions are reflected in the intended learning outcomes; the formulation of the end terms is adequate in terms of domain (computer science), level (bachelor) and orientation (academic) of the programme. Moreover, the ILOs cover both the European-wide Dublin Descriptors and the international domain-specific characteristics of the ACM curriculum.

While there have been many developments to the programme since the previous accreditation visit, the major change—a merger with the VU—did not come about. The panel considers that the current bachelor's programme is of adequate quality. Nonetheless, the situation with two universities in the same city offering separate bachelor's programmes in computer science requires a strategic vision on the future of the programme, the staff and the research groups at UvA. Furthermore, the panel suggests to discuss the new vision with the Professional Advisory Board, with the additional advantage of further enhancing the functioning of the PAB and its contribution to the programme in the long-run.

**Conclusion**
*Bachelor'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.

**Findings**

*Curriculum*
The bachelor's programme Computing Science amounts to 180 EC, which are spread equally over three years of two semesters / six blocks each. The curriculum consists of mandatory courses in the first two years (120 EC) followed by a third year of electives (30 EC), optional courses (12 EC) and a graduation project (18 EC). Appendix 3 to this report provides an overview of the curriculum. The panel gathered from the information materials that most courses have a study load of 6 EC and take either 8 or 4 weeks.

The panel obtained extensive information on the bachelor's programme and its curriculum in the self-evaluation report and the annexes. Studying the materials, the panel found that the curriculum is coherent. This coherence is particularly visible in six so-called 'learning lines' (*leerlijnen*): software systems; computer systems; mathematics and computer science theory; model based systems; data and information systems; academic competences. The panel noticed that these learning lines provide a good structure for the curriculum: each learning line is covered in several courses and most courses address multiple learning lines. Moreover, the learning lines reflect all Knowledge Areas of the domain-specific reference framework. Comparing the Computing Science programme with the model ACM Curriculum, the panel found that bachelor students at UvA spend more time altogether on the knowledge areas than what is expected by the ACM curriculum. This means that even when a certain area gets proportionally less attention throughout the courses, students still spend more contact hours on each knowledge area than what is prescribed in the model curriculum. The comparison also taught that the bachelor's programme at UvA dedicates proportionally more attention to the knowledge areas Graphics and Visual Computing, Intelligent Systems, and Networking and Communication.

During the visit, the panel looked into several course materials and found these to be of good quality and at the proper level for an academic bachelor's programme. It gathered from this sample review that altogether the courses cover the intended learning outcomes of the bachelor's programme Computing Science. In this regard, the panel noticed that through the introduction of the learning lines, the programme has addressed successfully the recommendation of the previous accreditation committee to enhance the course learning goals in the areas societal relevance, teamwork and learning skills. Further to its considerations on the programme end terms, the panel found that the Computing Science curriculum is in full alignment with the programme profile, the ILOs and the international domain-specific requirements.

An important topic of discussion during the site visit was the attention in the curriculum to academic skills. The panel noticed during the preparation of the visit that the programme features a well-developed learning line Academic Skills that is interwoven throughout the entire curriculum and extensively described and motivated in a dedicated document. During the visit both students and staff confirmed that the provisions stipulated in the document are implemented in the day-to-day reality of the programme: the skills covered in the two small courses on Academic Skills for Computer Science are trained, applied and tested in several disciplinary core courses of the first and second year. Students moreover indicated that the attention to academic skills in the curriculum prepares them very well for the bachelor project. Anticipating on its findings with regard to the bachelor's thesis quality, the panel thinks that the curriculum is very strong in terms of academic skills.

Students who desire more challenges can combine the Computing Science programme with a bachelor's degree in Mathematics and obtain two bachelor's degrees in three years with a total study load of 225 EC. Students indicated to the panel that this option is widely communicated, also prior to enrolment, and the programme facilitates this pathway. Students interested in education can opt

for a university-wide 30 EC educational minor, leading to a second-degree teaching qualification. In addition, the best performing students in the propaedeutic phase can enrol for an honours programme of 30 EC. The panel gathered from both students and staff that this option—students can design their own course combination within certain limits—has not received much attention in the (recent) past due to staff work overload. It seemed that the honours programme was not a priority concern for the management and the honours coordinator, but that there are plans to revive the programme in the near future. The panel welcomes this renewed attention and recommends the programme to develop a fully-fledged honours programme that will attract the targeted 10% of bachelor students.

*Language of instruction*
The bachelor's programme is offered in Dutch. The panel learned that teaching staff and guest lecturers who contribute to courses who do not speak Dutch can teach their part in English. The panel gathered from the discussions on site that all stakeholders—including students—are satisfied with this pragmatic approach: students sometimes do enrol at UvA because they consider the transition from secondary school to university a sufficiently big step that should not be made more complicated by attending courses in English; however, these students also think it is useful to be exposed to literature and some course components in English. The panel understands and subscribes to the programme approach with regard to the language of instruction.

*Educational concept*
The panel noticed in the self-evaluation report that the programme features an educational concept that is well-developed. It reflects the ambition to provide bachelor's students with a coherent set of knowledge, insights and skills in both computer science and several application domains. In this regard, students are educated in the individual components as well as in the relation between them. This attention to the interrelatedness of components is visible in the thematic learning lines, in the integration of mathematics components as much as possible in the computer science courses, and in repeating some fundamental concepts and techniques in several courses. According to the panel the educational concept befits the profile, the ambition and the intended learning outcomes of the programme.

Each learning line is set up according to the same principles: introduction, widening, deepening and integration. In the first year students get a full picture of the study when all six learning lines are introduced; in the second and third year, the themes are widened, deepened and integrated. Students first acquire and apply knowledge before they learn how to analyse, synthetise and evaluate what they learn. In the bachelor's graduation project, all previous knowledge and insights are brought together in an individual research project. Students indicated to the panel that this approach is implemented across the courses and the curriculum.

If anything, students thought that the curriculum structure is not always conducive to properly deepening the knowledge: the 6 EC compulsory courses are taught in blocks of eight weeks. While the size of the courses is fine, some course contents—such as discrete mathematics and programming languages—are very complex and students would benefit from spending a longer period on the course to have the knowledge sink in. Apart from students failing such courses at the first attempt, it is also important that they grasp the essence of the matter as it often constitutes a building block for further courses. According to the programme management, it is standard UvA-wide policy that courses last eight weeks. Nonetheless, the programme understands the student concerns and is looking for a pragmatic solution. The panel fully supports the programme in this regard.

The panel observed furthermore that the courses feature a variety of teaching methods ranging from plenary lectures to practical lab sessions and project work. Students indicated that they appreciate this variety, including the combination of individual and group work. According to the information in the self-evaluation, students have on average 11 to 13 contact hours per week. This amount looks adequate for the final year, but seems rather limited for first-year students who have just made the

switch from secondary school. Staff indicated that they face a considerable workload; the panel understands that they would appreciate spending more time with students.

*Intake*
Since the previous accreditation visit, the number of students has increased: the intake went up by 40% from 86 students in 2013-2014 to 120 in 2018-2019, while the total number of bachelor students in Computing Science increased by 60% in the same period from 218 to 347. According to the panel this level of increase is in line with developments in other Dutch-language computer science programmes. The panel understood from the information materials and the discussions that the growing number of students has a considerable impact on the workload and availability of teaching staff (see section below).

The panel noticed that the programme continues to have difficulties in attracting female students, although there is a steady increase from less than 4% in 2013-2014 to 12% in 2018-2019. According to the management, staff and students, these figures reflect a wider problem of perception in society and in secondary schools that computer science programmes are mainly about programming and are not for everyone. The bachelor's programme Artificial Intelligence, for instance, attracts many female students. While it acknowledges that there is a perception issue that goes beyond the remit of this accreditation report, the panel advises the programme to emphasise in its information materials and the Open Days that the programme focuses explicitly on the relevance of computer science for society.

*Feasibility*
Further to its didactic concept, the programme has made the choice to offer first-year students a broad variety of computer science related courses that are representative for the overall degree of complexity of the study programme. While courses tend to be of introductory and thus less complex nature in the first year, the curriculum does contain a few challenging courses that introduce students to the level they can expect during the remainder of the curriculum. The panel noticed from the data tables that this approach has the envisaged result, namely that almost all drop-out (roughly 30% of the respective cohorts) happens in the first year, and only few students fail the programme afterwards.

Moreover, each student is guided by a tutor, a senior student who is also involved in the academic skills courses in year 1 and 2. The study advisor of the programme supports students in study planning and in improving their study skills. Students indicated that they are (made) aware of these opportunities, that they use them and are generally satisfied with the availability and quality of both their tutors and the study advisor.

Students indicated both in the information materials and during the site visit that the workload is in line with what can be expected of a full-time study load of 60 EC. Apart from the above-mentioned courses that would benefit from a longer sink-in time, there are no specific courses that systematically hinder a smooth and timely realisation of the curriculum. Hence, students consider that the overall programme is feasible. The panel noticed that this is confirmed by the data available on success rate: on average 75% of the students obtain a positive Binding Study Advice; while roughly 30% of students who enrol in year 2 graduate within the nominal period of three years, another 30% does so in four years. In order to facilitate students who have incurred a small delay, the graduation project is organised twice per year. Nonetheless, a considerable share of students take (much) longer to graduate: many students have a job in addition to their studies and/or choose deliberately not to study full-time. The panel appreciates the efforts of the programme to monitor and guide students at the start of the programme and to reduce the average study length by scheduling two bachelor thesis projects per year. It is aware that very often reasons for completing the study with a considerable delay are outside the control of the programme.

*Staff*
The self-evaluation report provides an overview of the 31 staff members who are involved in teaching the bachelor's programme. According to the detailed table, 77% of the staff has a PhD, and more than 90% has a basic or senior teaching qualification. Twenty-two staff members are linked to one of the research groups, mainly but not exclusively in the Information Science Institute, while the others belong to the College of Science or the teachers' group at the institute. Five staff members use English as language of instruction. While almost all staff have a full-time or nearly full-time appointment, the share of their involvement in the bachelor's programme is often limited, resulting in a total teaching load of 7.57 FTE in the 2017-2018 programme.

Based on this information, the panel has used the site visit to discuss two staff issues: the limited teaching staff equivalents available for the bachelor's programme and the considerable number of staff that is not linked to a research group. With regard to staff numbers, the panel learned that the programme is using 4 FTE of student-assistants. Adding up the student-assistants to the staff, the student staff ratio has improved compared to the previous accreditation visit, from 1:32 to 1:28. However, if one would only take into account the teaching staff, then the ratio has gone up from 1:37 to 1:43. Moreover, the number and research capacity of the teaching staff is addressed in a strategic investment plan 2017-2021 of the Institute for Information Science. While it is too early to see concrete results, the Institute is currently recruiting for 15 new tenure track positions. Furthermore, the course offer has been reviewed and optimised pulling compulsory courses across programmes and suspending elective courses which only attracted few students.

The previous accreditation committee recommended that students should be made more familiar with research and that teaching staff in the bachelor's programme should be involved more in research. The panel noticed that on the one hand students do train their research skills and visit the research groups in anticipation of their bachelor's thesis, but that on the other hand the current proportion of teaching staff that is actively performing research is relatively low for an academically oriented programme. The management informed the panel that it was an explicit goal of the merger with the VU to increase the research intensiveness of the bachelor's programme by making optimum use of the complementary research expertise of the respective staff. When this collaboration was called off, the Institute addressed the number and research capacity of its teaching staff in the above-mentioned strategic investment plan. Moreover, some contracts with temporary staff with only teaching duties have not been renewed, which means that only a few courses in the first year are taught by staff without a PhD or a research assignment but with extensive and relevant teaching experience. Furthermore, the panel learned that there is no tradition at UvA to have full professors teach courses in the bachelor's programme: as of the academic year 2019-2020, one course in the entire curriculum (a compulsory course in year 2) will be taught by a full professor. Following the discussions on site, the panel welcomes the attention of the management to staffing issues and encourages the programme to continue enhancing the number and proportion of teaching staff with an active research profile, to have these staff integrate their research into their courses in the bachelor's programme, and to appoint full professors as course coordinators.

*Facilities*
All computer science programmes are located in one modern building on the Science Park campus of the UvA. Students indicated that they very much appreciate both the building and the (atmosphere on) campus. In fact, several students mentioned that the Science Park was an element that helped deciding where to study computer science. Moreover, the convenience of the location plays a role in deciding whether or not to go for a study period abroad and where to continue a master's programme.

The panel gathered from the information materials and the discussions that students play an important role in the quality system of the programme. They fill in course evaluations, are an active part of the programme committee and sit in on so-called sounding board groups ('*klankbordgroepen*'). According to this relatively new initiative, each student is called once per year to attend such sounding board and share his/her opinion on the current courses. Students indicated that they are taken seriously by the teaching staff and the programme management. In this regard,

the programme has done a good job in implementing the recommendations of the previous accreditation committee regarding the involvement of students in quality assuring the programme and the follow-up of improvement measures by teaching staff.

**Considerations**
The panel considers that the teaching-learning environment of the bachelor's programme Computing Science is up to standard. In fact, the panel thinks highly of several components of this standard, some of which have been adjusted following the recommendations of the previous accreditation committee: the curriculum is coherently structured along six learning lines; students are very well trained in the dedicated learning line on academic skills; the didactic concept underlying the programme is clear and befits the profile, the ambition and the intended learning outcomes of the programme; the programme has implemented several measures that enhance the feasibility of the curriculum; students are actively involved in quality assurance, among others through sounding board groups; and the Science Park is an important asset to the programme.

Furthermore, the panel considers that there is room for improvement of other components. Most prominently, the panel recommends to improve the embedding of research intensive education in the programme by increasing the involvement of (senior) research staff members in the courses. Furthermore, the panel appreciates that the management is not only aware of the development issues at stake but is already taking action with regard to the adjustment of some courses within the existing block structure and the increase of the staff numbers.

**Conclusion**
*Bachelor'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*
The panel noticed that the assessment system of the bachelor's programme Computing Science is based on the provisions set by the framework policy of the university. The organisation of student assessment is stipulated in the Teaching and Education Regulations (TER). The specific assessment rules that apply in the bachelor's programme are described in a dedicated assessment policy document, which serves as a clarification for both teaching staff and students. Moreover, the study guide (*studiewijzer*) describes per course the contents, organisation and the assessment method(s). The panel noticed in an annex to the self-evaluation report that the programme is using a variety of assessment methods—ranging from written exams to practical assignments, presentations and in two cases group work. Almost all courses have several ways to assess whether students have acquired the learning goals. Currently some assessments are organised digitally, a practice the programme would like to increase in the future in view of the growing student numbers and the workload associated with correcting written exams. When needed, the programme can call upon an assessment expert at faculty level to help out with the development and implementation of the assessment policy.

*Course and thesis assessments*
The panel noticed that the assessment principles underlying the bachelor's programme are sound and have been implemented in all courses. On site the panel looked into course files 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: they know in advance what they need to know for the exam and how they will be assessed. Furthermore, students informed the panel that fraud and plagiarism are addressed in several courses.

Both in the student chapter and the discussion, students emphasised that timely feedback on exams or intermediate tests is sometimes an issue. While they understand that teaching staff has a considerable workload, they would like to receive the results within the regular period stipulated in the TER. This is all the more important in case of formative assessments when feedback is part of the learning experience and helps students in preparing for the next test. The management is aware that sometimes assessment results are taking longer than envisaged and would expect in this case that teachers communicate this delay to students. The panel learned that the envisaged increase of staff members should do away with this inconvenience.

As part of its thesis review, the panel studied a sample of 15 bachelor's theses and their respective assessment forms. Every thesis is assessed by the supervisor and an independent second reader who use a dedicated form with 17 criteria clustered around three elements: research implementation, thesis product, and presentation. The criteria require an appreciation ranging from very good to insufficient, while the three elements each receive a score; there is an indicative but not mandatory weighing of the three elements in setting the final score. Assessors can provide written clarification on the form to motivate their scores on implementation, thesis and presentation. The evaluation form used to be filled in manually; since the academic year 2017-2018 the form is completed digitally.

In almost all cases the panel agreed to the final score, to the constituent sub-scores per element and found that the criteria had been completed properly. However, the panel found that only half of the forms contained insightful comments clarifying why the assessor(s) had given a certain score. Furthermore, the form does not invite the second reader to express an independent opinion on the respective criteria. The panel therefore suggests the programme management to reflect how the second reader can issue an independent opinion and to ensure that the criteria and the sub-scores are always motivated in an insightful way on the evaluation form.

*Examinations Board*
The quality of assessment and the end level of the bachelor's programme Computing Science are safeguarded by a subcommittee of the Examinations Board (*Examencommissie*) at faculty level. This subcommittee is also responsible for the joint master's programme Computational Science and features one member from VU. In order to safeguard the quality of assessment, the central Examinations Board has established an assessment committee which is composed of one delegated member per subcommittee. Each committee checks 10% of all regular courses per year and reviews eight theses, two per grade. The central Board also established a fraud and plagiarism committee, which exchanges its findings with the assessment committee.

The panel gathered from the discussion with representatives of the Examinations Board and assessment committee that the quality assurance of student assessment is organised properly and that the individual members have adequate experience to fulfil their various tasks. The panel learned that the assessment committee's checks of the bachelor's theses did not raise concerns on the quality or the score. The representatives agreed with the panel that the thesis evaluation form is not inviting for assessors to provide insightful qualitative feedback. The panel suggests that the assessment committee, when reviewing bachelor theses, also looks into the quality of the written feedback.

Furthermore, the panel learned that notwithstanding the university-wide regulations on fraud and plagiarism, the extensive communication to students and the systematic plagiarism control of computer code, the Examinations Board still has a lot of work in handling cases of plagiarism. The panel supports the efforts of the Examination Board and its fraud and plagiarism committee to keep track of the fraud cases and to exchange information with the assessment committee.

**Considerations**
The panel considers that student assessment is well organised in the Computing Science programme. The policy and principles underlying course assessments are up to standard. The 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 the assessment process of the thesis is adequate. If used properly, the evaluation form is relevant. While several assessors complete the evaluation form in an insightful way, the panel encourages the programme to impose that all assessors provide qualitative feedback to motivate their scores. Moreover, the panel suggests to further increase the quality of the thesis assessment by asking the second reader to form an independent opinion and report this opinion separately on the evaluation form.

According to the panel, the quality of the assessment is safeguarded properly by the faculty-wide Examinations Board and its subcommittee for the bachelor's programme, its assessment committee and its fraud and plagiarism committee. The individual members have adequate expertise to deal with their respective tasks. The panel encourages the assessment committee to verify in its thesis review sample that the scores on the three elements (research, thesis, presentation) are always motivated in an insightful way.

**Conclusion**
*Bachelor'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**

*Thesis quality*
In order to establish whether students achieve the intended learning outcomes, the panel has reviewed a sample of fifteen bachelor's theses that were accepted in the academic years 2017-2018 and 2018-2019. The thesis is an individual research project of 18 EC; students can either propose a topic or choose one from a list prepared by thesis supervisors.

The panel found that each of the fifteen theses were of a quality that can be expected of a final project at bachelor's level. In several cases the quality of the work was high. The theses that according to the panel deserved a high score had a strong research question, a decent methodological approach and a thorough theoretical study. Those at the lower end of the continuum all deserved to pass but did less well on the theoretical background, on the discussion of the research results and in terms of academic writing.

In a previous section, the panel considered that through the individual courses, the curriculum allows students to acquire the programme's intended learning outcomes. Having reviewed a selection of bachelor's theses, the panel considers that students who successfully pass the thesis have indeed achieved all intended learning outcomes. Moreover, the panel considers that the thesis delivers on its rationale: it is a final test where students demonstrate through an individual research endeavour that they have the competences to bring together the knowledge and insights they have acquired before. It also shows according to the panel that the extensive attention to academic skills in the curriculum pays off.

*Alumni*
In addition to verifying the quality of the final deliverables, the academic and/or labour market performance of bachelor graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. Both the information materials and the discussions indicated that most bachelor's graduates move on to a master's programme. Nonetheless, there is a significant minority of alumni that enters the labour market. In this regard

the programme fully delivers on both ambitions preparing students for a follow-study or a professional career.

The panel noticed that the data available on bachelor's alumni was rather limited; the quantitative information in the self-evaluation seems to indicate that at most half of the bachelor's graduates continue studying at UvA, while the percentage of students who do not continue a master's degree fluctuates extensively per year between 20% and 50%. The panel thinks that, in line with the recent initiative of the master's programmes, the programme would benefit from following-up more systematically the whereabouts of its bachelor alumni.

Furthermore, and in line with its recommendation under standard 1, the panel advises the management to reflect in its strategic vision on the programme future whether—and how—it wants a bigger share of its bachelor graduates to proceed to a master's programme at UvA.

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

Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at bachelor level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are eventually achieved at the end of the bachelor's curriculum.

Given that there is only limited information on the whereabouts of the bachelor graduates, the panel recommends the programme to follow-up more systematically the academic/professional careers of its alumni. Furthermore, the management may want to consider if—and how—it wants to increase the number/share of bachelor graduates who stay with UvA for a master's programme.

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

# GENERAL CONCLUSION

In the previous sections, the panel has come to the conclusion that the bachelor's programme Computing Science (Informatica) at the University of Amsterdam 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 Computing Science* is 'positive'.

# DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – MASTER'S PROGRAMME SOFTWARE 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**
Since its foundation in 2003 the master's programme Software Engineering was offered in close collaboration between the Institute for Informatics (IvI) and the Software Engineering department of the Dutch national research centre for mathematics and computer science (CWI). In the meantime, the structural involvement of CWI has come to an end. For several years the Informatics departments of both UvA and VU were planning to form a joint Amsterdam Department of Informatics at one central location on the current VU campus and to re-organise the portfolio of degree programmes accordingly. It was expected that the master's programme Software Engineering would be embedded in the Software Engineering and Green IT group of the VU. However, these plans were abandoned when the co-decision bodies (*medezeggenschap*) at university level did not approve the envisaged merger in April 2017.

At the time of the site visit in November 2019, the master's programme Software Engineering is embedded in the Graduate School of Informatics (GSI) of the Faculty of Science at the University of Amsterdam. The staff teaching in the programme belong mainly to the Systems & Networking (SNE) Lab, which groups the systems and engineering oriented research within the Institute for Informatics. These recent developments have been accompanied by a review of the master's programme; the updated curriculum is offered since the academic year 2018-2019.

*Profile*
The panel noticed that there are only two master's programmes in the Netherlands which are entirely dedicated to Software Engineering. According to the information materials, the programmes at UvA and the Open University are similar in terms of content, but differ in the way the programme is organised and delivered. Several comprehensive Computer Science programmes offer a track or specialisation in Software Engineering: the VU-UvA joint degree Computer Sciences for instance features a track Software Engineering and Green IT. This track is content-wise and staff-wise disjoint from the programme under consideration.

The panel gathered from the well-founded self-evaluation report that the programme has a clear profile. The master's programme Software Engineering at UvA aims to strike a balance between the technical and human aspects of software engineering: in addition to technical competences, human aspects are critical for success in large software engineering projects. The programme is education intensive, hence student numbers should be contained in order to maintain quality. Moreover, the one-year programme is offered in a full-time and a part-time variant allowing students with professional and/or family commitments to obtain an academic master's degree in two years. Over the years, the number of international students in this English-language programme has been increasing, and today represents about a quarter of the current cohorts.

*Intended learning outcomes*
The panel noticed that the balance between technical and human aspects of software engineering is reflected in the programme's intended learning outcomes (ILOs), which are listed in Appendix 2 to this report. The 13 exit qualifications are described precisely and formulated adequately for an academic programme at master's level. Each learning outcome is clearly related to one or more Dublin Descriptors, and each descriptor is addressed in several exit qualifications. The panel learned

that the formulated learning outcomes mostly focus on knowledge, while the course design also focuses on application, judgement, communication and learning skills.

Furthermore, the intended learning outcomes are based on the Software Engineering Body of Knowledge (SWEBOK), which promotes four elements: (software) engineering ability, research skills, knowledge foundation, and preparation for management positions. The panel noticed that these four elements are covered in the exit qualifications of the programme and form an intrinsic part of the curriculum. The domain-specific body of knowledge is described in Appendix 1 to the report.

*Professional field*
Furthermore, the panel noticed that the programme monitors the developments in the professional field in different ways: informally via staff contacts with industry and through the part-time students who offer continuous feedback on the relevance of the course contents in their daily professional practice; and formally in meetings of the Professional Advisory Board (PAB), which serves all degree programmes in Information Sciences. While it acknowledges both the contacts with the professional field and the relevant expertise of the individual PAB members, the panel thinks that more and better use can be made of such PAB by extending the membership to cover the entire domain of computer science and by having more regular meetings to discuss strategic developments in the respective programme domains.

The panel noticed during the discussions that the envisaged but discontinued merger with VU has been an important issue for the management of both faculties. This concerns the respective UvA, VU and joint UVA-VU programmes, as well as the staff in the respective computer science departments. Several interviewees indicated that it did not only require a lot of effort to prepare for the merger, but once the plans were dismissed it also took time to refocus the profile and strategy of the institutions and programmes. The panel recognises this, and thinks that the situation—with two universities in the same city offering similar programmes in computer science—requires a strategic vision on the future of the programme, the staff and the research groups at UvA. Concerning the master's programme, this vision could start from the current strengths of the Software Engineering programme, consider the analysis in the self-evaluation on the programme weaknesses, and reflect the particular situation that two universities in the same city offer similar computer science programmes.

**Considerations**
The panel considers that the master's programme Software Engineering combines an almost unique position in the Dutch higher education landscape with a specific profile balancing technical and human aspects of software engineering. The panel appreciates the pronounced attention to soft skills in the programme, as well as the opportunities it offers through the part-time variant for professionally active students. According to the panel, the profile is reflected in the intended learning outcomes, which are formulated adequately in terms of domain (software engineering), level (master) and orientation (academic) of the programme. Moreover, the exit qualifications cover both the European-wide Dublin Descriptors and the domain-specific Software Engineering Body of Knowledge.

While there have been many developments to the programme since the previous accreditation visit, the major change—a merger with the VU—did not come about. The panel considers that the current master's programme Software Engineering is a stand-alone programme of adequate quality. Nonetheless, the situation with two universities in the same city offering similar programmes in computer science requires a strategic vision on the future of the master programme, the staff and the research groups at UvA. Furthermore, the panel suggests to involve the Professional Advisory Board in the elaboration of this vision, with the additional advantage of further enhancing the functioning of the PAB and its contribution to the programme in the long-run.

**Conclusion**
*Master's programme Software 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 Software Engineering amounts to 60 EC, which are spread equally over two semesters of three blocks each. The curriculum consists of seven courses of 6 EC and a graduation project of 18 EC. Appendix 3 to this report provides an overview of the curriculum.

The panel obtained extensive information on the master's programme and its curriculum in the self-evaluation report and the annexes. Studying the materials, the panel found that the curriculum is relevant and coherent. It noticed that the course contents reflect very much the domain-specific requirements: the combination of four hard-skill courses, two soft-skill courses and the preparation/master's project ensures that students acquire engineering ability, research skills, management skills and foundational knowledge about software engineering. Moreover, during the visit the panel looked into several course materials: these are of good quality and at the proper level for an academic master's programme. This sample review showed that altogether the courses cover the intended learning outcomes of the master's programme Software Engineering.

Students indicated both in the self-evaluation report and during the visit that they find the courses very relevant as they are trained to not only acquire and apply the knowledge, but also to critically evaluate what they learn. Each course also relates the theoretical knowledge to what happens in terms of practical applications in industry. Moreover, students emphasise that they get the necessary tools to apply critical thinking and objectively judge research and practical applications. In this regard, the two soft-skill courses also look into relevant psychological and philosophical theories.

The positive appreciation by students confirms according to the panel that the programme contents are relevant and well elaborated. Further to its considerations on the exit qualifications, the panel found that the Software Engineering curriculum is in full alignment with the programme profile, the ILOs and the international domain-specific body of knowledge.

The programme is offered in a full-time and a part-time variant. Part-time students follow three instead of six courses per year. They attend the Preparation Master Project during the first semester, prepare a research proposal by the end of January and spread the work on the master's thesis over the remaining semesters. Courses are scheduled carefully as part-time students come to the Science Park campus for two consecutive days per week. Students appreciate this structured schedule, as well as the opportunity to switch from one variant to the other. The panel gathered from the discussions with management, staff and students that the part-time variant is well-embedded in the programme.

The panel noticed that the research component of the programme is spread across the entire curriculum: the course Preparation Master Project starts during the first block and aims to familiarise the heterogeneous student cohort with scientific research in small work groups. Students learn about possible research topics in the second block and are expected to write their research proposal in the third block. The master's project starts already in block four with students dedicating themselves entirely to their thesis in the last two blocks. The panel learned moreover that students acquire research skills in several courses and in different ways, using a problem-based learning approach in which methods are discussed when relevant and can be applied right away in a relevant context. Students informed the panel that they appreciate both the research component and the way it is organised within the programme. Anticipating on its findings with regard to the master's thesis quality, the panel thinks that the curriculum is very strong in terms of research skills.

The panel also gathered from the materials and the discussions that there are various ways in which the learning outcomes and the curriculum match the needs and expectations of the professional field: the courses cover topics and competences that are relevant for the field; the cases used in class are derived from real situations in industry; most courses include guest lectures by professionals; and students can undertake a research project in industry.

*Language of instruction*
The master's programme Software Engineering has been taught in English since 2011. The panel learned that all master's programmes in the Graduate School of Informatics and the Faculty of Science are offered in English. Staff and students appreciate the international dimension of the programme: it provides opportunities for international and cross-cultural collaborations among and between students and staff, and prepares students for similar settings in their professional career. Students indicated that they are satisfied with the level of English of the teaching staff. The panel noticed that it would be difficult nowadays to organise the programme in Dutch given that only a minority of core staff are native Dutch speakers. According to the panel, the choice for an English-language programme is well-substantiated: the international student and staff body is clearly an asset for the programme and it prepares students for an international career.

*Educational concept*
The educational paradigm underlying the curriculum is active learning combined with intensive guidance. Students work on real cases in lab assignments to see how theory applies to practice and where it might fail or reach its limits. In this way they learn how to master the scientific material needed for solving real-world issues. Moreover, lecturers practice research oriented teaching when discussing with students on the best solutions for difficult problems. In terms of guidance, the programme organises several initiatives to support student—teacher communication and to guide the student from enrolment to graduation: a programme-specific welcome session where incoming students meet each other, key teaching staff and management and learn about the internal organisation of the programme. Moreover, the lecturer who coordinates the Preparation Master Project and the Master Project is also the programme manager and the reference person for students throughout the curriculum.

Students indicated to the panel that the programme expects them to work hard and communicates this clearly right from the start. During the programme, students learn how to focus and set priorities, and discuss learning strategies to cope with the workload. Staff are challenging the students through open assignments that allow for more than one correct solution and approach; at the same time, staff also creates a safe environment for students where they are allowed to explore and also fail. Students emphasised that there is little distance between lecturers and students: they experience this informal atmosphere as positive because it makes communication and feedback from both sides easier. Furthermore, they appreciate the personal feedback, support and attention from lecturers; the intensive schedule ensures frequent contact with lecturers and other students, and creates many opportunities to acquire feedback and address issues with assignments and work. The panel gathered from the discussions that the programme has created a particular learning environment that is well developed and aligns with the ambition to challenge students and motivate them to excel.

*Intake*
The panel noticed that over the years the student intake has been quite stable. According to the table in the self-evaluation report, the number of students has increased from 34 (in 2015) to 50 (in 2017). In the academic year 2018-2019, 37 full-time and 7 part-time students enrolled in the master's programme Software Engineering: 33 students are Dutch and 11 have another EU nationality. The number of female students is growing slowly, but even the most recent intake of 5 female students only represents 11% of the cohort.

The programme management indicated that the current size of the cohort, between 40 and 50 students, perfectly suits the intensive and small-scale character of the programme. In this respect the management has no ambition to increase significantly the number of students: such growth

would either reduce the quality of education or require a considerable increase of staff. It deplores the limited number of female students, which seems to be in line with the share of female bachelor's graduates. Nonetheless, since a few years the programme includes a very active female lecturer, who is involved in the external communication of the programme and is visibly present during the information days.

The panel obtained detailed information on the admission criteria. Bachelor's graduates in computer science from a Dutch university have direct access to the master's programme and represent roughly half of the cohorts. Students who obtained a bachelor's degree abroad submit their diploma for review. This group represents between 15% and 20% of the yearly intake. Admission applications from international students are either accepted or rejected. Both students and staff indicated to the panel that deficiencies are spotted quickly and remedied accordingly: after a few weeks in the programme all students are up to speed.

Students with a bachelor's degree from a University of Applied Sciences follow a pre-master programme: the total programme consists of six courses taken from the bachelor's programme and two self-study courses. The panel learned that the Admissions Board is interviewing all candidates before deciding on a pre-master curriculum that is tailored to the prior knowledge of the individual applicant. The share of incoming students from a university of applied science has reduced over the years from 40% in 2015 to just over 10% in 2018. Students indicated that the pre-master programme is tough but those students who are successful in enrolling on the master's programme, find it a very good preparation that allows them to start at the same level as their academically educated colleagues.

*Feasibility*
The panel gathered from the discussions that on the one hand the workload of the programme is high; on the other hand, the programme is well structured providing both full-time and part-time students a clear trajectory as well as sufficient monitoring and guidance to successfully finish the programme. Prior to the visit, the panel studied the dedicated Master Software Engineering Handbook, which was published for the first time in 2019 and guides students through their study. The panel found this handbook very detailed and a valuable piece of information that should further enhance the study efficiency.

Students mentioned to the panel that they appreciate the structured approach of the programme, as well as the guidance they receive from the teaching staff and the programme coordination and management. According to the students there are no specific courses that systematically hinder a smooth and timely realisation of the curriculum. Hence, students consider that the overall programme is feasible. The panel noticed that this is confirmed by the data available on success rate: roughly 60% of the full-time students and over 50% of the part-time students graduate within their respective nominal periods; another 20% does so in one more year.

*Staff*
An important item of discussion during the visit was the number of staff and their embedding within the research structure of the university. Prior to the visit, the panel noticed in the self-evaluation report that the programme had been through "a period of strategic change and at times uncertainty", that many staff had left and that the previous accreditation committee had suggested to build up teaching capacity in software engineering. The programme management confirmed during the visit that currently, the programme disposes of sufficient staff with appropriate domain-specific and educational expertise to deliver the programme, and that these staff are now embedded within the Software & Networking Lab of the research Institute of Informatics. Nonetheless, the university does not have a dedicated software engineering research group while the links with such groups at VU and CWI have been reduced.

The panel gathered from the discussions with management, staff and students that the current situation is workable but not ideal: 13 staff members contribute to at least one course, another 20

people have recently been supervising graduation projects, and about 20 professionals from industry have been involved as guest lecturer. However, the core team of teachers is quite limited in view of the number of students and the intensive educational approach; moreover some staff members joined the programme only recently and need some further guidance in order to guarantee coherence and quality. Students appreciate the quality of the staff and their dedication to the programme, a statement the panel fully subscribes based on its meetings with highly enthusiastic teaching and support staff. Nonetheless, the panel also noticed that the backbone of the programme is critically depending on one or two motivated and pro-active individuals.

According to the panel it is important that the programme continue to generate enthusiasm and motivation among both students and staff. It therefore supports the management in its search for more staff to divide the work, maintain good quality and ensure long-term viability of the programme. Further to its finding under standard 1, the panel thinks that the strategic vision on the future of the programme should certainly include a reflection on staff numbers and their scientific embedding.

*Facilities*
All computer science programmes are located in one modern building on the Science Park campus of UvA. Students indicated that they very much appreciate both the building and the (atmosphere on) campus. If anything, students and staff are missing a dedicated software engineering work space, a facility that was recommended by the previous accreditation committee. So far, the programme did not manage to obtain such space, but hopes that the situation will improve once they can move to a new building on the Science Park campus that will mainly be devoted to Computer Science and Artificial Intelligence.

The panel gathered from the information materials and the discussions that students play an important role in the quality system of the programme. They fill in course evaluations and are an active part of the programme committee. Given the small scale character of the programme, individual feedback from and interaction with students is encouraged. Moreover, students indicated that because of the approachable—and safe - educational environment they are taken seriously by the teaching staff and the programme management, and feel at ease to address issues of concern.

**Considerations**
The panel considers that the teaching-learning environment of the master's programme Software Engineering is up to standard. In fact, the panel thinks highly about most components of this standard: the programme contents are relevant and well elaborated; the curriculum is in full alignment with the programme profile, the intended learning outcomes and the international domain-specific body of knowledge; the part-time variant is well embedded in the programme structure; the international student and staff body is clearly an asset and contributes to the overall atmosphere and a safe programme environment; the educational concept is well developed and aligns with the ambition to challenge students and motivate them to excel; the admission process is thorough; the pre-master programme offers a very good preparation and attracts motivated students with high potential; students appreciate the structured approach of the programme, as well as the guidance they receive from the teaching staff and the programme coordination and management, which in turn contributes to making this intensive programme feasible; students are actively involved both formally and informally in quality assuring the courses and the programme.

Furthermore, the panel acknowledges that the programme has gone through 'tough weather' since the previous accreditation visit with regard to its embedding in research groups. It appreciates the dedication of the core staff to the programme and fully supports their focus on maintaining high levels of quality and on challenging students to excel. While the current staff either have extensive domain specific expertise and didactical skills or are in the process of acquiring these, the panel also noticed that the backbone of the programme is critically depending on one or two motivated and pro-active individuals. The panel therefore supports the management in its efforts to ensure the long-term viability of this programme by hiring more staff and embedding the teaching staff in the appropriate research structure of the faculty.

**Conclusion**
*Master's programme Software 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 noticed that the assessment system of the master's programme Software Engineering is based on the provisions set by the framework policy of the university, by the faculty's Assessment Assurance Plan and by the GSI Assessment Plan. The latter document informs examiners and students about all rules governing assessments and is meant to ensure quality, validity and fairness of examinations. The organisation of student assessment is stipulated in the Teaching and Education Regulations (TER). Moreover, the assessment methods per course are described in the course catalogue.

The panel gathered from the information materials and the discussions that all courses have multiple assessments and that students are tested through a variety of assessment methods—ranging from written exams to practical assignments, presentations and lab work. While many tests are based on group work, each course also features some individual assessments. Most assessments are formative tests and in several courses students have to improve their work based on feedback from staff and fellow students. Several assessments are not only graded but also extensively discussed with the student.

*Course and thesis assessments*
The panel noticed that the assessment principles underlying the master's programme are sound and have been implemented in all courses. On site the panel looked into course files and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that in most cases assessment is transparent: they know in advance what they need to know for the exam and how they will be assessed. However, they also mentioned in the student chapter and during discussion that in a few cases the expectations with regard to a deliverable were not clearly communicated. This resulted in students not knowing what grade to expect and indeed getting unexpected grades. Moreover, students indicated that the feedback cycle is sometimes lagging behind, which can be problematic in case of formative assessments where feedback is part of the learning experience and helps students in preparing for the next test. In all cases, however, students knew whom to address—programme director, programme coordinator and/or course teacher. The management is aware that sometimes assessment results are taking longer than envisaged and would expect in this case that teachers communicate this delay to students. The issue of the grading schemes is also picked up through the course evaluations and followed up in the regular quality assurance system.

As part of its thesis review, the panel studied a sample of 15 master's theses and their respective assessment forms. Every thesis is assessed by a defence committee that consists of the academic supervisor, the daily supervisor(s) from industry or academia and an independent second reader. The evaluation form consists of 19 criteria clustered around three elements: research, thesis, and presentation/defence. The criteria require an appreciation ranging from excellent to insufficient, while the three elements each receive a grade; there is an indicative weighing of the three elements in setting the final score. Assessors can provide written clarification on the form to motivate their scores on research, thesis and presentation. The evaluation form used to be filled in manually; as of this academic year 2019-2020 the form will be completed digitally.

In most cases the panel agreed to the final score and the sub-scores per element and found that the criteria had been completed properly. While the form has the potential to be informative, the panel

found that less than half of the forms contained insightful comments clarifying why the assessors had given a certain score. In most of these cases the remarks part was only superficially filled out and added little insight in the motivation of the assessors. Furthermore, the panel noticed that the evaluation form does not invite the individual members of the defence committee to express an independent opinion on the respective criteria. The panel therefore suggests the programme management to reflect how the members can issue an independent opinion and to ensure that the appreciation of the criteria and the sub-scores are motivated in an insightful way on the evaluation form.

*Examinations Board*
Since September 2016, the quality of assessment and the end level of the master's programme Software Engineering are safeguarded by a subcommittee of the Examinations Board at faculty level. This subcommittee is also responsible for the Security and Network Engineering master's programme. In order to safeguard the quality of assessment, the central Examinations Board has established an assessment committee which is composed of one delegated member per subcommittee. Each committee checks 10% of all regular courses per year and reviews eight theses, two per score category. The central Board also established a fraud and plagiarism committee, which exchanges its findings with the assessment committee.

The panel gathered from the discussion with representatives of the Examinations Board and assessment committee that the quality assurance of student assessment is organised properly and that the individual members have adequate experience to fulfil their various tasks. The panel was informed that over the years, not a single case of plagiarism or fraud was reported in the master's programme Software Engineering. Until now, the assessment committee has only reviewed one course of the master's programme Software Engineering. In view of the above-mentioned transparency issues, the panel invites the assessment committee to identify the courses concerned and control the quality of their grading schemes. The committee's check of the master's theses did not raise issues on the quality or the score. The representatives agreed with the panel that the thesis evaluation form is not inviting the defence committee to provide insightful qualitative feedback. The panel suggests that the assessment committee, when reviewing master's theses, also looks into the quality of the written feedback.

**Considerations**
The panel considers that student assessment is well organised in the master's programme Software Engineering. The policy and principles underlying course assessments are up to standard. The course assessments are valid, reliable and in most cases transparent. Moreover, the panel appreciates that the programme is taking fraud seriously.

Based on its own sample review, the panel considers that overall the assessment process of the thesis is adequate. If used properly, the evaluation form is relevant. While several defence committees complete the form in an insightful way, many others do not: the panel therefore encourages the programme to impose that all committees provide qualitative feedback to motivate their scores. Moreover, the panel suggests to further increase the quality of the thesis assessment by asking the individual members of the committee to report their opinion separately on the evaluation form.

According to the panel, the quality of the assessment is safeguarded properly by the faculty-wide Examinations Board and its subcommittee for the master's programme Software Engineering, its assessment committee and its fraud and plagiarism committee. The individual members have adequate expertise to deal with their respective tasks. Further to the student comments, the panel encourages the assessment committee to verify in its course review sample that the different assessment components and their respective grading schemes are communicated and implemented properly.

**Conclusion**
*Master's programme Software 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 fifteen master's theses that were accepted in the academic years 2017-2018 and 2018-2019. The thesis is an individual research project of 18 EC. In order to find a topic, students attend a thesis fair where industry and research institutes present possible research topics and available real-world data; students who wish to perform a thesis 'in-house' inquire about research projects with staff members of the Institute for Informatics. Since 2019, these projects are also presented in a separate event.

The panel found that each of the fifteen theses were of a quality that can be expected from a final project at master's level. In several cases the quality of the work was high. The theses that according to the panel deserved a high score had an interesting topic, a clear research question, a decent methodological approach and were well written. Those at the lower end of the continuum all deserved to pass but did less well on the theoretical background, on the discussion of the research results and in terms of academic writing. The sample contained several graduation projects that were conducted in collaboration with industry; the panel noticed that the good quality theses were indeed of relevance to the companies involved.

In a previous section, the panel considered that through the individual courses, the curriculum allows students to acquire the programme's intended learning outcomes. Having reviewed a selection of master's theses, the panel considers that students who successfully pass the thesis have indeed achieved all intended learning outcomes. Moreover, the panel considers that the thesis delivers on its rationale: it is a final test where students demonstrate through an individual research endeavour that they have the competences to bring together the knowledge and insights they have acquired before. The panel appreciates furthermore that students are supported to present their work at (inter)national conferences and are actively encouraged to publish scientific papers based on their graduation projects.

*Alumni*
In addition to verifying the quality of the final deliverables, the academic and/or labour market performance of master's graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. Both the information materials and the discussions indicated that the master's graduates are effective in pursuing a career in industry. Alumni indicated that they are satisfied with the programme, which prepared them well for the labour market. In fact, many graduates who completed their graduation project in industry are offered attractive permanent positions by their host company.

Although the programme explicitly aims at preparing students also for a career in academia, this has not been an attractive career path so far: the panel understood from the discussions that the market pull for computer scientists is very strong. Nonetheless, the panel noted with satisfaction that the master's programme Software Engineering is motivating its students to also consider a scientific career in academia. As the quality of several theses shows that graduates do possess the competences to enter a PhD trajectory, the panel encourages the programme to continue its efforts.

**Considerations**
Based on its review of the final thesis projects and the discussions on site, the panel considers that students who graduate from the master's programme Software Engineering are adequately prepared for a position in both industry and academia.

Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at master's level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are eventually achieved at the end of the master's curriculum.

It is to the credit of the programme that most graduates find an attractive position with companies or in public service soon after graduation. Moreover, the panel welcomes the efforts of the programme to motivate students for an academic career: several theses demonstrate that graduates from the master's programme Software Engineering possess the competences to pursue a PhD.

**Conclusion**
*Master's programme Software 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 master's programme Software Engineering at the University of Amsterdam fulfils the quality requirements for both the full-time and part-time variant 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 Software Engineering (full-time and part-time)* is 'positive'.

# APPENDICES

# APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

**Bachelor's programme Computing Science (Informatica)**
The bachelor's programme Computing Science 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 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 organizational 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.

**Master's programme Software Engineering**
The intended learning outcomes are based on the Software Engineering Body of Knowledge (SWEBOK): www.computer.org/education/bodies-of-knowledge/software-engineering/v3

The following principles explain how the exit qualifications relate to the SWEBOK.
1. At the heart is (software) engineering ability: getting the work done based on a lacking design; obtaining a better understanding of the problem while solving it (design thinking); using a wide variety of languages, frameworks and tools, some enabling innovative solutions.
2. Research skills are not just important to pursue an academic career, these are also fundamental to successful software development. Software engineering is about continuously making decisions based on assumptions and trade-offs. Some decisions have a high impact: the wrong decision is very costly to revise. Success depends on the ability to continuously learn and timely adapt. This requires research skills: divergent thinking and conscious experimenting.
3. This master provides students with a strong foundation in important topics across the development life cycle, zooming in upon core aspects of the field. Important topics that have a place in our master are: agile, model-based development, DevOps, cloud-based development, automated testing, autonomous systems, software quality and maintenance.
4. We give engineers a strong basis to grow into management positions or start their own company.

# APPENDIX 2: INTENDED LEARNING OUTCOMES

**Bacheloropleiding Informatica (Computing Science)**

De afgestudeerde van de opleiding:

1. heeft grondige kennis en begrip van algoritmen en datastructuren, theorie van de informatica, architectuur van systemen, netwerken, programmeren, programmeertalen en software engineering, databases en informatiesystemen, multimedia en van simuleren en modelleren;
2. heeft kennis van een reeks van onderwerpen uit de wiskunde en statistiek en hun toepassing binnen de Informatica;
3. beschikt over voldoende vaardigheden om Informatica problemen van technische of wetenschappelijke aard zelfstandig te analyseren, om oplossingen te formuleren, oplossingen te implementeren en resultaten te valideren;
4. beschikt over schriftelijke en mondelinge vaardigheden en voldoende communicatieve- en samenwerkingsvaardigheden om op een academisch niveau zowel zelfstandig als in teamverband kunnen functioneren;
5. heeft inzicht in de maatschappelijke betekenis van de Informatica en de verantwoordelijkheden van deskundigen op dit gebied binnen de wetenschap en in de samenleving.

**Master's programme Software Engineering**

1. Graduates are familiar with the most relevant theories, methods and techniques in the domain of Software Engineering.
2. Graduates have the necessary background knowledge to familiarise themselves with novel methods and techniques for life-long learning.
3. Graduates can successfully apply theory in practice in order to find innovative solutions for both general and domain-specific software engineering problems.
4. Graduates can make valuable contributions to complex software engineering projects through the independent and critical application of academic knowledge and skills.
5. Graduates have sufficient technical understanding and intellectual capacity to play, after some years of practical experience, a managerial or advisory role in software engineering.
6. Graduates can clearly report their findings, both in oral and in written form, and can explain problems at an audience-focused level of abstraction.
7. Graduates have research skills at the academic level and are capable to autonomously perform research in the domain of software engineering.
8. Graduates understand why user needs are difficult to express, capture and understand and graduates are familiar with best practices in requirements engineering as well as their shortcomings.
9. Graduates are able to produce formal specifications of modest-sized samples of software and to use them for the generation of meaningful tests; they understand the essential concepts of software verification.
10. Graduates master the methods and techniques for analysing existing software systems and their evolution in the context of changing requirements.
11. Graduates are familiar with the characteristics of software for embedded systems and know how to accommodate these characteristics in the software design and development phases.
12. Graduates understand why big software projects are prone to failure and are familiar with software engineering process models, their situation-awareness and their general shortcomings.
13. Graduates are familiar with the concept of DevOps and their benefits for organisational IT infrastructure and services management; they understand how to build cloud-based applications and how to use cloud automation tools across a wide range of application scenarios).

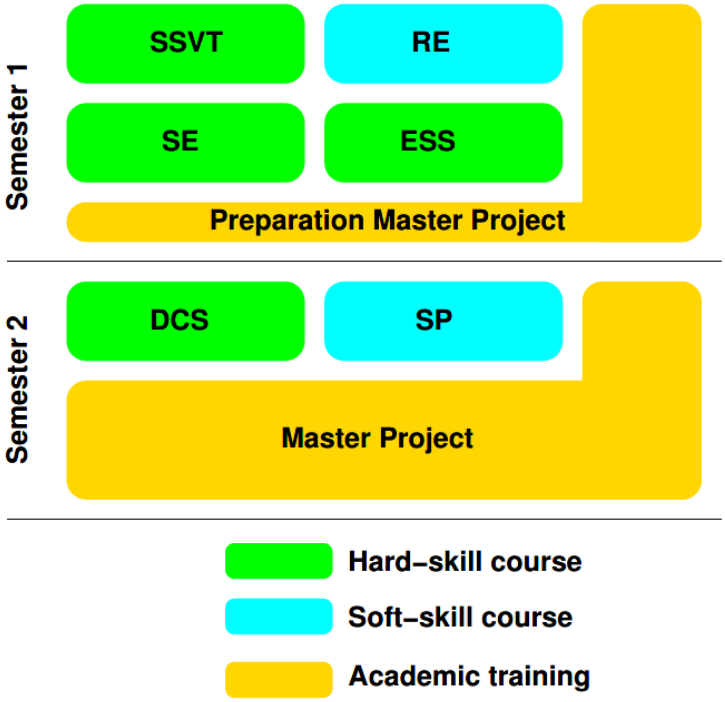
# APPENDIX 3: OVERVIEW OF THE CURRICULUM

**Bachelor's programme Computing Science (Informatica)**

| | Periode 1 Week 1-8 | Periode 2 Week 9-16 | Periode 3 Week 17-20 | Periode 4 Week 21-28 | Periode 5 Week 29-36 | Periode 6 Week 37-40 |
|---|---|---|---|---|---|---|
| Jaar 1 | Inleiding Programmeren | Datastructuren | Web-program-meren en Databases | Lineaire Algebra | Besturings-systemen | Multi-media (5EC) |
| | Architectuur en Computer-organisatie | Discrete Wiskunde en Logica | | Programmeer-talen | Automaten en Formele Talen | |
| | Academische Vaardigheden Informatica 1 | | | Academische Vaardigheden Informatica 1 (1EC) | | |
| Jaar 2 | Networks and Network Security | Concurrency en Parallel Programmeren | Numerical Recipes Project | Statistisch Redeneren | Beeldbewerken | Project Software Engineer-ing (5EC) |
| | Algoritmen en Complexiteit | Graphics en Game Technologie | | Introduction Computational Science | Reflectie op de digitale samenleving | |
| | Academische Vaardigheden Informatica 2 | | | Academische Vaardigheden Informatica 2 (1EC) | | |
| Jaar 3 | *Keuzeruimte* | *Keuzeruimte* | *Keuze-ruimte* | *Gebonden keuze* | Afstudeerproject Bachelor Informatica (18EC) | |
| | *Keuzeruimte* | *Keuzeruimte* | | *Gebonden keuze* | | |

- De opleiding duurt drie jaar. Elk studiejaar is opgedeeld in twee semesters van elk twintig weken. Elk semester is opgedeeld in twee perioden24 van acht weken (met in elk twee parallelle vakken) en een periode van vier weken (met één vak), met uitzondering van het tweede semester van het derde jaar.
- Vakken worden binnen één periode van vier of acht weken ingepast, met uitzondering van Academische Vaardigheden Informatica 1 en 2 die gedurende het hele respectievelijk eerste en tweede studiejaar doorlopen en Afstudeerproject Bachelor Informatica dat 12 weken duurt.
- Het curriculum bestaat uit een verplicht gedeelte (120EC) in de eerste twee studiejaren, gevolgd door een vrije keuzeruimte (30EC), een gebonden keuzeruimte (12EC) en de afstudeerfase (18 EC) in het derde studiejaar.
- Het curriculum omvat hoofdzakelijk vakken van 6EC, met uitzondering van de vakken Multimedia en Project Software Engineering (beide 5EC), Academische Vaardigheden Informatica 1 en 2 (beide elk 1EC) en Afstudeerproject Bachelor Informatica (18EC).
- In de Keuzeruimte kan de student kiezen uit verbredende vakken van andere opleidingen en universiteiten en uit de volgende aanbevolen verdiepende informaticavakken: Moderne Cryptografie, Digitale Signaalverwerking, Scientific Data Analysis, Introduction to Quantum Computing, Netcentric Computing en Project Computational Science.
- In de Gebonden Keuze worden twee vakken gekozen uit: Klassieke Cryptografie, Theoretische Aspecten van Programmatuur, Moderne Databases en Compiler Construction. Het Afstudeerproject Bachelor Informatica wordt ook in de tweede en derde periode van het eerste semester van het derde studiejaar aangeboden voor studenten die studievertraging hebben opgelopen (niet getoond in dit schema).

**Master's programme Software Engineering**




**Course acronyms:**

**SSVT:** Software Specification, Verification and Testing

**RE:** Requirements Engineering

**SE:** Software Evolution

**ESS:** Embedded Software and Systems

**DCS:** DevOps and Cloud-based Software

**SP:** Software Process

| Courses | Type | Period | ECTS |
|---|---|---|---|
| Software Specification, Verification and Testing | Hard skill | 1 | 6 |
| Requirements Engineering | Soft skill | 1 | 6 |
| Software Evolution | Hard skill | 2 | 6 |
| Embedded Software | Hard skill | 2 | 6 |
| Preparation Master Project | Group and project work | 1,2,3 | 6 |
| DevOps and Cloud Base | Hard skill | 4 | 6 |
| Software Process | Soft skill | 4 | 6 |
| Master Project Software Engineering | Group and project work | 5,6 | 18 |

# APPENDIX 4: PROGRAMME OF THE SITE VISIT

**Venue**: University of Amsterdam, Science Park 904, Beta Lounge (room B1.25)

**Monday 4 November 2019**

10.30 Arrival panel, internal preparatory meeting + lunch
13.00 Session with management UvA (including representative VU)
13.30 Session with programme management
14.30 Session with bachelor students
15.30 Session with lecturers bachelor programme
16.30 Session with Examinations Board
17.30 Session with Alumni and Advisory Board
18.30 Internal panel meeting
19.00 End of day one

**Tuesday 5 November 2019**

08.30 Open consultation hour
09.30 Session with master students Computational Science
10.30 Session with lecturers Computational Science
11.30 Session with master students Software Engineering
12.30 Session with lecturers Software Engineering
13.30 Internal panel meeting + lunch
14.30 Session with programme management
15.15 Internal panel meeting
17.30 Plenary feedback
18.00 End of site visit

# APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

- Bacheloropleiding Informatica, Kritische zelfreflectie 2019, Universiteit van Amsterdam
- Master Software Engineering, Critical Reflection 2019, University of Amsterdam

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

In addition to the numerous appendices that were part of the two self-evaluation reports, following materials were made available by the College of Science and the Graduate School of Informatics during the site visit, either as hard copy or through the faculty's electronic learning environment:

**Annual Reports**

- OC BSc Informatica 2017-2018
- OC Software Engineering 2013-2014, 2014-2015, 2015-2016, 2017-2018,
- OC Computational Science 2017-2018
- Examencommissie IW/EW

**Courses and study materials BSc Informatica**

- Architectuur en Computerorganisatie: vakcode 5062ARCO6Y
- Compiler Construction: vakcode 55028COC6Y
- Graphics and Game Technologie: vakcode 5062GRGT6Y
- Discrete Wiskunde en Logica: vakcode 5062DIWL6Y
- Networks and Network Security: vakcode 5062NENS6Y

**Courses and study materials MSc Software Engineering**

Software Specification, Verification and Testing (2018/2019) course code 5364SSVT6Y
- Exam and answer model (available on CANVAS)
- Reading material (available on CANVAS)
- Lecture slides (available on CANVAS)
- Exercises and assignments (available on CANVAS)

Software Evolution (2018/2019) course code 5364SOEV6Y
- Exam and answer model – course has no standard exam (2 grading sessions)
- Reading material including reader (available on CANVAS)
- Lecture slides (available on CANVAS – folder: FILES)
- Assignments (available on CANVAS)

Software Process (2018/2019) course code 5364SOPR6Y
- Exam and answer model – course has no standard exam
- Reading material (available on CANVAS)
- Assignments group and individual (available on CANVAS)
- Lecture slides (available on CANVAS)
- Lecture summaries (available on CANVAS)