RESEARCH REVIEW

Computer Science

2015-2020

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Preface

Computer science research, and the products of computer science research, Information and Communication Technologies (ICT), permeate every aspect of our life and our society. ICT has improved our lives considerably, but also the negative side is becoming more and more clear, with some aspects of ICT like social media platforms being divisive and polarising, huge pressure on our energy infrastructure as data centres grow more widespread and demanding, more and more traits of a surveillance society, cyberattacks and even cyber warfare. In academia, all sciences need more and more ICT-specialists, and more and more computer science methods and innovations.

Europe is dependent on big tech companies from the United States and from China, and needs to establish digital autonomy, and needs to step up its digital defense. In the Netherlands, our vital ICT-related companies (such as ASML) need more and more ICT-specialists, educated at the universities and by computer science researchers whose outputs are the subject of this assessment. These researchers are inspired by current applications, and work to achieve the applications and innovations of computer science for the future.

This assessment of the quality of computer science research of most of the Dutch universities was a challenging, but also a very interesting task. Many people, staff members and PhD candidates of computer science departments, staff members and PhD candidates of national research schools as well as the members of the committee, and the secretaries of the committee have worked hard to perform this assessment of computer science research in the Netherlands over the period 2015 - 2020. I sincerely thank everyone involved in this difficult task for their dedication as well as for the pleasant and informative interactions during the site visits, which due to the corona pandemic had to take place entirely online.

The result of all this work is presented in this report. I am very pleased that the main conclusion of the review committee is that computer science research in the Netherlands is of a very high quality, broad and with high impact in international perspective. The committee was pleased to note a lot of collaboration on a national level, and also a start of coordination on a national level (due to the sector plan). We have identified research of top quality in several places. To all departments, we offer a number of constructive recommendations, to motivate them to do even better.

All departments in this assessment have experienced a period of growth in the assessment period. This was very challenging. The committee feels that further growth is indicated for the coming period.

Jos Baeten, Chair of the committee

Contents

1. Introduction

1.1 Terms of reference for the assessment

The quality assessment of research of Computer Science is carried out in the context of the Standard Evaluation Protocol For Public Research Organisations by the Association of Universities in The Netherlands (VSNU), the Netherlands Organisation for Scientific Research (NWO), and the Royal Netherlands Academy of Arts and Sciences (KNAW).

The committee was asked to assess the scientific quality and the relevance and utility to society of the research conducted by nine research institutes and three research schools in the reference period 2015-2020, as well as its strategic targets and the extent to which it is equipped to achieve them.

The research institutes are:

- Subdepartment of Computer Science, Eindhoven University of Technology (TU/e);
- Department of Computer Science and Department of Information Science, Open University (OU);
- The Leiden Institute of Advanced Computer Science (LIACS), Leiden University (UL);
- Department of Data Science and Knowledge Engineering, Maastricht University (UM);
- Institute for Computing and Information Sciences, Radboud University (RU);
- Department of Computer Science, University of Twente (UT);
- Informatics Institute, University of Amsterdam (UvA);
- Department of Computer Science, VU University Amsterdam (VU);
- Utrecht Research Institute of Information and Computing Sciences, Utrecht University (UU).

The research schools are:

- Advanced School for Computing and Imaging (ASCI);
- Institute for Programming research and Algorithmics (IPA);
- Netherlands Research School for Information and Knowledge Systems (SIKS).

Accordingly, three main criteria are considered in the assessment: research quality, relevance to society, and viability. During the evaluation of these criteria, the committee was asked to incorporate four specific aspects: Open science, PhD policy and training, academic culture, and human resources policy.

This report describes findings, conclusions, and recommendations of this external assessment of the research of Computer Science.

1.2 The committee

The Board of the participating universities appointed the following members of the committee for the research review:

- Prof. Jos Baeten, Centrum Wiskunde en Informatica (chair);
- Dr. Christine Morin, Inria Rennes (National Institute in Digital Science and Technology), France;
- Prof. Ann Nowé, Vrije Universiteit Brussel, Belgium;
- Prof. Paola Inverardi, University of L'Aquila, Italy;
- Prof. Karl Bringmann, Saarland University and Max Planck Institute for Informatics, Germany;
- Prof. Laurie Williams, North Carolina State university, USA;
- Prof. Alan Smeaton, Dublin City University, Ireland;

- Prof. Eero Hyvönen, Aalto University, Finland;
- Tim Gubner MSc, Centrum Wiskunde en Informatica (PhD candidate).

The Board of the participating universities appointed dr. Annemarie Venemans and drs. Esther Poort of De Onderzoekerij as the committee secretaries. All members of the committee signed a declaration and disclosure form to ensure that the committee members made their judgements without bias, personal preference or personal interest, and that the judgment was made without undue influence from the institutes or stakeholders.

1.3 Procedures followed by the committee

Prior to the site visit, the committee reviewed detailed documentation comprising the self-assessment report of the institute including appendices.

The committee proceeded according to the Strategy Evaluation Protocol (SEP) 2021 - 2027. The assessment was based on the documentation provided by the institute and the interviews with their respective management, selections of senior and junior researchers, and PhD candidate representatives. The interviews took place between January 24 and January 28, 2022 (see Appendix A).

The committee discussed its assessment of each institute during several sessions of the site visit. The committee chair had the coordinating role in the writing procedure and delegated the writing of sections to members of the committee. The members of the committee commented by email on the draft report. The draft version was then presented to the institutes for factual corrections and comments. Subsequently, the text was finalised and presented to the Boards of the universities.

2. General remarks

2.1 Changes in Computer Science landscape

Since the last research assessment in Computer Science six years ago, computer science in the Netherlands has gone through an enormous change. First of all, the number of bachelor and master students in computer science and related fields, such as data science and artificial intelligence (AI) has grown tremendously. Given the situation in the job market, this upward trend is likely to continue. As a result of the increasing student numbers, the research units of this assessment have started to grow. Reinforced by the sector plan, some of the research units have even doubled in size. Coupled with the pull on the best researchers from other countries offering better labour conditions and from big tech companies, this has posed a huge challenge to the Dutch computer science departments.

Also, there have been rapid changes in the field of computer science itself. The combination of data science and artificial intelligence has enabled breakthrough applications, and the area of computer security has grown tremendously. Quantum computing is a growing new field. This required all departments to reconsider their research portfolio.

Computer science is playing an increasing role in many interdisciplinary collaborations (e.g., in the National Research Agenda), leading to new questions and new developments in computer science research itself.

2.2 Status of Computer Science

The committee is happy to see that the research units have met these challenges very well. Research in the units that have been assessed, is in good shape, with many excellent examples of research output and many internationally prominent researchers. Computer science in the Netherlands has always had a strong position with high quality researchers and high international impact. The committee is happy to note that this is still the case.

In the assessment period, funding from national gas proceeds was no longer available, and funding for EIT Digital is declining. However, other forms of funding have become available. Computer science is doing very well in Gravitation funding and is also present in funding from the National Research Agenda. Direct funding from industry has exploded with the start of the ICAI labs, initiated by the Amsterdam Universities but now present on a national scale.

The organisation of the field has improved, with IPN playing an important role, with its Special Interest Groups and role in the sector plan.

2.3 Needs of Computer Science

In this general section, the committee first wants to address two important issues that need improvement. First of all, funding opportunities for core computer science need to improve. Second, the research staff (especially junior staff) need more time for research.

The first major issue is that the funding landscape in the Netherlands is heavily skewed towards application-oriented and multidisciplinary research, to the detriment of research in core computer science. This point is also made very well in the IPN Vision document (https://ict-research.nl/wordpress/wp-content/uploads/2022/01/IPN-vision-paper-ENG.pdf). This situation is not satisfactory, because future innovations and applications will arise from research in core computer science.

The units involved in this assessment have succeeded in filling many new staff positions in recent years, in many cases by offering starting packages to incoming junior staff. For the retention of these staff members, it is essential that they can find and grow their research specialisation by means of personal grants. For this, they rely on the personal grant competitions of NWO and ERC. Dutch computer scientists do well in the ERC competition, but the success rates at NWO are far too low, given the size and importance of the field. One reason for this is the use of evaluation panels not composed of computer science experts only. The committee recommends that NWO sets aside adequate funding for computer science in the personal grant schemes VENI, VIDI, VICI, improving the success rates to 30% at least.

The second major issue is that the research units have grown in size in this review period, but that student numbers have increased at an even higher rate, resulting in a high student-staff ratio. Given the situation in the job market, it is not likely that this trend will be reversed in the near future. Therefore, it is imperative that first-stream funding for computer science increases. The best way to achieve this is to have another Sectorplan for computer science. The added benefit of such an additional Sectorplan is that the coordination in the sector improves. This time, the Sectorplan should include all ordinary members of IPN.

2.4 Research quality

Despite the huge challenges the departments have faced in the assessment period, the research units have met these challenges and maintained (in some cases improved) their research quality and international standing and collaboration.

Because of the change in evaluation procedures in the new SEP protocol 2021-2027, some research metrics can no longer be used in the evaluation. However, all research units exhibit examples of research output with very high impact, and present important marks of recognition. The committee recommends developing other research metrics (with fewer drawbacks as the current ones) to supplement the more narrative self-assessments of the current assessment. For instance, each research institute could mention the top venues where they want to publish, and then give the number of times they succeeded in doing so.

2.5 Societal relevance

All research units in the assessment have many examples of research programmes with high societal relevance and also perform well in outreach activities. There are ample funding possibilities for large programmes with high societal relevance in the short term. For innovations and applications in the longer term, it is necessary to strengthen core computer science research.

The Innovation Centers in Artificial Intelligence (ICAI labs) have increased direct funding from industry and other organisations considerably.

Some units employ internally funded research software engineers to sustain the impact of research collaborations with industry and other organisations. The committee feels this is a welcome development, as it increases software output quality, visibility, and impact.

2.6 Viability

The viability of the sector is very good. However, as mentioned before, there are two major concerns. First, the funding possibilities for the departments are limited. All units have gone through a period of

growth and attracted many new staff members in a very competitive job market. For the retention of this incoming staff, and further growth of the units, it is essential that the funding possibilities in core computer science improve. The success rate of computer science proposals in the personal grant scheme of NWO should be at least 30%. The committee is pleased to note that many units offer starting packages to incoming junior staff, such as an internally funded PhD student. The committee recommends that units without these packages also consider this.

The other major concern is that the student-staff ratio in the units is still far too high. The committee recommends that there is a second Sectorplan for computer science, involving all ordinary members of IPN, to improve this balance and further coordination between the units.

2.7 PhD programme

The units in the assessment all have a well-thought-out PhD programme. With these programmes, the units produce excellent researchers that are internationally competitive. Issues are drop-out rate and time taken to completion, which are too high in some units. Some units are recommended to employ a stricter Training and Supervision Plan, with some mandatory courses, making this less dependent on the supervisor. An interesting introduction is the TA-PhD, with a longer completion time and a higher teaching load. This seems to work well, but needs to be closely monitored.

2.8 Open science

The units have addressed the challenges of open science with various degrees of success. Some units need to work at divulging open science practices to all members of staff and PhD candidates. Some units have already taken measures for proper management of research data (FAIR, GDPR, etc). Some units stand at the forefront, others need to push forward the efforts to ensure all staff are well trained to write data management plans.

For open access, Dutch universities are spending an enormous amount of money in transformative agreements with large commercial publishers. This is not an effective way of spending public money to further open science. A lot more can be achieved, if this money is used directly on diamond journals and proceedings, or gold journals and proceedings with low article processing charges (APCs).

2.9 Working environment and personnel policies

Concerning the ethics of computer science, all units are aware of possible misuse of products of computer science research, and of the risks of collaborating with research partners with dubious ethical practices. Still, the committee feels that the role of ethical review boards needs to be enhanced, in any case in contract negotiations, more in general in all projects, and that there needs to be more computer science expertise in these review boards.

Further, the committee feels that in some cases, academic freedom is limited. There should always be some room for curiosity-driven, blue-sky research, as it will open unexpected applications.

A welcome development since the previous assessment is that currently, associate professors can have the ius promovendi (in some units, under some conditions), that is the right to promote students to a doctorate. This gives them greater independence and visibility through their own PhD candidates.

The committee has the impression that there is strong awareness of and ample examples of proactive action regarding diversity in terms of nationality and gender. However, in all units, representation of women at all levels is still too low. Communication between the units is encouraged to adopt best

practices. Other aspects of diversity, such as people with disabilities, migration background or ethnicity, get far less attention.

An explicit strategy regarding the support for diversity in all its aspects appears to be lacking in some of the units. The committee recommends that the institutes continue to build increased awareness of diversity in many aspects in order to promote the establishment of a more balanced structure at all levels.

The committee sees differences within the units in the amount of time staff spend on research and education. In the framework of the Recognitions and Rewards programme, this can also work well. The committee warns against creating staff positions devoted only to teaching, as academic teaching needs to have a strong connection to research. The units are encouraged to improve student-staff ratios by other means.

The units realise that the work pressure on incoming staff and tenure track staff is high. The amount of support the units offer varies. In general, the units should consider what kind of support they offer to help junior staff with open science, proposal writing, project management, data management plans and so on.

2.10 Conclusion and recommendations

Computer science in the Netherlands has always had a strong position with high quality researchers and high international impact. The committee is happy to note that this is still the case.

Despite the huge challenges the departments have faced in the assessment period, with a tremendous increase in student numbers and a brain drain to big tech companies and other European countries such as Germany and Switzerland, the departments have met these challenges and maintained (in some cases improved) their research quality and international standing and collaboration.

The committee makes the following recommendations for further improvements in the future:

- More funding for core computer science is needed. For instance, success rates for computer scientists in the personal grant funding from NWO needs to rise to more than 30%;
- A second Sectorplan for computer science is needed to improve the student-staff ratio in computer science and to increase coordination between the members of IPN;
- The committee recommends to make room for curiosity-driven, blue-sky research;
- The committee recommends developing other research metrics (with fewer drawbacks as the current ones) to supplement the more narrative self-assessments of the current assessment;
- The use of research software engineers to increase the impact of research is a welcome development;
- The committee recommends that all units provide starting packages to incoming junior staff;
- Dutch universities spend too much money on transformative agreements with large commercial publishers. It is much more effective to spend this money on open science initiatives directly;
- The use of ethical review boards needs to be enhanced;
- The units are encouraged to pay more attention to diversity, in all its aspects.

3. Subdepartment of Computer Science, Eindhoven University of Technology

3.1 Organisation, strategy and targets

The CS/e unit is one of the two sub-departments of the Mathematics and Computer Science (M&CS) department, one of the largest departments of Eindhoven University of Technology, which is located at the heart of the high-tech industry Brainport region. The department has been restructured in 3 domains, the last 2 being in the CS/e unit: mathematics, computer science, and data science. The CS/e unit comprises of 8 research clusters on a broad range of Computer Science topics:

- ALGA = Algorithms, Geometry and Applications,
- DAI = Data and Artificial Intelligence,
- FSA = Formal System Analysis,
- IRIS = Interconnected Resource-aware Intelligent Systems,
- PA = Process Analytics,
- SEC = Security,
- SET = Software Engineering Technology,
- VIS = Visualisation.

Each cluster has between five and fifteen research staff (full professors, associate professors, assistant professors).

Being embedded in the high-tech industry region of the Netherlands, the CS/e unit has placed its relationships with industry and socio-economic impact at the core of its strategy. It targets high-quality fundamental and applied research and first-class educational programmes to have impact in industry and governmental organisations.

The CS/e unit manages two bachelor programmes, Computer Science & Engineering and Data Science, the latter being created during the evaluation period, accounting for an annual intake of currently 470 students. It also runs three master programmes (Computer Science & Engineering, Data Science & AI, Embedded Systems) accounting for an annual intake of currently 320 students. During the evaluation period the CS/e unit has faced a rising number of students.

3.2 Research quality

The M&CS department currently has five research themes: Data Science, High-Tech Systems, Computational Science, Cybersecurity and Complex Networks. Research-wise the CS/e unit is clearly among the top Computer Science departments in the Netherlands, as indicated by 29 best paper awards, a large number of prestigious doctoral dissertation awards for the PhD candidates, and many research grants (including 3 VENI, 1 VICI, 4 TOP, 1 ERC Starting grant). Several PhD theses published during the evaluation period have been downloaded more than 1000 times.

The accomplishments list the top 10 publications of each cluster. The committee noticed that the referenced publications were all in top international journals and high-quality conferences (rated A* or A) in their respective domain for most of the clusters. ALGA, DAI, SET, SEC, and VIS seem to be the best performing clusters in terms of publications in top venues. IRIS and PA top 10-publication records seem to lag behind the other records. Some papers published during the evaluation period have already been cited more than 200 times.

The CS/e unit has also contributed to highly recognised software and datasets. For instance, the open source AutoML Benchmark from the DAI cluster has become the de-facto standard benchmark for AutoML.The mCRL2 formal specification language and its open-source tool set developed by the FSA cluster in collaboration with CWI and the university of Twente was awarded the Distinguished User-Assistance Tool Feature. The paper describing the SAIBERSOC open-source security tool developed by the SEC cluster won the best paper award at ACSAC 2020. The Process Mining Workbench ProM developed by the PA cluster is downloaded more than 20.000 times per year.

The CS/e unit also participates in various partnerships, national and international. For example, the CS/e unit participates with the university of Amsterdam, Leiden University and CWI in the Networks 10-year Gravitation project funded by the Ministry of Education. Nevertheless, the committee noticed that the slope of increase of grants and contracts does not follow the same rate of increase as the direct income (which depends on the number of bachelor and master students).

The CS/e unit is visible in the international research community. Several staff members serve on editorial boards of several international journals (e.g., CGTA, JoCG, JASE, IPL, SCP, TALG, TSE, EMSE, JSS, JLAMP…) and on prestigious steering committees (e.g. steering committees of Computational Geometry, ETAPS, PACE challenge, ICPC, ICSME, SCAM…) and Programme Committees of international conferences, with leading role as PC Chair or Co-chair of international conferences (e.g. ICALP 2015, DATE 2016, SPIN 2016, EuroVis 2016 and 2017, ICMT 2017, SoCG 2018 …). The CS/e unit's researchers were also involved in the organisation of international events such as ETAPS 2016, SoCG 2015, IDA 2018 renowned conferences. The committee recommends keeping a healthy balance between second- and third-stream income. In addition, applying to competitive personal grants should not be neglected to get funding for fundamental research.

3.3 Societal relevance

TU/e has a strong focus on industrial relevant research. The CS/e unit has excellent connections with industrial partners, taking advantage of its geographical location in the heart of the Brainport region. Strong links with industry are established through different means: collaborative projects, PhD candidates funded by industry, PDEng programmes (software technology and automotive system design) hosted in the department, thesis projects in industry for master students, and joint professorships. In particular, the unit obtained fifteen joint industry-driven European grants (ECSEL, ITEA, PENTA) and five projects funded by the NWO TTW Perspective Programme. It also has bi-lateral contracts with companies funding PhD candidates. Over twenty PhD candidates were funded in the framework of strategic partnerships with industry (ASML, Philips HealthTech, Signify). In total 22% of the research fte is funded by contract research. There were ten professorships with industry during the period (six having their main affiliation in industry) and 60% of the master students did their thesis project in industry.

The large number of co-publications with industrial partners (more than 15%) is an indicator of successful collaborations. However, the drop-out rate of PhD candidates funded by industry is high. The committee recommends a close monitoring of PhD candidates funded by industry.

The CS/e unit targets high socio-economic impact through technology transfer to industry. The DAI, SEC, PA and VIS clusters generated successful spin-offs and some of them were acquired during the period. The CS/e unit has kept strong links with its spin-off through master internships and PhD candidates.

Several researchers contributed to the shaping of research agendas in cybersecurity, big data, and connectivity systems. There are a few contributions to standardisation in data and information systems (e.g., NIST (CVSS), Open AIS in IoT).

The committee was impressed by the number of MOOCs (13) produced during the evaluation period and their success in terms of the number of learners (thousands of learners for all of them).

3.4 Viability

TU/e has taken into account the concerns of the previous evaluation. The organisation of the department has been improved. The Department Board consists of a dean, a vice-dean and a managing director. The department is organised in the three domains: Mathematics, Computer Science, and Data Science, each consisting of several clusters. Chairs of these clusters, together with the education directors of the domain, form a management team for the domain; this team meets on a monthly basis. They have frequent meetings to ensure a tight connection between the Board and the domain management teams, creating a feeling of shared responsibility. The Board meets weekly on HR, finances, and other organisational topics.

There is no plan to increase the number of clusters, but the management team rather seeks to strengthen the existing ones. The CS/e unit wants to support the existing staff with the direct funding which is increasing with the number of students rather than hiring new assistant professors. The support will be offered through the hiring of programmers with a 50% teaching load. The CS/e unit also plans to continue to hire PhD-TAs and Postdoc-TAs. The goal is to alleviate the high teaching load of the junior staff, but this may incur a substantial management load. Given the extreme increase of student numbers in the past and the comparatively low number of hires in the reporting period, the committee recommends additionally hiring new research staff members. The CS/e unit should take measures to attract and keep talents, especially in data science and cybersecurity which are domains under pressure. A high turnover could be detrimental to future research quality.

In the Netherlands, a new system for Recognition and Rewards is being developed to recognise diverse career paths. The committee encourages the CS/e unit to move forward in this direction.

The CS/e department is well poised to continue to have a socio-economic impact in the coming years thanks to its solid network of industrial partners. The CS/e unit seems to lack space which may become a major issue after the pandemic.

3.5 PhD policy and programme

PhD candidates at TU/e appear to be well embedded in their research groups.

The requirements for the PhD candidates are formalised in a TSP (Training and Supervision Plan). The TSP defines the goals, to be achieved, in a rather free form (e.g., there is no predefined amount of credit points/ECTS), which is typically custom-tailored to each PhD candidate's needs. PhD candidate's performance is evaluated yearly and, if necessary, their TSP can be adapted. After the first year, the evaluation is used to make a go/no-go decision.

Most PhD candidates have multiple supervisors (typically daily supervisor and promoter). Typically, PhD candidates have weekly meetings with their daily supervisor, and less frequent meetings with their promoters. However, in certain cases there was only one supervisor (typically only the promoter), which the committee found risky, because the promoter might not have sufficient time to ensure good supervision, coaching and mentoring. The PhD candidates, however, appeared to be satisfied with the amount of supervision they received.

The TSP includes scientific training as well as personal development. For scientific training, the PhD candidates are encouraged to follow courses from the Research Schools. While it is commendable that

TU/e participates in the three Research Schools IPA, SIKS and ASCI, it appears that not all PhD candidates are enrolled in the national Research Schools.

Personal development is handled by the PROOF (PROviding Opportunities For PhD candidates) programme which includes writing, presentation courses as well as Scientific Integrity. The latter course is mandatory for every PhD candidate at TU/e. In addition, PhD candidates have teaching duties to develop their teaching skills.

It is noteworthy that the candidates appeared to be satisfied with the programme. Still, the committee believes that the TSP should be made slightly more standardised and strict i.e., less reliant on the supervisor(s). In particular, the committee imagines mandating a rather open set of courses (e.g., writing and presentation) for general skills and other educational courses (e.g. from Research Schools).

To reduce the teaching load on the remaining (junior and senior) staff, TU/e introduced a PhD-TA track which includes a higher teaching load (25%) and a longer contract (5yr). While PhD candidates appear to enjoy teaching in general, the actual teaching load should be closely monitored such that it does not (unintendedly) exceed 10%/25%.

It is commendable that 58% doctoral candidates complete their PhD in 4yrs and 3 months, and 87% within 5yrs. However, the percentage of candidates finishing within 4 years and 3 months has been lower in the more recent cohorts (32% for the cohort 2015, and 14% for the cohort 2016), which is somewhat concerning. While the dropout rate has marginally improved (from 23% to 19%), it is still rather high. Moreover, a major concern is the low success rate for PhD candidates working in industry. Therefore, the committee recommends that both the recent increase in delays as well as the dropout rate should be closely monitored and investigated.

3.6 Open science

TU/e promotes open science and the library provides support to researchers for open access publications. TU/e has national agreements with major publishers. The CS/e unit is strongly committed to open science. Its strategy is to publish as much as possible open, also software packages and datasets are made freely available if possible. Most researchers make their papers available on arXiv and all publications are available on the TU/e repository (which manages the access conditions to make the papers publicly available after the embargo). TU/e appointed a data protection officer. There are data stewards in departments providing support with research data management topics such as FAIR principles, GDPR and ethics and giving advice. A new data steward position has been opened in the M&CS department.

Researchers are also supported by ethics committees both at the TU/e and M&CS department levels for reviewing the ethical aspects of their research projects and experiments.

The committee noticed that two open journals were launched by CS/e staff: automotive software engineering and journal on object technology.

Overall, the committee applauds the university and M&CS department's commitment to open science and commends that the needed support for open science is already in place. The department should continue to provide high-quality and proximity support to researchers to ensure all new research projects undergo an ethical review before they start and rigorous research data management.

3.7 Working environment and personnel policies

3.7.1 Academic culture

The leadership of the department went through several changes. Several processes have been formalised and good progress has been made towards a good working atmosphere. In particular, there are so-called department dialogues where the whole department meets (including support staff). New members introduce themselves at these meetings. Since 2018, the department has followed the new university personnel policy where associate professors can lead research groups and be promoters.

The department has followed the Dutch code of conduct for research integrity from 2018. TU/e has a code of conduct regarding collaboration with industry.

3.7.2 Human resources policy

TU/e established a diversity office and Interdepartmental Committees (IFC) with members who are trained to be bias aware and who participate in hiring, tenure, and promotion committees across departments. The department strives for a diverse staff and an open culture where everyone feels welcome, irrespective of gender, nationality, sexual orientation, or age, and where all employees have equal opportunities. The M&CS department has been the first one at TU/e to have a Diversity and Inclusion Committee (D&I) and also has a student group working on D&I. Currently 41% of the professors (assistant, associate, full professors) are international, most of them from Europe. 60% of the PhD candidates s and 80% of the postdocs are international.

New faculty members are typically appointed in a development track. The CS/e unit has a welcome package (PhD candidates funded on direct funding) for new staff to kick start their career. The department created the Project Development Office to support researchers in writing grant proposals. Assistant professors have annual reviews with their supervisor. Promotion is considered within at most four years after the appointment. The evaluation criteria (including indicators and minimum requirements) are described in a document that also describes criteria for further promotions. The Board decides, based on advice from the Career Development Committee (CDC), whether to install an Appointment Advisory Committee ("BAC") that formally evaluates the candidate. The Board ultimately decides on whether to promote the candidate. TU/e is in the process of reshaping its current recognition system to recognise teamwork and good academic citizenship. CS/e has several members in IFC, and each hiring committee at the M&CS department has at least one or two IFC members. Moreover, a CS/e researcher is a member of a national advisory board on diversity and inclusion in higher education.

Several female TU/e researchers perform outreach activities at high schools to promote science to high school girls. To support the women among its research staff, TU/e has a network Women in Science Eindhoven (WISE) and it has established the Marina van Damme grant for talented young women among its graduates.

In the summer of 2019, TU/e decided that more drastic measures were needed and the Irène Curie Fellowship programme was started: all vacancies for professors should be open exclusively to women during the first six months of the vacancy. In addition, newly hired women receive a starting package of 100,000 euro to support their research line. The percentage of 33% women among the most recent recruitments is reasonably high, given the market situation.

The department has its own Nanny Fund, which helps parents finance the travel or care for their children during research visits. The Nanny Fund covers travel and accommodation of a family member, friend, or childcare professional (a nanny) to the conference location to take care of the child(ren) or to finance additional help at home if the children do not travel to the conference location.

The committee is of the opinion that all these measures are going in the right direction towards transparency in recruitment and promotion processes, better gender balance, diversity, and support to parentship. Still the CS/e unit is far from the target regarding gender balance and should pursue its efforts.

3.8 Conclusions and recommendations

3.8.1 Conclusion

The quality of the research during the evaluation period was very good to excellent as demonstrated by a number of indicators such as the number of best paper awards, the numerous prestigious PhD awards, the use of the results by peers, the high visibility in the international community, its researchers taking leading role in editorial activities and organisation of scientific events.

The TU/e CS unit has maintained strong ties with industry and is thus well poised for its research to continue to have a strong socio-economic impact in the future.

During the review period, the TU/e CS unit experienced a considerable growth in the number of bachelor and master students, which was not fully anticipated. Consequently, researchers have had a very high teaching load. The department has taken advantage of the Sectorplan funding and the increase of the first stream funding to hire a large number of assistant professors. Moreover, to alleviate the teaching load it hired PhD-TA and Teaching Assistants. In the future, the department management team should pay attention to the teaching load of its staff, the duration of PhD theses, and career development of the newly recruited research staff members.

3.8.2 Recommendations

The committee makes the following recommendations for further improvements in the future:

- The management team needs to continue working hard on appropriate means to alleviate the teaching load as it may have negative consequences on the research quality and attractivity in the medium to long term;
- Curiosity-driven research should be encouraged as well as application-oriented research.
- The department should continue its efforts for increasing the amount of second- and third-stream funding;
- The requirements in terms of training and achievements for PhD candidates to be authorised to defend their PhD thesis should be clarified. PhD candidates should have more mandatory courses (e.g., a course on writing a data management plan);
- Putting in place a clear process involving all relevant stakeholders to ensure that each new research project undergoes an ethical review as well as a review of its data management plan before it starts or at its early beginning;
- Monitoring the PhD completion time for PhD-TA and analysing the reasons for the high drop-out rate, especially for PhD candidates s working on projects with industry. The department should devise processes to better monitor the progress of these PhD candidates to ensure they fulfil the requirements to defend their PhD thesis in a reasonable time.

4. Department of Computer Science and Department of Information Science, Open University

4.1 Organisation, strategy and targets

As of 2020, the Computer and Information Science (C&IS) research unit at the Open University (OU) is situated in the Faculty of Science, which is one of six faculties of the OU. From 2014 to 2020, C&IS was part of the Faculty of Management, Science & Technology (MST). During those years, the Faculty of MST consisted of seven departments including the Department of Computer Science and the Department of Information Science. Thus, the research unit has been part of some very recent structural reorganisation which leaves it staggered across Computer Science and Information Science.

OU's computer science disciplinary research program is relatively young when compared with other universities nationwide and internationally. Prior to 2010, the research mission of OU was targeted at educational science due to OU's focus on providing distance education. In 2010, OU was assigned the explicit task to also conduct disciplinary scientific research and research focused on professional practice. The first disciplinary research programme in computer science focused on software technology for teaching and learning and on software technology for quality improvement. In 2012, this research was expanded to include performance aspects at the interface of business processes and information technology. In 2014, the Faculty of MST created the multidisciplinary research programme called "Learning and Innovation in Resilient Systems" (LIRS). The intention of the LIRS programme was to foster multidisciplinary research in three overarching research lines: Resilience, Learning and Innovation. With the restructuring in 2020, the LIRS research programme was integrated into the OU-wide multidisciplinary research programme "Innovating for Resilience." In 2020, the C&IS research mission also included "New Horizons for Science." This "New Horizons for Science" programme includes a "high quality and intelligent software" programme within the Department of Computer Science and the "advancing information science" programme within the Department of Information Science.

Currently, the C&IS research mission has a clear link between research and its implication for education and practice, as follows: "*Our mission is to stimulate the growth of knowledge about and with information in order to enable people to continually develop in a way that is meaningful to individuals and society. To this end, we provide open, online, personalised and innovative academic distance learning and conduct related research. We take into account the diverse learning needs of individuals and the requirements of the digital society as a whole".*

To achieve this mission, the C&IS research unit has established four strategic goals related to: 1) increasing resources allocated to research; 2) promoting a lively research culture; 3) being recognised nationally and internationally in the field of sciences; and 4) creating research lines that are socially relevant, scientifically challenging, and focused on education and practice. The C&IS department has set targets for each of these goals. The key performance indicators are publications, use of software by peers, research grants awarded (government and contract research), second appointments, external media and lectures addressed to societal target groups, projects in cooperation with societal parties, use in education, and membership of civil-society organisation. The committee noted that with the background of the OU in teaching and learning by distance and its roots in education, the researchers could have chosen to focus more on the computer science research needed to underpin the development of this important component of the education landscape but instead chose to research across broad areas of the discipline. This decision to offer research and supervision expertise more broadly, seems to indicate losing that niche area of expertise.

The C&IS faculty are geographically and organisationally dispersed. The scientific staff are located at the headquarters in Heerlen and at study centres throughout the Netherlands and Flanders, in combination with being hosted at other universities such as Radboud University in Nijmegen and Utrecht University. The distributed model has pros and cons. On one hand, the faculty are able to collaborate closely with related research groups at other universities and to broaden the scope of the experts available for scientific discussion and advancement. On the other hand, the distributed nature may complicate the exchange of ideas and 'spur-of-the-moment' discussions that are beneficial for driving research.

4.2 Research quality

Research at C&IS is fuelled by the large number of master students that are mentored, often in cohorts/groups, by faculty, PhD candidates, and experts in the field outside of the OU, such as retired colleagues for example. This work aids PhD candidates in obtaining their own research results but only a small proportion of these master students end up contributing to the research outputs of the group, most just go back to work for industry when they finish.

The scientific research output has increased significantly during the review period. This is demonstrated by both an increase of publications in refereed journals (from 11 in 2015 to 24 in 2020) and an increase of refereed conference publications (from 35 in 2015 to 46 in 2020). Although the number of scientific publications has grown over the review period, the committee recommends more rapid growth based upon the number of new faculty and through increased focus on disseminating research results in highly visible venues.

The culture of C&IS does not include significant pressure for publishing, including publishing in highly visible venues. The lack of this pressure was welcomed by the faculty, but additional pressure to publish would increase the international visibility of the C&IS research unit.

In addition to the scientific publications, CS&I has also produced different software that is widely used in the discipline. The self-evaluation report describes several interesting examples, such as 'TimSort' and 'TESTAR'. Research funding has more than doubled during the review period from 0.6M to nearly 1.3M euro, largely due to research grants (+.2M) and contract research (+.4M). This growth in research grants, was partly achieved by the acquisition of one NWO Rubicon and one NWO VENI research grant. In the future, increased efforts on obtaining research grants may enable the faculty to be more proactive about their research direction.

Faculty are supported in their grant writing through guidance and feedback from an external company and through their own grant officer. Faculty expressed an interest in this grant officer providing greater support in finding research opportunities beyond the more common granting agencies.

4.3 Societal relevance

C&IS is distinguished by its focus on practical relevance - impacting for teaching and learning, and on software technology for quality improvement. C&IS research is highly socially relevant due to the amount of external PhD candidates and master students research and the cooperation with companies. During the review period, (2015-2020) 21 external PhDs candidates enrolled. This large number of external PhD candidates demonstrates societal relevance because these external PhD candidates not only create new knowledge, but also advance their careers and facilitate the path to translate new knowledge into practice. External PhD candidates work on societally related topics based upon the current challenges of their employers. These PhD candidates bring in case studies and are able to use company data. In the general research community, obtaining real-world data is challenging, so OU

benefits greatly from the industry data. To some degree, the strategy of aligning external research with faculty interest did not seem systematic such as soliciting more research with companies that are interested in certain topics, but instead the process seemed to be industry-driven and more opportunistic than strategic.

Societal impact is also demonstrated through projects in cooperation with societal parties, contract research, and the use in education. The self-evaluation report describes several interesting cooperations with societal partners, including the Dutch government (on internet voting). A prime example for the 'contract research' is the involvement of C&IS in the Centre for Actionable Research of the OU (CAROU) where researchers collaborate with other knowledge institutes such as TNO, SBE, and Zuyd University of Applied Sciences. This involvement helps both increasing the visibility of C&IS and closing the gap between research and practice. The use of MOOCs is an ideal way to reach out to several communities. The C&IS research unit developed and offered MOOCs on green sustainable data centres and the MKB datalab.

4.4 Viability

One strategic aim of C&IS is to increase resources supporting the research mission and to create impact. During the review period and amid increasing demand for scientific staff worldwide, the C&IS staff grew from 20 to 37 fte, primarily in assistant and associate professor ranks.

C&IS has a policy of allocating 30% of the time of scientific staff to research and to support multidisciplinary PhD candidates. The faculty seemed generally satisfied that they are close to being able to achieve this 30% despite the rapid growth in the number of students. The faculty indicated that they may have been able to more easily accommodate covid implications and rapid growth due to their experience with distance learning. They also seem satisfied with the amount of grading and teaching support they are provided.

The committee recommends that C&IS develops a more strategic research direction rather than what seems to be an opportunistic approach based upon industry interests. The committee also recommends a focus on acquiring important international grants to enable more strategic, fundamental research. The unit should consider investing more in increasing second stream funding from prestigious funding bodies such as the European Research Council and the NWO. Strategic alignment of research goals and hiring could align with the "New Horizons for Science."

4.5 PhD policy and programme

Like many other universities, OU also utilises a Training and Supervision Plan (TSP) to formalise supervision and required activities, like e.g., courses, teaching, conference attendance.

Typically, each doctoral candidate has at least two supervisors, a promoter, and a co-promoter. PhD candidates have yearly performance assessments with their supervisors, but also regularly get direct feedback. After the first year, the supervisor(s) decide if the candidate can continue his/her PhD (i.e., go/no-go meeting).

To fulfil their educational requirements, PhD candidates can choose courses from the OU Graduate School, but are also encouraged to follow courses from national Research Schools. C&IS requires attending courses on research ethics and data management. But it should be noted that the committee has the impression that the TSP is relatively supervisor dependent. Therefore, the committee recommends tightening the TSP to ensure that PhD candidates attend certain courses related or beneficial to their research or skillset.

Often, teaching is also a part of the TSP. In this case, PhD candidates frequently support classes or supervise master students. For the PhD candidates, the committee spoke to, the master thesis topics are often related to their research. OU also offers a PhD track with a higher teaching load and longer contract duration (25% teaching, 5 years, PhD-TA), which the candidates the committee met, enjoyed.

Noteworthy is that OU does not have many internal PhD candidates. Internal PhD candidates very rarely drop out. In fact, in the review period no one dropped out. Only 14% finish their PhD within 4 years and 3 months, but roughly 57% graduate within 5 years. The committee recommends monitoring the success rates and investigating the delays.

During conversation with PhD candidates, the committee noticed that some PhD candidates might find it difficult to connect with other PhD candidates and find resources. The committee recommends increasing connectivity, e.g. through social events, and providing a source of information for newcomers. In addition, the committee gathered that the budget for attending conferences is rather limited. Therefore, the committee recommends allocating more resources to conferences, workshops or similar.

4.6 Open science

The committee is of the opinion that greater focus should be placed on an open science strategy, awareness and compliance. The self-evaluation report did not appear to strongly embrace a definitive strategy but instead more of general awareness and direction. Despite the high reliance on industry-driven research and associated data, the faculty did not indicate issues with publishing due to the proprietary nature of the data.

4.7 Working environment and personnel policies

4.7.1 Academic culture

Results of a recent staff survey indicate the positivity of the research faculty toward working at OU. During the meetings, the committee noticed that this positivity and team spirit is certainly present, which was exemplified by a staff member's comment: "Once you enter our group, you never leave it. People appreciate the atmosphere." The faculty indicate a low turnover rate in staff due to this loyalty.

An important cultural component is the explicit actions taken to enable the facilitation of communication, collaboration, and cooperation across department and physical divisions and to make the staff be more cohesive. Facilities for enhanced hybrid meetings have been installed. Informal "walk-in" meetings are planned on a regular basis. Research is discussed at department meetings which are held four times per year for a full day. In each department meeting, the morning is about staff and organisational matters and the afternoon is about research. These meetings include lunch and dinner which enhance the ability for faculty to get to know each other, particularly given the distributed nature of the C&IS research unit. Researchers present their work regularly in monthly seminars and quarterly "computer science study days" for students and PhD candidates. Annually, a mini-PhD conference is held.

4.7.2 Human resources policy

Young faculty are positive about the mentoring and coaching they are provided with, which include being assigned a mentor in the same research field as well as additional informal mentoring. PhD candidates are also pleased with the mentorship and guidance provided by their advisors and possibly external collaborators. Overall, faculty are positive about the academic freedom they have, including the autonomy of whether to spend their research time on publications or proposals.

The Faculty of Science currently has no tenure track policy. As explained in the self-evaluation report, the faculty recently has developed uniform standards for promotion from assistant professor level to associate professor level, derived from the national guidelines. These standards are currently being approved by the OU. The committee strongly supports the implementation of these uniform standards providing more clarity about the promotion criteria.

Over the review period, diversity in the form of international PhD candidates and faculty and gender diversity had increased. However, more proactive actions to improve the gender balance are encouraged. While C&IS ensures a female is on all committees, the recruiting efforts must be started much earlier, including among master students and PhD candidates and even younger such as high school.

4.8 Conclusions and recommendations

4.8.1 Conclusion

C&IS is distinguished by its focus on practical relevance due to the large number of external PhDs and master students and the cooperation with companies.

Overall, the review committee applauds C&IS for going through the assessment process given the "young" age of research at C&IS. Being open to scrutiny and feedback in order to grow and learn will serve the advancement of research at C&IS.

4.8.2 Recommendations

The committee makes the following recommendations for further improvements:

- Provide more support for funding internal PhD candidates to reduce the reliance on external PhD candidates (and the research interests/challenges of their employer sponsors) for conducting research. This funding could take the form of starting packages for new faculty;
- Develop a culture in which more master students publish the results of their research and continue to pursue a PhD;
- Create a culture that promotes goal-driven research and a greater dissemination of research results including at highly visible venues (conference and journals);
- Continue to grow the faculty to reduce the teaching load;
- Consider proactive actions to develop a more diverse pipeline of PhD candidates and faculty;
- Particularly as in-person conferences restart, junior faculty should be given more conference budget to enable them to make more connections and collaborations;
- Develop more explicit promotion criteria. Provide more clarity about the promotion criteria by the implementation of uniform standards.

- Enhance the awareness of Open Science and develop and communicate strong Open Science procedures and direction;
- Provide the faculty with more software/infrastructure to improve their efficiency.

5. The Leiden Institute of Advanced Computer Science (LIACS), Leiden University

5.1 Organisation, strategy and targets

The Leiden Institute of Advanced Computer Science (LIACS) is the institute for research in computer science and artificial intelligence (AI) within the Faculty of Science of Leiden University (LU). The mission of LIACS is to further fundamental knowledge of computer science, AI and its applications. This includes a focus on theoretical foundations of computer science and AI, as well as its applications in science and society. It consists of eight research clusters: Artificial intelligence and machine learning, Data science, Media & Interaction, Programming education, Science based business, Systems and security, Theory and Vision & Imaging. The clusters are not limiting the research scope, as staff can collaborate over these clusters.

LIACS has acted upon the seven recommendations provided to them during the previous evaluation. This has resulted in significant improvement in research quality. In particular, the self-evaluation reports a drastically reduced drop-out rate of PhD candidates (only 1 in the reporting period), an increased number of full professors, a significant investment in research infrastructure, acquisition of more external funding, and the building of strategic alliances with industry. Since 2016 LIACS has consciously stimulated increasing contract funding, which has indeed increased from 2.3 to 10.5%. The institute wants to stimulate this positive trend further and invests in additional support for attracting funding. To support this, a LIACS Project Office has been established, consisting of three project officers providing and facilitating funding and project management support. In addition, two research software engineers have been hired.

Where previously there was a clear focus on data analytics for the biosciences, currently the scope is much broader and covers health as a more general topic, as well as sustainable industry, and joy, culture & expression. The approach however still has a strong basis in computer science. The research strategy reserves a prominent place for fundamental, long-term research.

The university has set up the SAILS programme to encourage interdisciplinary collaboration. It offers opportunities to collaborate with other disciplines like social sciences, law, and medicine. SAILS works on a project basis, with a budget of 5.2 million euro for 4 years spread over the faculties.

LIACS is responsible for two bachelor programmes (Computer Science and Artificial Intelligence), and three master's programmes (Computer Science, Media Technology and ICT in Business & the Public Sector), as well as the faculty-wide master's specialisation Science Based Business, three 30 EC minors Data Science and AI, Cyber-Security Governance Essentials, and Science Business & Innovation, and participation in the minor Game Studies and Cultural Analysis. In 2022 a new bachelor's programme in Data Science and AI will be launched.

5.2 Research quality

LIACS as an institute and individual researchers at LIACS maintain a wide network of research partners that strengthens its position as a centre of excellence in computer science and AI. LIACS believes in a bottom-up approach founded in a safe and trusting environment. Initiatives are often started by individual researchers or research groups and the institute provides support wherever possible, in the form of facilities, staff support and finding opportunities for funding. LIACS has developed into a key

player in several internal, national and international networks. For instance, the Confederation of Laboratories for Artificial Intelligence Research in Europe (CLAIRE) is a network launched in 2018 with LIACS being one of the initiators. LIACS has also developed as a major player in the Dutch and international quantum computing community. These examples witness that the LIACS team has a strong reputation.

LIACS has been very successful in acquiring national grants (e.g., 5 Veni grants, 2 TOP grants). LIACS participates in three NWO Gravitation projects: the Quantum Software Consortium, Hybrid Intelligence, and Ethics of Socially Disruptive Technologies. This is impressive. LIACS is also involved in two Horizon 2020 projects and a number of EU-funded projects on AI: ELE (European Language Equality), VISION (Value and Impact through Synergy, Interaction and coOperation of Networks of AI Excellence Centres), TAILOR (Foundations of Trustworthy AI - Integrating Reasoning, Learning and Optimization), HumanE-AI-Net (HumanE AI Network) and Humane AI (Toward AI Systems That Augment and Empower Humans by Understanding Us, our Society and the World Around Us). LIACS currently also participates in three Innovative Training Networks (ITN), namely AIDD: Advanced machine learning for Innovative Drug Discovery, xCTing: Enabling X-ray CT based Industry 4.0 process chains by training Next Generation research experts and ECOLE: Experience-based Computation: Learning to Optimise. One ERC Consolidator grant has been acquired, but no ERC Starting grant was obtained in the reporting period despite the hiring of quite a number of new associate professors.

All three funding streams have increased in the past six years. The largest increase in absolute numbers (+4 M€) is the increase in direct, first-stream funding; in relative numbers, second- and third-stream funding has seen the largest increase.

The research staff publish at major events and high impact journals. There is also a remarkable number of publications based on master's theses.

5.3 Societal relevance

LIACS is involved in an impressive breadth of outreach activities with societal relevance, e.g. developing the educational programming language Hedy, being among the founding members of the recent initiative CLAIRE on AI in Europe, an extensive list of industry cooperation, and joint projects with all faculties of LU. While the approach taken is mainly opportunistic, this seems to work well. However, the plans are to organise this more formally, as some opportunities might be missed currently. The hiring of two research software engineers is expected to provide more continuity, and to reduce the risk that efforts finally do not pay off.

In the previous reporting period, LU was not really known for its collaboration with industry. This has changed, amongst the industrial partners are KLM, Honda (Honda Research Institute Europe), Amazon, and Total (TotalEnergies). The collaboration provides cases and problems which feed into the fundamental research. An ethics board within the faculty checks the collaboration from an ethical perspective.

Initiatives for spin-off companies are supported whenever the opportunity arises. The university-wide Leiden Knowledge Exchange Office and incubator PLNT offers practical support and sometimes start-up funding through the incubator. Several staff members have had their own companies, such as for consultancy and advising. Data science especially offers many opportunities for impact in society. A recent example is the spin-off company Data Science Agency that offers data science consultancy to industry and organisations.

LIACS has also expanded its aims towards primary education by launching a research line on programming education for primary schools. The institute believes that interest in computer science can be sparked at an early age, and that this might be instrumental in removing the gender bias towards boys that computer science has been struggling with for decades. With its activities for children in the primary school age, LIACS aims to contribute to the development of this spark for all children. This initiative aligns well with the interests of the Programming Education Research and Learning (PERL) group at LIACS, who developed the programming language Hedy.

5.4 Viability

The expertise of LIACS aligns well with the United Nations Sustainable Development Goals (SDGs). Given the fact that funding agencies require this connection this is an advantage in acquiring funding. Throughout the reporting period LIACS has been very successful in increasing funding from research grants and industry cooperation. The Sectorplan and SAILS have contributed to this.

LIACS is very successful in acquiring grants by junior staff. Staff members are supported by the grant support office within LIACS, while before the support was on the faculty level. By integrating it into LIACS, the support is more tailored to the needs of the researchers. Best practices, such as mock defenses, are still shared over the different institutes.

Over the reporting period, student numbers increased significantly, which led to an increase in direct funding. This development led to an extreme growth of the institute, from 69 to 190 research staff. This immense growth is a sign of success, but also raises some concerns. While the LIACS team is still searching how to address this in a sustainable way, some initiatives have been taken with positive effect, such as the organisation into clusters. Members of the Management Team (MT) meet monthly with the cluster representatives to discuss daily affairs, research policy, improvements and innovations. The staff is formally represented by an Institute Council (a strategic advice council consisting of researchers, lecturers, support staff and students) augmented with more informal staff meetings organised by the MT. LIACS also has an external advisory board, which is asked for advice on a needs basis. Apart from research and educational staff, LIACS has its own support staff, consisting of project, administrative and secretarial support, ICT, valorisation and communication.

To be able to cope with the increasing teaching load, full-time teaching assistants and university teachers have been appointed as well as software engineers who can help for valorisation and out-reach activities.

The building quality and amount of space is mentioned as a problem. A new building is planned, but given the growth in the reporting period, the new building will not suffice. Currently the team is very well connected with many internal collaborations. The lack of suitable accommodation might become an issue. To counter this potential thread, LIACS has invested in more organised communications. Staff members appreciate this and they are happy with the support that is provided.

5.5 PhD policy and programme

The PhD programme of Leiden University is well structured and clearly defined: PhD candidates are required to have an Education and Supervision Plan with a fixed number of hours spent on two sections: transferable skills and academic activities. Transferable skills include local courses from UL, most notably Scientific Integrity, writing and presentation. Academic activities include attendance of courses from Research Schools (ASCI, IPA, SIKS), summer/winter schools, workshops or conferences.

While the relatively strict structure of the Education and Supervision Plan could potentially lead to challenges for PhD candidates (to fulfil the hours), the PhD candidates interviewed did not experience such problems.

PhD candidates are typically supervised by two persons, one is the formal promoter and one is the daily supervisor (can be the promoter). In addition, PhD candidates have regular meetings with their supervisors on a weekly basis, or with a higher frequency. Yearly, each PhD candidates' progress is evaluated by her/his supervisor(s). After the first yearly evaluation a go/no-go decision is made.

It is commendable that the PhD candidates interviewed appeared to be aware of open science practices. Their implementation, however, appeared to depend on their supervisor. PhD candidates also receive guidance for the "life after the PhD" from career preparation courses as well as networking events, as e.g., provided by national Research Schools.

Similar to other universities, Leiden University introduced a more teaching focussed PhD track (PhD-TA) with a longer contract duration and higher teaching load.

The committee was positively surprised by the dropout rate of virtually zero (2%). While, over the period 2012-2016, roughly 47% completed their PhD within 4 years and 6 months and 57% within 5 years, the recent trend towards higher delays gives some reason for concern. Therefore, the committee recommends that success rates should be closely monitored and delays should be investigated.

Due to the recent growth of the LIACS, it appears that PhD candidates lack the physical office space to efficiently fulfil their duty. The committee recommends that sufficient space should be provided.

5.6 Open science

Clearly, LIACS is fostering open science principles at all levels and strives to increase its output to different stakeholders.

LIACS increasingly publishes in open access journals and shares its papers through arXiv.org. All research data is stored according to a central data management policy and accessible for verification and in some cases as open data. LIACS also increasingly promotes the development of software to translate its research results into products. Software is usually published under an open-source license on GitHub. The institute has recently created the LIACS Software Lab and hired two research software engineers tasked with collecting and presenting the software developed at LIACS through GitHub.

LIACS contributes to the international project for developing the FAIR Guiding Principles for scientific data management and stewardship. There is support for data management, this is however not so well known, especially amongst the PhD candidates.

5.7 Working environment and personnel policies

5.7.1 Academic culture

LIACS provides an open and safe research environment. There are many opportunities for informal interaction, collaboration and information sharing. Due to an extreme growth of the department, the management structure was changed in the reporting period, towards a more formal management and communication structure, in order to streamline communication structure between management and staff. While such a change may be necessary, it also comes at the risk of losing the connection to the researchers, and strategic decisions no longer being in the hands of researchers.

The culture of academic freedom at LIACS produces strong and independent researchers, however this had resulted in a less focussed set of research topics. This might lead to a decrease in recognition and visibility in the academic field.

5.7.2 Human resources policy

LIACS provides an open and welcome environment. Junior staff are mentored by senior staff. The gender balance among the postdoc (42% female) and assistant professor (34% female) hiring's is reasonably high, given the market situation. In 2020, a separate Diversity Committee (DivCom) was founded to address diversity and inclusivity in a more general way for all LIACS staff members. A key function of DivCom is to provide an interface between the management team and the LIACS community on diversity and inclusivity: staff members can contact the DivCom directly and if necessary, the DivCom gives advice to the MT on matters related to inclusion. This is complemented by the university-wide efforts with regards to diversity and inclusion.

The open and supportive atmosphere is very much appreciated. Currently, new staff do not receive a starting package, but are invited to be involved in ongoing projects and supervision of PhD candidates. Most of the new staff come with already acquired funding, such as a Veni grant. The institute is exploring the possibility to provide a starting package.

The university-wide requirements for tenure are demonstrating a leading role in research, teaching and administrative tasks. Performance indicators cover practicing science, earning power (grants), education, and leadership and management. In these performance indicators, Leiden University increasingly recognises other qualities than research practice as viable career paths in academia. It has embraced the 'Recognition and Reward' national initiative which is in turn inspired by the DORA Declaration on Research Assessment, that promotes more diverse and flexible assessment criteria for quality and a transparent career policy and a reduction in workload for research staff. The expectations for tenure track staff are clear, but for personnel on fixed term contracts this is not always the case. Some junior staff experienced some anxiety because of this.

With respect to switching to online teaching, the support provided by the university was considered to be very good.

5.8 Conclusions and recommendations

5.8.1 Conclusion

LIACS is a strong and viable programme with a good national as well as international reputation. The programme takes a leading role in a variety of topics and regularly receives important awards. During the review period, an increasing number of research grants has been acquired and the collaboration with industry has been strengthened. The institute has grown significantly the past years, and up till now has been able to attract promising researchers. While LIACS seems to have the challenges that come with growth under control, it is important to keep focus, and to foster fundamental research also in the future.

5.8.2 Recommendations

The committee makes the following recommendations for further improvements in the future:

- Carefully monitor the different money streams and keep a healthy balance between fundamental and applied research;
- The informal contacts and information sharing is well appreciated. Make sure the accommodation fits your way of working when the LIACS is growing further;
- Central computer infrastructure should be aligned with the ambition of the institute and follow the growth of LIACS;
- Consider increasing the number of research software engineers, their support is important to reach the objectives of combining fundamental research and applied research;
- Encourage and support senior staff to apply for prestigious funding, such as ERC, so as to also increase their contribution in these funding streams;
- Pay greater attention to the regularisation and systematic implementation of open science principles throughout LIACS.

6. Department of Data Science and Knowledge Engineering, Maastricht University

6.1 Organisation, strategy and targets

The department of Data Science and Knowledge Engineering (DKE) is a large department within Maastricht University with 33 tenured and tenure-track staff members, though this translates into a lower number of FTEs, and 21 PhD candidates, research and postdoctoral research staff. There is a strong presence of young and vibrant academics. The ratio of PhD candidates to academic staff appears lower than at other universities, suggesting that the number of PhD candidates could be increased, though this is partially dependent on the availability of external funding as well as on the funding brought in to support the teaching and education mission.

The topics of research at DKE represents a wide range from classic computer science to new areas which have emerged in recent times including NLP, Computer Vision, affective computing, algorithms complexity and optimisation, cognitive robotics, game theory, explainable AI, game AI and search, machine learning as well as complex systems, signal and image processing. The selection of areas for growth and expansion appear to involve a good amount of bottom-up direction which means all staff are brought into the significant growth phase in numbers and in funding, which took place during the evaluation period. The research areas are supported by three chairs and an endowed chair as well as three recently-appointed chairs, each with specialised remit in machine reasoning, in data fusion and in intelligent interaction and explainable AI, respectively. The department has a strong visibility throughout Maastricht University, in companies, and elsewhere.

In addition to the core competencies, there is a strong emphasis on interdisciplinary research and this is exemplified by joint work in the biomedical and healthcare domains, in neuro-robotics and neuromorphic machine learning, in physics, at the intersection of AI, technology, and law, on robots and AI for children and the elderly as well as on the responsible use of AI. It is clear that such interdisciplinary work is an important aspect of the department's strength and is more than just computer science in the service of other disciplines but is genuine computer science working within other areas. The areas of explainable AI and quantum computing in a collaboration with researchers in Physics are particularly niche for the department which is building up a nice strength in these areas.

During the evaluation period the department moved from the Faculty of Humanities and Sciences (FHS) to the Faculty of Science and Engineering (FSE) as part of a university-wide re-organisation partly to accommodate the growth in DKE. While this caused some inevitable challenges, along with the relocation of the department, increased growth across all areas, the pandemic and a cyber-attack at the University, the department managed these difficulties quite well and reported a commendable increase in all of the evaluation metrics. The department was also proactive in ensuring that new staff were integrated into a fast-growing department and in putting in place a number of structured initiatives.

The stated mission and strategic aim of DKE is to be a leading research unit in the areas of AI and Computer Science in the Netherlands, with five dimensions: research output that is strong, open and has societal impact, a PhD policy with high quality training, an inclusive and open academic culture, a HR policy that embraces diversity that rewards career progression and community contribution, and an expansion policy for both research and education that remains financially viable and strong. The research aims at high impact applications in collaboration with domain experts and stakeholders in areas including healthcare, business and society, though DKE researchers are free to choose their areas

of research and targeted funding sources, both national and international, private and public, independently of this aim.

6.2 Research quality

DKE focuses on high-quality peer reviewed articles in scientific journals and conference proceedings and the output in these areas has almost doubled during the evaluation period. This is partly due to the increase in fte but the scientific research output per fte has also increased during the reporting period and this is to be commended. One of the contributing factors to this is the investment in direct departmental support structures as noted later, which helps DKE researchers at all levels to maintain research outputs and research quality.

In addition to publications, research quality is also reflected by the datasets, software and hardware the department developed and the use of those resources by the scientific community, which is another form of peer recognition and acknowledgement. This includes the Ludii general game system and Myokit software applications and the ALLEN GPU framework. The committee is positive about the examples DKE presented in their self-evaluation report such as highlighting certain publications and the fact that they are spread across research areas and not concentrated in a small number of areas. This is a considerable body of research output with many of the scientific papers being of top quality. It is also a compliment to the research quality and a form of peer recognition that DKE researchers have been asked to co-supervise PhD candidates at other universities and departments.

DKE has been successful in acquiring substantial research funding including from H2020 via ITN, RIA and IA projects, and ERC award and NWO grants, though the teaching mission still brings in 80% of income. This is also a mark of recognition of the quality of research at the department along with the other awards including best paper/poster awards. The academic reputation of the department is good with many good collaborations with other universities and with companies such as IBM and Facebook.

6.3 Societal relevance

The department reports a number of activities which are deemed to have societal relevance and has received several awards for societal impact and has substantial media coverage for such work. These range across dynamic game theory, code development and social robotics and include for example the use of the EDMO robots for STEM education of children. The use of robotic hardware by third parties is something that DKE could usefully exploit and support as a strong demonstration of the societal relevance of their work.

Among the activities of societal relevance is the strong element of cross-disciplinary work that is incentivised and rewarded in DKE and in the university. By its nature such cross-disciplinary work is more likely to create societal impact and relevance and this is realised in DKE across medicine, healthcare and neuroscience. Several of the areas of research that DKE focuses on, such as explainable AI and intelligent interaction, are by definition topics of societal relevance and this should be encouraged further. Some good examples of the societal relevance of DKE output are how the Ludii general game system is used in archaeology by helping archaeologists to understand ancient games, how the ALLEN GPU framework is used at CERN's Large Hardon Collider, EDMO for education in robotics, the dataset for behaviour understanding with application in assistive living and elderly care, and more. These collectively represent a meaningful and substantial contribution to society.

6.4 Viability

It is clear that the department has acted upon the feedback from previous reviews and evaluations and has reorganised itself into eight research areas which are more than just branding of loose collaborations among individuals. It has also increased its number of senior staff, thus improving the senior:junior staff ratio. While this broadening of research topics is welcome, and improves the overall viability of the department going forward as it is research-active across more topics and areas, there is a danger that DKE may spread itself too thinly. Some research areas will naturally attract more funding than others given the nature of computer science, and the fact that developments and changes in computer science can be so rapid and fast-paced means that some areas will naturally decrease in importance and funding. By having a broader range of research areas, DKE is "covering more bases" and increasing its chances of attracting more research funding which is good to see. However, there is a danger that the department's research areas may become two-tier, some may be more successful than others and may seem to carry the less successful ones. The committee's recommendation is to closely monitor the viability of each research area as it develops and not to be slow to adjust by merging, or re-aligning areas so there is no two-tier among areas, if this becomes necessary.

Departmental management has not yet had to deal with a period of consolidation or reduction, only to deal with the recent and current periods of growth. In times of growth, managing a department is usually easier but when growth plateaus, or the department reduces or shrinks, hard choices on which research gets supported and which does not may have to be made. Likewise, hard choices on which research areas to focus on going forward may also be required. If the department had chosen fewer and broader research topics, then such choices may not be necessary but strategic planning needs to be aware of these sensitivities. DKE has done well in integrating its new staff and creating a shared identity among its staff in the recent period of rapid growth and there is no evidence of fragmentation.

DKE aims to continue its growth in research and in education in a sustainable way thus insulating it from sudden disruptions in the funding landscape and allowing long-term contracts and personal development plans for its research and teaching staff to be offered to talented researchers. Yet for a department which is aiming to be so strong in collaboration with other disciplines, the department's name, Data Science and Knowledge Engineering, may appear to be a limiting factor as there are other aspects of computing outside those covered by the title which lend themselves to interdisciplinary work. The department should consider re-examining the appropriateness of its title if it seeks to expand its interdisciplinary research.

6.5 PhD policy and programme

PhD candidates at DKE appear well embedded in their respective research groups. There is a requirement for each graduate to fulfil a Training and Supervision Plan (TSP). The TSP has a rather free shape and can include different kinds of activities ranging from publications to attending courses. This allows tailoring a plan specific to each candidate's needs. To fulfil their TSP, candidates typically have to follow courses. UM's own FSE STEM graduate school not only provides courses, but also opportunities to connect with their fellow PhD candidates via annual PhD conferences. In addition, candidates are also encouraged to follow courses from the Research Schools SIKS, DISC and LNMB, in which they are typically also enrolled.

It is noteworthy that during the assessment period the TSP does not include mandatory courses. From interviews, however, the committee gathered that mandatory courses, e.g. on Research Integrity and Open Science, are planned. The committee recommends that the requirements for the TSP should be tightened by, as possibly already planned by DKE, mandating important courses on transferable skills

and practices (most notably Research Integrity, Open Science, writing and presenting). Consequently, this would make implicit requirements more explicit.

Each candidate tends to have two supervisors, one of whom is their promoter, the other is the daily supervisor. Each candidate's performance is monitored by their supervisors twice a year. The evaluation after the first year includes a go/no-go decision on progression of their PhD.

Besides attending courses, doctoral candidates also have teaching obligations. The teaching duty for PhD candidates is officially limited to 10%. While candidates found it hard to quantify the exact time spent on teaching, they consider it valuable to their own personal development and the teaching load is manageable.

Candidates at DKE can receive job guidance via the PhD coordinator, who can recommend the most suitable courses, and a university-wide career centre.

The completion time of PhD candidates appears to be too long. During the assessment period no PhD candidate dropped out, but also none graduated within a period of four years and three months. Among those PhD candidates who did graduate, only 23% did so within five years. The committee recommends that graduation times should be monitored more closely and reasons for delays should be investigated.

DKE features a low number of its own PhD candidates, partly because many of the PhD candidates who work in the department are formally registered elsewhere, in other faculties or universities. This harms the optics of the true size of the department. The candidates themselves would prefer to have more fellow PhD candidates at DKE to collaborate with. This could potentially lead to increased scientific output, which might help towards a better timeline for completion. Additionally, candidates noted that they would prefer more external collaborations and possibly internships, which could improve their output as well as improve their future job opportunities.

6.6 Open science

While there is broad familiarity with the principles of open science at DKE and while it is considered as an important component of the department's overall strategy and more broadly throughout the university and it is called out explicitly in the DKE strategy document, the awareness of open science and putting it into practice in terms of publications, data and code, varies across research groups. In some research groups it is integral to their operation while in others it appears to be less of a priority.

DKE does support FAIR and encourages its researchers to generate and share datasets, software and (robotic) hardware for use by others, but the department would benefit from a more systematic approach to making open science more embedded in the day-to-day activities of all researchers. This could take the form of a greater familiarity with open science practices spread more evenly across the different research groups, and some groups could learn from others.

6.7 Working environment and personnel policies

6.7.1 Academic culture

With seven chairs covering eight research areas and each area supported by a range of staff at all levels, there is good support for each other throughout the organisation within the research areas, yet there is no feeling of the department being a hierarchical organisation. Junior staff have input into the direction

of the department strategy and choose their own research funding routes and the management structure has flat hierarchies, transparent policies and open communication.

The department has used its funds as a result of the growth in teaching, to put in place some of its own support structures. These include a department manager and a communications officer who helps with research dissemination, a project officer to help with research proposal writing, and a business development and education development officer. Each of these supports junior and senior staff in their work to secure research funding, removes some administrative load from the senior academic staff, and fosters collegiality among all staff.

All DKE research staff adhere to the Netherlands Code of Conduct for Research Integrity.

6.7.2 Human resources policy

During this evaluation period, DKE has gone through a large amount of recruitment so its HR policy has really been tested in practice.

The department represents great diversity among its own staff and researchers, with 25 nationalities when postdocs and PhD candidates are included. The vast majority of DKE scientific staff and postdocs/PhD candidates are non-Dutch which speaks to a strong element of diversity in the department, though that itself can bring challenges regarding local collaborations with companies and others. It also raises challenges for the department to truly integrate and embed those researchers and avoid future potential mobility of them to elsewhere.

There is good awareness and action around being gender-neutral both in policy and in practice. Gender balance in the department is better than in some other institutions but more can be done, though the department is aware and is active in this area.

6.8 Conclusions and recommendations

6.8.1 Conclusion

In recent years, DKE has been a fast-growing department with that growth fuelled by an increased teaching mission allowing more fte's to be added to the department, as well as some successes in competitive research funding. Such rapid growth in a short period of time has presented challenges which have been compounded by external factors, but the department has grown gracefully and in an integrated way as a result of the management structures put in place.

In terms of quality of research, the outputs from DKE are strong with several examples of high esteem across its many sub-areas of computer science. The strong presence and nurturing and support for interdisciplinary and cross-disciplinary research makes the work of DKE highly relevant and this, along with the quality of recent recruits, makes the department strongly viable for the future.

6.8.2 Recommendations

The committee makes the following recommendations for further improvements in the future:

- The areas of explainable AI and quantum computing are particularly niche for the department which is building up a nice strength in these areas. Please continue this;

- The number of PhD candidates could be higher or something could be done to recognise those PhD candidates who work at DKE but who are registered elsewhere. This would present a fairer picture of the size of the DKE research activity;
- Open science practices could be more systematically embedded in the day-to-day operation of all researchers across all research groups;
- Requirements for the PhD TSP should be tightened by mandating the inclusion of important courses on transferable skills and practice;
- Re-consider the department's title and whether it does justice to the aims to expand on cross-disciplinary and interdisciplinary research;
- Closely monitor the success of each of the research areas and be agile in considering merging or re-aligning those areas so as not to have a two-tier ranking among those research areas;
- The committee found that more and more time of the junior staff in particular is spent in teaching with the increasing number of students. Although part of this could be due to the pandemic, the committee recommends investigating this matter further and seeing that enough time for research for the staff is allocated.

7. Institute for Computing and Information Sciences, Radboud University

7.1 Organisation, strategy and targets

The Institute for Computing and Information Sciences (iCIS) is a medium-sized department of the Faculty of Science of the Radboud University (RU). The department has experienced in the current assessment period a fifty per cent growth in the scientific staff (31/45) and a moderate growth in postdocs and PhD candidates (74/82).

The institute is divided into three sections. Each section focuses on a research theme: the *software* theme in the Software Science Section, the *data science and artificial intelligence* theme (subfields *data modeling & analysis* and *machine learning*) in the Data Science Section, and the *security and privacy* theme in the Digital Security Section.

The research mission of iCIS is to improve the security, reliability and validity of computer systems and algorithms through mathematically founded theories, methods, and tools.

The institute considers pure curiosity-driven research as crucial to fertilise the research landscape to foster future applied research. Research problems are inspired by concrete problems stemming from reality and by investigating limits and theoretical assumptions of computer science and their potential impact for developers and system integrators.

7.2 Research quality

The iCIS department has a consolidated structure in the three areas of interest. Each section has flagship research themes that are internationally recognised. A limited number of new research areas have been introduced to complement/modernise the core areas focus. This broadening of topics goes in small steps due to the moderate increase of staff and the strategic choice to maintain the international standing of the core areas.

The overall quality is very high in terms of publication venues, scientific value, awards, and individual grants. The unit has a tradition and a policy, maintained in the assessment period, in delivering open-source research software artifacts that are successfully transferred in the academic, industrial, and societal communities of their eco-system generating direct and indirect impact. Collaboration with the eco-system actors is also strengthened through a set of nationally funded collaborative projects and ICAI (Innovation Centre for Artificial Intelligence) labs.

Publications of iCIS researchers have generated multiple follow-ups in terms of industrial and scientific interest. The researchers are also very active in the international community in promoting benchmarking activities, participating, and organising international competitions, participating in international networks and standardisation bodies. There is clear evidence that they actively participate in their respective international research communities through multiple activities, like the Automata Wiki initiative, the participation in cryptography standardisation initiatives, and the ELLIS unit.

During the assessment period, iCIS researchers have been able to attract 3 ERC advanced grants, 1 ERC starting grant, a VIDI, a VENI and a Marie Sklodowska-Curie fellowship. Although this is a very good record, the figures provided in the self-assessment show that there has been an absolute and relative decrease of funding in research grants in the past six years. This data suggests that beyond the

remarkable performance of some researchers, the overall performance of the iCIS researchers in obtaining funding in the reference period 2015-2020 is not on a positive trend. The same trend is also visible in the acquiring of contract research, measuring the ability of the department to productively interact with the industrial actors of their eco-system.

Despite its scientific international visibility, the unit seems to not consider developing international collaboration through Horizon projects as a priority. The committee understood from the interviews that the institute rather focuses on personal grants, and has been able to achieve a higher-than-average success rate because of its selective approach. Although the unit has initiated training events, and has organised with Radboud Innovation to share a monthly newsletter that reviews upcoming international collaborative calls, the committee is of the opinion that the unit should have put in place measures that can help the applicants in terms of administrative burden and difficulties in writing and shaping a proposal rather than just advertising calls. The committee encourages the management to explore ways to acquire international funding.

iCIS has recently launched the Innovation fund for blue-sky research that aims to offer to any member of the staff, on a five-year period, the possibility to have a PhD funded internally. This is a positive initiative that may help involve a larger number of staff in active research.

7.3 Societal relevance

The institute has a good network to link to society. Primarily it exploits the initiatives carried out at the university level that facilitate inter university and intra society collaborations. Some research themes, for example in the data science, privacy and security domain, have a higher readiness level than other themes for the society at large. However, significant overall effort in bringing scientific discoveries to societal values through different levels of personal engagements and relationships with the economic side of the society (both public and private) has been observed. For example, the committee appreciates the new open-source graph database system that combines methods from databases and information retrieval for ranking property graphs to counter Big Tech's dominance in search and social media.

It is worth noticing the bunch of activities carried on the educational side that move in the direction of innovating teaching in different areas of computer science. This is an extremely important although not easily rewarded innovation area that can help mitigating the lack of ICT-skills the society is suffering.

Connections to industry through PhDs remain the most practiced way to achieve individual researcher collaborations with IT industries and other IT bodies, complemented with internships at the bachelor and master level. This seems an area where a more structured approach would make impact more visible.

7.4 Viability

The institute's strategy for the next years will keep investigating the three research themes with the same research methodology: on one hand pursuing curiosity-driven research that may anticipate solutions for new emerging ICT developments, on the other hand exploiting knowledge transfer back and forth from society and industry for the formulation of research questions and application of research results.

The institute has a number of strengths as detailed in their SWOT analysis, notably their flat and open management structure, the presence of leading scientists, and the possibility of blue-sky research

through the internal Innovation fund. The SWOT analysis also identifies weaknesses that require further specific attention. The first weakness concerns funding: the need to increase the number of researchers that can acquire grants and thus expand their research, the different capacity of the sections to attract funding, and the modest involvement of the institute in European collaborative projects. The committee has learned from the interviews that iCIS has a very good success rate in the NWO competitive calls. Furthermore, iCIS supports researchers in the choice of calls depending on the level and maturity of their research. However, this policy seems mainly directed to individual grants and to excellent researchers. Collaborative projects, especially European ones, may be too constrained and require strong links with industrial/public partners and a strong international network. Competent support, for example training events, can help but is currently not sufficient. Explicit policies to reward the researchers that engage in competitive applications may be useful. For example, researchers may be promised a small funding if a project is not funded but has reached a certain threshold.

The other proposed countermeasures may not hit the target. Indeed, pushing for external contracts by strengthening the links with industrial partners and/or the hospital, as well as promoting cross-section research can be beneficial for the institute but may not help individual researchers in expanding their research.

Finally, the weaknesses concerning the risk of missing relevant research topics because of too focused research remains unconfronted. Indeed, the previous research assessment recommended *"… that iCIS continues focusing on publishing in high quality venues and growing new research areas based on interactions with new areas and disciplines, in addition to maintaining their standards of excellence in their core areas of computer science."* The exploration for new research area to grow has been limited. In the opinion of the committee, the institute has a solid core base, and it is in the position to accept a moderate risk and to explore new research themes in the sections and beyond the section's themes. The foreseen recruitment plan could be exploited to acquire expertise that is not present now but might become crucial in the future. The faculty's strategy to create the interdisciplinary research platform can be the context in which some of these initiatives can be developed.

7.5 PhD policy and programme

At RU the educational and training requirements of doctoral candidates are formalised in a Training and Supervision Plan (TSP). The TSP is custom tailored to each PhD candidate's needs. RU has two mandatory courses: 'Didactical Skills' and 'Scientific Integrity'. However, PhD candidates typically have teaching duties (roughly 10% of their time). The committee recommends that the TSP should be made more explicit and less reliant on the individual supervisor(s). For instance, RU should consider adding mandatory courses for transferable skills and good practices (Scientific Integrity, writing, presentation).

In their TSP, PhD candidates typically follow courses offered by Research schools IPA and SIKS, as well as generic courses offered by RU. From conversations, it appeared that courses on didactic training lacked a hands-on component. In addition, the committee recommends introducing a course on writing grant proposals as such a course would clearly benefit PhD candidates as well as junior staff.

Most PhD candidates have two supervisors. In exceptional cases, however, some PhD candidates who started before September 2020 only appear to have their promoter as their sole supervisor. PhD candidates tend to have regular, mostly weekly meetings, with their supervisors as well as meetings on a "on need" basis. Yearly, the PhD candidate's performance is evaluated, plans for the next period are made and, if needed, the TSP is updated. After the first 12 months, a go/no-go decision is made whether the PhD track should be continued.

At RU, it is common that PhD candidates spend some time abroad. The committee agrees that this can help PhD candidates to extend their network and prepare them for future jobs. In addition, PhD candidates receive job guidance from their supervisor as well as from a university-wide job fair. The job fair, however, appears to have been postponed due to COVID.

The committee commends that, at RU, there are virtually zero dropouts (4%). But, only a quarter (25%) of PhD candidates graduate within 4 years and 3 months and roughly half completed their PhD within 5 years. It is noteworthy that RU has introduced a monetary incentive for PhD candidates to graduate in time.

7.6 Open science

According to the committee, iCIS has been at the forefront of promoting open science practices in the university. The institute adopts the policy to release open-source research software. It also pushes for open access publications. In this direction it has volunteered as first institute at RU to participate in a pilot project to make all the short scientific works available in open access via the Radboud Repository.

The institute has contributed to the development of the university research data management plan and has written its own RDM policy. It has made efforts to improve findability and accessibility of research data that resulted in an increased number of registered and deposited data sets. Active involvement of scientists, early career researchers and PhD is stimulated to drive the change.

7.7 Working environment and personnel policies

7.7.1 Academic culture

From the self-evaluation report and from the interviews with junior staff and PhDs, emerges the view of a working environment that cares for its members in multiple dimensions. The department has put in place formal and informal policies to ensure openness, safety, and inclusivity. Because of the flat organisation, the institute has short communication lines. English is the main language for research and teaching staff meetings.

7.7.2 Human resources policy

The institute targets the recruitment of excellent talents. In the last years, it has doubled the number of assistant professors and increased the number of full professors with 50%. Recruitment has also targeted diversity in terms of gender and nationalities, and it has succeeded in improving the respective percentages. Future plans will keep on the same objective, especially in the units that still suffer of severe gender unbalance.

Gender diversity is a top priority of the institute's agenda. In 2017, the institute won the second Minerva Informatics Equality Award in recognition for its measurable efforts in monitoring gender issues and promoting the advancement of female careers in Informatics. The Radboud Women of Computing Science (RWoCS) organises events to connect women, both students and employees, who are studying or working in Computing Science or related fields. The committee appreciates these efforts and urges the institute to continue this.

The career path for young researchers is well defined and communicated transparently at the beginning of the employment. Despite the general focus of the Institute on excellence, there is an effort to not put

pressure on young researchers in terms of publication criteria for promotion. Indeed, from the interview with junior staff, the general feeling was that promotion is the result of an overall evaluation and that there is no need and pressure to excel in all criteria.

The committee is positive about the specific role of a tenure track counsellor, covered by a senior scientist, that has been created to support tenure track researchers.

7.8 Conclusions and recommendations

7.8.1 Conclusion

iCIS is a medium size department with a well-defined research profile. It covers three macro-themes: Software, Data-Science and Security. Within each theme there are specific core research areas that excel at the international level. This is demonstrated by the awards, competitive grants, impactful research software and visibility in the international community through invited talks and committee participations. The department has a strong network of contacts to the society, and it is well positioned to embark on interdisciplinary research through the university and faculty initiatives. iCIS demonstrates active attention to maintaining high quality of the working environment, favouring openness, inclusivity, transparency, and reliability especially for younger researchers and PhDs.

Research-wise iCIS is a top player in its field of expertise and is highly motivated in maintaining this position. However, in the opinion of the committee, this is at the expense of being too conservative. New research topics are added incrementally to the core ones, application of the core expertise in different domains and cross-sections is ranked first in iCIS strategy for the future. Although the institute introduced a blue-sky research fund, a limited plan or strategy to open new core areas or significantly widen the existing ones is foreseen.

The committee feels that in the present fast-changing ICT landscape with iCIS entering a five-year period that may see a significant turnover due to retirements coupled with the availability of extra funding, a long-term view of where iCIS would like to be in five to ten years' time is crucial, in order to steer the next development phase. The committee recalls here that the mission of iCIS is to improve security, reliability and validity of computer systems and algorithms through mathematically founded theories, methods and tools. Computer systems and algorithms are changing dramatically in the future, in their architecture, software, computational models and more. In order to maintain its mission and leadership, iCIS needs to start considering some of these changes.

7.8.2 Recommendations

The committee makes the following recommendations for further improvements:

- The committee recommends that iCIS continues focusing on its core area of expertise but at the same time engages in the effort to develop a longer-term strategy that may suggest new research areas to invest in. A long-term view where iCIS would like to be in five to ten years' time is also crucial to steer the next development phase;
- The committee encourages iCIS to accept a moderate risk and to explore new research themes in the sections and beyond the section's themes. The foreseen recruitment should also focus on acquiring expertise that is not present now but might become crucial in the future;
- The committee encourages the management to explore ways to acquire international funding;

- The management should encourage participation in European collaborative projects. This is not only useful to improve research funding but also to expose researchers to different research and industrial priorities and cultures;
- Interdisciplinarity is increasingly important as ICT is the enabler of the digital society. The committee recommends that iCIS members engage in inter-disciplinary projects, but maintaining a CS foundational approach, mitigating the risk of CS as a service approach;
- The committee recommends a more structured approach to make the impact by individual researcher collaborations with IT industries and other IT bodies more visible;
- The committee advises to make the TSP more explicit and less reliant on the individual supervisor, for instance by adding mandatory courses for transferable skills and good practices (Scientific Integrity, writing, presentation).

8. Department of Computer Science, University of Twente

8.1 Organisation, strategy and targets

The Department of Computer Science (CS) is part of the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS). The research, inspired by real-world challenges, is organised around four clusters: Cyber-Physical Systems; Cyber-Social Systems; Software Science; and Data Science. Security is a cross-cutting topic dealt with in several of these clusters. The CS department comprises of seven research groups: Computer Architecture and Embedded Systems (CAES), Design and Analysis of Communication Systems (DACS), Data Management and Biometrics (DMB), Formal Methods and Tools (FMT), Human Media Interaction (HMI), Pervasive Systems (PS), Services and Cyber-Security (SCS). The research groups contribute to five focal areas:

- Dependable cyber-physical systems (CAES, DACS, PS);
- Dependable cyber-social systems (HMI, DMB, PS, SCS);
- Data science and engineering (DMB, HMI, DACS, PS, SCS);
- Software science and engineering (FMT, SCS);
- Security (DACS, SCS).

The size of a research group ranges from 6 to 18 staff researchers with an average of 13 research staff members.

The mission of the Computer Science department is to establish a seamless integration of ICT into the modern digital society, by investigating the development of systems that one can justifiably rely on, and that people can effortlessly interact with. In collaboration with other disciplines, the department aims to combine fundamental and applied research that addresses the needs of people and the world at large.

There were important changes in the organisation of the research at UT at the beginning of the evaluation period. Previously, the research was organised through research institutes. The (current) CS department was at the heart of the Centre for Telematics and information technology (CTIT) dedicated to research in CS. The governance and financing of research was transferred to the faculties in 2017. The current institutes are responsible for setting up multidisciplinary research across faculties. The relevant institutes for CS are the Digital Society Institute (DSI) and the Technical Medical Centre (TechMeD). The CS department is very well inserted in its research ecosystem.

During the evaluation period, it worked on increasing collaborations between groups, with other departments and faculties to strengthen the focal areas. In particular, there are collaborations with the mathematics and electrical engineering department within EEMCS on energy, security, health and well-being & robotics. Outside the faculty, the CS department has developed its collaborations with other disciplines mainly with physics, biology, linguistics, and psychology. The CS department has set up two centres with the aim to increase collaborations with industry: the Centre for Networked Systems and Intelligence (NESSIE) and the Twente University Centre for Cyber-security Research (TUCCR). Research on security is carried out in close collaborations with industry and government.

The CS department conducts multi-disciplinary research in the framework of two UT interdisciplinary institutes targeting impact on society, DSI and TechMed, with high involvement in programmes on eHealth and Robotics. DSI focuses on five themes: data science & AI, smart industry, eHealth, robotics, and cybersecurity. TechMed offers access to clinical institutions and facilitates applications in real world settings.

In terms of education, the department has been responsible or heavily involved in three bachelor programmes on technical computer science, business information technology and creative technology and in five master programmes on technical computer science, business information technology, interaction technology, embedded systems and robotics. The bachelor programmes are taught in English and thus attract international students. The number of students was multiplied fivefold during the evaluation period while it significantly decreased during the previous period.

8.2 Research quality

The scientific production has decreased in the period during which senior research staff members left (for retirement or to the next step in their career) while several junior staff members were hired. However, high quality research is still present though there seems to be heterogeneity among the groups. The CAES group had a decreasing number of publications at the end of the period (2019-2020). The DACS group publishes in top (wireless) networking journals and conferences as well as in network measurement and, to a lesser extent, in security conferences. DMB publishes not only in the computer science domain (e.g., ML, ICML)) but also in biometry, medicine. This group has a very large number of publications in 2021, including a fair number of publications in top level journals and conferences. The FMT group has several publications including high quality conferences and journals. The HMI group has publications in renowned journals and conferences on human-machine interactions and behavioural development.

There are good signs of high-quality research including a test of time award in 2015, several best papers and distinguished papers. Furthermore, several staff researchers received personal awards during the evaluation period.

Several datasets have been published during the period by different groups, some of them received a best dataset award in 2018 and 2019. The OpenINTEL DNS Measurement Platform (DACS) is the flagship software of the department. VerCors verifier for the verification of concurrent software and GROOVE (6100 downloads worldwide in 2015-2020) are also very visible. In addition, CS produced a lot of software in the security and privacy areas.

The CS department obtained two ERC grants during the evaluation period, a StG grant in 2016 and a CoG grant in 2019. Its researchers submitted 23 VENI proposals and obtained two VENI grants. Three VIDI and two VICI proposals were submitted during the period leading to one VICI grant being funded. The committee notices the submission effort and encourages the department to continue to encourage submissions to ERC and NWO personal grants and to provide high quality proximity support to applicants.

A number of staff researchers have responsibilities in the international scientific community, nationally (NWO), and at UT. Several researchers serve in the editorial board of renown international journals, some of them having top level responsibilities.

The CS department has a leading role in the AI coalition and AI net and is involved in Gravitation projects.

8.3 Societal relevance

The CS department was involved in several European and national collaborative projects in applied research during the period including some projects coordinated by CS department researchers and large projects (H2020 Concordia in cybersecurity for instance). HMI has been particularly successful in the

European Research Area. In particular, the coordination of H2020 DE-ENIGMA project on Multi-Modal HRI for Teaching and Expanding Social Imagination in Autistic Children.

Regarding direct collaboration with industry, only 10% of the department funding comes from contract research, which appears to be low. The department is involved in projects funded by large companies such as Tata Consultancy Services, Bertelsmann, SAP AG, and Siemens. It is also involved in the Twente/47 initiative (IoT accelerator). The CS department created six spin-offs during the evaluation period (one in 2016, four in 2017, one in 2018). Two additional start-ups were created by students trained in entrepreneurship.

Several industrial partners are financing part-time positions in the department, e.g.., TNO, SIDN Labs, NCSC, Nedap, Northwave, SURF, NLNet. Symmetrically, a number of researchers have a part time appointment with industry.

Research staff members are involved in the definition of the national and European agenda in various initiatives. For instance, in the security area, CS researchers are involved in the shaping of the national cybersecurity research agenda. The CS department attracted funding from the related calls and is also a partner in several large-scale H2020 projects with strong industry participation. For instance, UT is one of the leading partners in the Concordia project.

It is very positive to see a number of projects developing digital technologies for children, elderly people with dementia or low literate persons (dependable cyber social systems). The CS department is also involved in several projects related to sport.

8.4 Viability

The CS department faces a number of challenges. The rising number of students may continue and undermine research capacity. The department plans to hire teaching staff to cope with this situation. During the meeting with the management team, it appeared that there are also plans to cap the number of students. The committee encourages the department to take a series of measures to improve the research / teaching time ratio to allow assistant professors to develop their research.

Another challenge concerns the composition of the research staff. The total research staff increased from 49 persons in 2015 to 70 persons in 2020. The number of full professors declined (from 20 to 16), while the number of assistant professors has risen sharply (from 18 to 38). Considering that in the same time the total number of PhD candidates and postdocs declined (from 153 to 110), the postdocs + PhD students)/research staff ratio decreased significantly. The department should invest efforts in attracting more PhD students in order to maintain high quality research in the long term.

The committee is concerned about the funding situation observing a decline in the second and third streams funding. The funding obtained through research grants has considerably decreased during the evaluation period (from 5.6 M€ to 2.7 M€). The funding obtained through contract research is rather low and declined from 1.8 M€ to 1.6 M€. The direct funding has been growing fast during the period from 8M€ to more than 14 M€. The committee recommends the department to urgently analyse the situation and adopt a plan to alleviate the teaching load and provide more support to researchers to prepare high quality personal research grants.

There are clear research and work directions for the five focal areas that will remain the same in the forthcoming period. All of them will benefit from the Sectorplan funding allowing the recruitment of eight research staff members.

The department has identified three new strategic partnerships to be invested in the forthcoming period. In Apeldoorn a collaboration has been established between knowledge institutions, companies,

organisations and governments (Police Academy, Saxion, Achmea, Tax Authority, Land Registry) in a Center for Security and Digitisation (CVD). In addition, the Vrije Universiteit (VU) and the University of Münster (WWU) are strategic partners of the UT. Focusing on clearly identified partnerships is a good choice to have impact. While the benefits expected from the Apeldoorn partnership from the CS department research point of view appear quite clear, the objectives for the other two strategic partnerships could probably be clarified.

Another challenge is the space issue though there are plans to overcome the space limitations after the corona crisis. Moreover, the space that is being used has some habitability issues. For instance, the obsolescence of the ventilation system in the current building is a major issue.

8.5 PhD policy and programme

PhD candidates must fulfil a Training and Supervision Plan (TSP) with 30 credits points. The TSP consists of generic subjects, topic-specific subjects as well as teaching duties.

PhD candidates are typically supervised by the formal promoter and the daily supervisor. In conversations with PhD candidates, it appeared that it is possible that both can be the same person, i.e. the PhD candidate effectively only has one supervisor. The committee sees this as a risky choice, as the promoter might not always be able to allocate enough time to ensure proper supervision, coaching and mentoring. The PhD candidates indicated that there is variety in how often students meet with their supervisors (often weekly, sometimes only once a month). The committee commends that the meeting schedule allows for sufficient time to ensure proper supervision, e.g., ensure weekly meetings.

PhD candidates have periodical evaluations with their supervisor(s) in which the TSP can be adapted, if needed. After the first year, a go/no-go decision is made. If a no-go has been given, the student has three months to convince his/her supervisors of the opposite.

Generic subjects cover transferable skills, such as writing, project management, as well as mandatory courses on Academic Integrity and Data Management. These courses are typically offered through the local graduate school (Twente Graduate School). The panel was pleased to note that PhD candidates were aware of and encouraged to use Open Science practices.

Topic-specific subjects include courses given by the national Research Schools (ASCI, IPA and SIKS), presentations at scientific meetings (e.g. conferences, workshops) and paper reviews. From conversations, the committee gathered that PhD candidates are typically expected to publish four papers. The committee recommends that such guidelines could be alleviated to four chapters (i.e. four significant contributions) in the thesis.

PhD candidates at UT have a teaching load of at most 20%, which is significantly higher than at other CS departments (10% is the regular load). In conversations with PhD candidates, it appeared that it should be made clear that 20% is indeed the maximum amount of time allocated for teaching-related activities, as opposed to a guideline percentage.

It should be noted that UT also allows a more teaching focused PhD track, with a six-year contract and 30% teaching. The PhD candidates, the committee spoke to, appeared happy with choosing the more teaching focused track.

Of the PhD candidates enrolled at UT, only 15% graduate within 4 years and 3 months, and 40% complete their PHD within 5 years. Additionally, the committee observed that roughly 20% of PhD candidates dropped out. The committee recommends that UT should monitor success rates and dropout rates closely and analyse the reasons explaining the current non satisfactory situation.

In conversations with PhD candidates, the committee noted that UT lacks office space and PhD candidates sometimes have to share a desk. The committee is of the opinion that this influences their productivity negatively.

UT could also stimulate its PhD candidates to go abroad (during their PhD), which could positively affect the student's network, future job opportunities and encourage scientific collaboration.

The committee is concerned by the very small number of PhD theses defended during the evaluation period, the number of defended PhD decreasing since 2018. For some groups (DACS, DMB, HMI, PS) the situation appears to be particularly worrisome. This is a worrying trend for the whole department and the committee urges the department to analyse the reasons explaining the high drop-out rate and to devise an action plan to increase the number of PhD students. On the positive side, a few PhD theses in cybersecurity, software engineering, and formal methods received Best PhD thesis awards.

8.6 Open science

UT has had an open science policy since 2015 which was updated in 2018. The goal is to reach 100% open access publications by 2023, preferably immediate open access publications. For the whole period only 45% of the CS department's papers were published in open access despite the university-wide support and tools provided (UT open access website). However, the CS department made progress recently reaching 67% of its publications in open access

The UT strategy (shaping 2030) states that FAIR data is the new norm for UT researchers. The Faculty of EEMCS has invested in this direction. A data steward has been hired to provide direct practical support on research data management for EEMCS researchers. In 2019 the EEMCS department formulated a tailored research data management policy which is a refinement of the UT-wide policy. There were further efforts in 2021 with the launch of UT-CC Digital Competence Centre funded by the Dutch government with a coordination role, knowledge, and advice centre for open science, FAIR data/software, digitalisation of research, and related ICT facilities.

The CS department's researchers are active on open research data, for example, by chairing the artifact evaluations of TACAS 2018 and TACAS 2020 and by organising the QComp 2019 and QComp 2020 competitions in quantitative verification.

The committee recommends to pursue the efforts to reach 100% of the CS department's publications in open access as soon as possible and acknowledges that the CS department stands at the forefront in the country regarding research data management.

8.7 Working environment and personnel policies

8.7.1 Academic culture

The department has a flat management structure, and the management team aims at making every department member feel at home.

Regarding research integrity the university is well equipped. Comprehensive information and guidelines are provided on the university website. The processes to handle integrity issues are in place.

Regarding ethics, there is university-wide ethical policy with different processes depending on the nature of the research (medical or non-medical research). Committees are in place to handle ethical reviews of research projects. For non-medical research, ethical review of research plans are organised in

four domain specific committees including one for computer and information sciences. Complex multidisciplinary research projects, quality assurance and moderation of complaints about domain reviews) are handled by a UT-wide committee. The faculty of EEMCS is responsible for the domain-specific Ethics Committee Computer & Information Sciences (EC-CIS). This committee advises on ethical issues related to research projects involving human participants, personal data, AI technology, cybersecurity, and dual-use. A web page describes the procedure to be followed. This committee has started to develop materials to train staff and students as the number of reviews has increased a lot during the evaluation period. Some staff members are involved in ethical committees, not only at UT but also for instance, as a member of the Ethical Advisory Board of the Human Brain Project.

8.7.2 Human resources policy

A concern is that the department has several vacancies for research staff positions and suffers from its geographical location and from the competitive offers in Germany. The CS department should consider offering welcome packages and more generally should find the right balance between hiring new assistant professors and supporting the existing ones.

The department pays attention to diversity in all committees and HR has recently started an onboarding programme. Some staff members have a very active role, also in the IPN working group on Equity Diversity and Inclusion, and the Ambassadors Network of the UT.

Gender balance remains to be improved. Indeed, female researchers represent 19% of the full professors, 13% of the associate professors, and 29% of the assistant professors. The CS department has not yet reached the target set by the EEMCS faculty to be attained by 2025 (20%, 20%, 35% for respectively full, associate, and assistant professors). The committee observed a recent improvement of the gender balance in the postdoc and PhD student population. Almost 30% of the PhD candidates are female candidates. While the CS department seems to nurture its female research staff (e.g., three female researchers were recently promoted to associate professor), there was apparently no clear strategy during the evaluation period to recruit more women. A women-first strategy is under investigation for research staff member recruitment.

60% of the postdoc and PhD students are international. The number of international research staff members is increasing, especially at the assistant professor level.

The CS department makes use of the university Strategic Business Development (SBD) organisation providing support for the entire chain of the funding acquisition process. It provides support for research data management (open science) and for grant applications (EU and research grants). However, during the online visit, the committee got the impression that the newly recruited research staff was not fully aware of the services and support provided by the university. The department management team could better inform them of the support they can get to write proposals and even more importantly it should establish a department-wide strategy in terms of research proposal submissions. The committee had the feeling from its discussion with assistant professors that they were under pressure to acquire funds while the management team told the committee that researchers often join forces to submit proposals. Clear guidelines should be provided to junior research staff members, who should not spend the majority of their research time in writing proposals and should get support at the department level.

There is an annual performance appraisal for evaluating the potential and performance of each employee. Chairholders in CS discuss together about staff performance and potential. Chairholders in CS discuss together about staff performance and potential. The 9grid tool is used to manage talents and is used in the preparation of the annual appraisal. For the recruitment process a game-based evaluation

tool is being experimented with to aid in the selection. Mixed feelings about the benefits of using the game-based assessment tool in the recruitment process appeared during the discussions the committee had with the management team during the online visit. The tool is mostly a guiding tool providing indications on aspects requiring special attention after recruitment but in no way an instructive instrument.

The department is open to a wide range of talents. It is possible for a staff member to grow as associate or full professor with an emphasis on teaching.

Junior staff members seem to have a clear understanding of the promotion criteria. However, it appears to be unclear to junior staff not on tenure-track when they should trigger the discussion about entering in the process to move to the next level.

8.8 Conclusions and recommendations

8.8.1 Conclusion

During the review period, several staff members left (for retirement or to the next step in their career) while several junior staff members were hired. Although this has presented challenges, high quality research is still present. However, the committee has some concerns.

The committee is concerned about the small number of PhD theses defended during the period and the high drop-out rate. The low number of PhD students and high teaching load may impact the quality of the research in the coming period. The committee is also worried about the work pressure in the department resulting at least partially from a very high teaching load.

The department is well connected to the socio-economic world through collaborative projects, institutes in which researchers and industrial partners can work together on multidisciplinary projects. However, while the department is highly visible in the European Research Area being involved or coordinating a number of European projects, the funding situation is unhealthy with a decreasing amount of both second and third streams funding.

8.8.2 Recommendations

The committee makes the following recommendations for further improvements in the future:

- The CS department should devise and implement a global plan to alleviate the teaching load of its assistant professors in order to reach a better balance between the time devoted to research and the time devoted to educational tasks (both teaching and administrative tasks). This is essential to sustain high quality research and keep the work pressure reasonable. The department should consider capping the number of students;
- The committee recommends defining a publication strategy for the department and making it known to all department members so that the 100% open access publications can be reached in the delay set by the UT;
- The committee recommends defining a department-wide strategy to increase the second and third streams funding while ensuring that junior staff can spend enough time on their research activities rather than spending a large amount of time writing proposals;
- The committee recommends increasing the support staff for technological developments and key software maintenance;
- The committee encourages the management team to explore ways to fund cross-border collaborations, in particular with Germany.

9. Informatics Institute, University of Amsterdam

9.1 Organisation, strategy and targets

UvA's Informatics Institute (IvI) mission remains to perform curiosity-driven and use-inspired fundamental research. Its vision encapsulates three main driving forces behind its research: 1) *create impact from concept to application*, 2) *create high quality by setting high standards, and 3*) *create contact by being inspired in society.*

The Institute resides at the Faculty of Science (FNWI). The research is organised around four research themes: Artificial Intelligence, Computational Science, Data Science, and Systems and Networking. The staff is organised in sixteen research groups. IvI researchers work across these themes on transversal topics such as Trust and Bias, Health, Sustainability, Social Systems, etc.

The key values in IvI governance are transparency, inclusiveness, service driven, and consensus-based decision making. The institute is ambitious and aims to be a core member at the national level as well as in European excellence networks.

With respect to collaboration with industry both the COMMIT and the Innovation Center for Artificial Intelligence (ICAI) initiative have played an important role in promoting public-private research funding.

Despite the fact that a formal merger with the VU was not consolidated, the two universities still have strong ties, and together they make a solid Amsterdam eco system for computer science. The priorities of which profiles to hire are complementary. During the assessment period, IvI has experienced significant growth, and was able to recruit some twenty tenure-track assistant professors, and four full professors. There is collaboration at research level as well as at the education level in three big areas: health, business, and sustainability.

IvI has also many internal collaborations, and has started new collaborations with the Institute for Language, Logic and Computation (ILLC) and other units, which look promising.

9.2 Research quality

The institute aims to deliver high quality impactful research leading to excellent publications, software, and datasets. In line with the computer science field, the majority of the publications are conference contributions. The number of journal contributions is also significant and accounts for roughly 40% of the total production during the review period. Overall, the scientific output of IvI is very high and increasing in terms of volume. The high quality of the research is demonstrated by the attention these publications have received (citations) and by the venues in which these publications appeared. The self-evaluation report highlights a number of publications that have appeared in top journals and venues. Along with publications, IvI has made several software products that had a large impact on the communities.

IvI has also been successful in attracting funding via both individual and consortia grants at the National and European level. Two ERC starting grants were obtained in the evaluation period, as well as one VICI and two VIDI grants. IvI also played a major role in the *Zwaartekracht* (Gravitation) project on Hybrid Intelligence. In the past five years, there has been a significant shift towards direct collaboration and funding (i.e., ICAI and IAS). This complimentary funding source enables research that involves direct co-creation with private and public partners. Other grants of note include the QUVA lab which has recently

been renewed for a further 5 years and served as the inspiration for the ICAI labs, of which there are 50 in The Netherlands (end 2021).

Quite some staff members also received international awards or other tokens of recognition (leading role at editorial boards of journals and conferences), and have been recognised as being influential.

9.3 Societal relevance

The institute has launched several societal relevant initiatives addressing both commercial sectors and public sectors. The Institute is very visible in the Dutch academic computer science landscape with highly valued initiatives, and plays a crucial role in different networks of excellence and strategic alliances (see also viability).

The work at the department seems particularly strong in terms of the diversity of aspects of relevance. For example, IvI is active in media (informing general public, debates, etc.), has contributed computational models to tackle segregation in primary schools, and collaborations with the Dutch police to organise interventions. Not only staff but also the students are participating in outreach activities. The Dutch Nao Team is a robot soccer team, which is fully run by students. They have travelled throughout the Netherlands and abroad to showcase their robots and to play robot soccer games. They also participated in a television program for children '*De proefkeuken'.*

The institute encourages entrepreneurship, by providing guidelines and constraints. The collaboration with industry is well organised and monitored. Clear agreements on IP and the rights to publish have been laid out. Some staff members have a double appointment in the university and industry. In these situations, clear rules with checks and balances apply.

ICAI plays an important role with respect to economic impact and has become the flagship of public-private partnership and funding. It has raised a multi-million Euro budget from private corporations that wish to fund research activities. At the same time ICAI has developed a set of policies that ensure academic integrity and freedom, knowledge transfer between academia and industry, shared output in terms of patents, and opportunities to spin out. The relevance of the research is also demonstrated by the high number of patents and high number of start-ups. IvI in collaboration with Amsterdam Center for Entrepreneurship (ACE), Innovation Exchange Amsterdam (IXA), and Innovation Center for Artificial Intelligence (ICAI), has made an effort to boost up the foundation of IvI spin-offs. In particular, IvI through ICAI is setting up a fund for supporting spin-off companies through a new Venture Capitalist (VC).

9.4 Viability

During the review period, IvI has been successful in acquiring funding from a variety of different national and international sources, including 3.7M euros in research grants and 7M euros in contract research (in 2020). As the later source of funding is relatively high, attention needs to be paid to the sustainability of this income.

IvI has taken a leading role in obtaining national and international funding and it plays a crucial role in different networks of excellence (e.g., ELLIS). The institute has created many strategic alliances including public-public (e.g., Netherlands Cancer Institute, City of Amsterdam, and Rijksmuseum) and public-private collaborations (e.g., ICAI collaboration with e.g., TomTom, Ahold Delhaize, Bosch, Elsevier, Booking.com, and Qualcomm).

The national role of the institute resulted in strong interdisciplinary scientific collaborations via, e.g, the Institute for Advanced Studies (IAS), Amsterdam Data Science (ADS), Amsterdam Data Exchange (AMDEX), Amsterdam Security (AMSsec), and the AI4Science lab. In the next period IvI aims to prioritise new fields, such as AI&Fintech and Quantum Computing. Attention is paid to the fact that the expertise of the institute is not only considered to be a service to other disciplines, but the collaboration should also lead to novel challenges for the IvI team. The institute is also investing in the creation of a full position for an interdisciplinary professor in AI, who should be initially positioned to acquire funding in interdisciplinary AI calls including NWO funding. This profile seems an ambitious plan, which is maybe not entirely feasible.

With the new offices the research facilities of IvI have been improved; the new LAB-42 building will provide more cohesive spaces for the staff and students, and will further enhance synergies between the four research themes.

9.5 PhD policy and programme

The PhD candidates the committee met appeared well embedded into their research groups. Their education, training and supervision is described in a Training and Supervision Plan (TSP). Education and training include transferable skills as well as research-related activities.

PhD candidates typically have two supervisors: one of them is the promoter, the other one is typically the daily supervisor. They tend to have regular, often weekly or biweekly, meetings with their supervisor, but are encouraged to ask for help according to their needs. The committee is of the opinion that biweekly meetings with supervisors might not give the best supervision, and therefore recommends ensuring such meetings are scheduled weekly.

The performance of the PhD candidate is evaluated in fixed intervals (at months 9, 24, and 36 of the PhD trajectory) by the supervisors. After the first 14 months, PhD candidates are evaluated by an institute wide committee of three staff members (not part of the PhD candidate's research group) to create an independent view of their research and progress. At this stage, a formal decision to discontinue the PhD project can be made if needed, taking the advice from the 14-months evaluation committee into account.

The transferable skills section of the TSP includes mandatory courses like Scientific Integrity or Dissertation Procedure. The committee considers the latter mandatory course an interesting approach to prepare doctoral candidates for the final steps in their PhD track. Additionally, PhD candidates can also choose career development, writing or other courses.

The TSP also describes research-related activities. Usually, PhD candidates follow courses from the national Research Schools ASCI, IPA and SIKS, in which they typically are also enrolled. But it is also possible to attend international summer schools. PhD candidates are also actively involved in teaching, either by supervising BSc or MSc students, or by helping as a teaching assistant.

PhD candidates are expected to publish four papers during their PhD track. From conversations, the committee gathered that the implementation of this guideline appears to be rather supervisor dependent. Therefore, the committee recommends relaxing this guideline to four significant scientific contributions, i.e., four chapters in the thesis.

Of the PhD candidates who started during or after 2012 and have since graduated, 50% obtained the PhD within the nominal duration and 74% within a period of 5 years. These numbers reflect a substantial improvement in success rate in comparison to the previous research assessment. As described in the self-evaluation report, there remains a challenge in the sense that there still is a

substantial number of PhD candidates who take 6 or more years to graduate, if they do at all (the overall dropout rate is around 15%). The committee encourages the management to closely monitor the success rate and investigate the reasons for delay and dropout.

From conversations with PhD candidates, it appeared that IvI could improve its collaboration across groups. Furthermore, IvI should also ensure that new PhD candidates feel included, know their colleagues, and know where/whom to ask for help (e.g., by appointing a fellow PhD candidate as mentor).

9.6 Open science

The institute is committed to making research data FAIR, i.e., findable, accessible, interoperable, and reusable. IvI is committed to open publications, with the vast majority of published work freely available either published in open access journals, or paying an open access license, or in most cases made available in ArXiV, self-archive, or archived by the UvA.

The institute has its own research data management (RDM) policy that describes how and when scientific data should be shared and used. This complements the policy at the university level. Currently, IvI is in the process of making the plan for data management more operational, for example working with data stewards.

9.7 Working environment and personnel policies

9.7.1 Academic culture

Measures have been taken regarding promoting good academic culture. As described in the self-evaluation report, IvI is raising public and political awareness and trust in science and its achievements by enforcing academic integrity protocols and the Dutch scientific code of conduct for research integrity, by ensuring transparency in their collaborations, by implementing policies of data sharing and knowledge transfer, and by making use of numerous communication channels to inform the public. There is a Faculty Ethics Committee (FEC) that provides advice on ethical questions connected to research proposals, which is especially relevant for research in areas such as cyber security and AI that may concern privacy related issues.

IvI aims to form an open community in which all members are seen and heard and feel at home. Peer support is provided, and staff are coached.

9.7.2 Human resources policy

The institute provides a start-up package to new scientific staff which includes funding for at least one PhD candidate. New staff also have zero workload in administration tasks and a reduced teaching load for the first year. Tenure track staff are assigned a mentor from a different group so that potential issues can be discussed more openly. The requirements for tenure track are perceived to be feasible and clearly defined, there is room for some personal focus. The procedure for promotion to full professor is documented, and the initiative is up to the candidate. A career plan is made and signed, and monitored by a committee. After 3 years, there is a midterm evaluation, and after maximum 5 years the candidate gets promoted if the agreements are met.

Due to the huge increase of students the workload has significantly increased. This might have an impact on the quality of the work. Especially the junior staff seems to be concerned with the workload and getting too demanding tasks to complete. The institute is, however, hiring lectures to alleviate some of the work. When personal grants are awarded, candidates are allowed to reduce the administration load so that they can better focus on their research in order to develop themselves into the scientific leaders of the future. The number of PhD candidates and master students the staff are supervising varies a lot, from 1 or 2 PhD students, to 6 or 7, and from 1 up to 20 master students.

There are two alternative paths to tenure ship, one for junior and one for senior level tenure-trackers which enable the Institute to acquire talent at different levels of seniority. The former path has been installed because attracting sufficient talent has become hard, and it is especially appealing to promising internal postdocs. During the interviews, several concerns were raised about the transparency of the different tenure track paths.

As described in the self-evaluation report, IvI aims to be an equal opportunity employer that actively develops and implements policies to improve diversity in all respects, attracting and supporting staff from underrepresented backgrounds and groups. IvI aims to form an open community in which all members are seen and heard and feel at home. The targets for gender balance are currently far from met despites the efforts. There is active scouting of women for open positions, and attention is given to unconscious-bias. The institute participates in the McGillavry fellowship programme, which is a faculty-wide initiative that periodically offers a number of tenure track positions across the faculty for women only. To improve the gender balance, IvI will also start identifying female talents in the bachelor programme, to motivate them pursuing an academic career.

9.8 Conclusions and recommendations

9.8.1 Conclusion

IvI has a strong reputation, nationally as well as internationally. The institute delivers high quality impactful research leading to excellent publications, software, and datasets. The institute has very strong industrial collaborations, as well as extensive public-public and public-private partnerships like those facilitated by ICAI. The institute has grown significantly over the past years, this growth is due to an increasing number of students, but even more due to an increase in projects in collaboration with industry. This growth has been well managed. Overall, the procedures are well organised and documented. Measures to support the staff have been taken. The workload is however still high. Especially junior staff perceives the job as very demanding, with a lot of balls to handle, and hard to keep a healthy work-life balance.

9.8.2 Recommendations

The committee makes the following recommendations for further improvements:

- Carefully monitor the different money streams, and try to get more funding to fulfil the duties for education, as the teaching load is high, and the income through collaboration with industry;
- Make sure the expectations for the different tenure track paths are transparently communicated;
- Monitor the number of PhD and master students the staff are supervising and look for a healthy balance;

- Explore increasing teaching staff, to reduce the workload. More personnel seems to be needed for supervising the increasing number of MSc theses. A possible approach is to employ more additional supervisors from the industry. Organising more mentoring events for the new staff could be helpful, too, to mitigate problems of increased workload;
- The changes in IvI due to growth have been substantial and a challenge to the personnel to cope with. Measures for analysing the challenges in detail and mitigating them accordingly are recommended. Try first to consolidate initiatives taken, before making further changes;
- During the interviews the personnel expressed the need for more collaboration between the different research groups in IvI. More networking events between the groups could be helpful here;
- Continuing the close collaborations between UvA and VU in the Amsterdam area in order to coordinate mutual research and education and to avoid unnecessary competition of students and staff in the hot CS market;
- As for the gender balance, there is an increase from 10% to 15% of the female staff from 2015 to 2020, but more measures are needed.

10. Department of Computer Science, Vrije Universiteit Amsterdam

10.1 Organisation, strategy and targets

The Department of Computer Science of the Vrije Universiteit Amsterdam (CSVU) consists of twelve research groups collaborating on six research themes:

- Artificial Intelligence;
- Bioinformatics;
- Computer Systems;
- User-Centric Data Science;
- Software and Sustainability;
- Theoretical Computer Science.

Three new research groups were added during the assessment period. The total number of fte's of full, associate, and assistant professors has increased by 29% in 2015-2020, from 31.6 to 40.8.

The strategic goals of CSVU have been to:

- Attract top talent;
- Optimise the internal cohesion and strengthen collaboration among research groups;
- Use the strong reputation of CSVU to form networks with key scientific and societal partners;
- Invest in joint infrastructure that stimulates collaborations;
- To achieve high societal relevance of our work.

To achieve these goals, open science principles are employed, PhD education based on local training as well as national research schools is given, and there are active Human Resource policies to improve gender balance, junior staff support in the career development and independent research.

10.2 Research quality

Based on the detailed material provided by CSVU, the quality and scientific relevance of the unit is deemed excellent. As an indication of this, several influential and highly cited publications in esteemed venues are listed. In the self-evaluation report, the department described two publications with more than 250 citations. According to the committee, these publications are examples of large scientific impact.

The department has developed several software systems and datasets, many of which are widely used by peers of the research community. The self-evaluation report lists some key examples, such as a website with a range of tools made available to the bioinformatics community and a collection of open-source security solutions.

Another indication of the high quality of research are the numerous national and international awards that CSVU researchers have received in 2015-2020, for example at prestigious conferences like IEEE Security & Privacy, RAID, RTA, ISWC, and HRI, and the 10 years most influential paper award by IEEE Requirements Engineering. The success of young researchers is evidenced by several ACM SIGOPS best thesis awards.

The number of staff and funding each increased across the six-year review period. The department has had great success in obtaining research grants, some of which are worth millions of euros, such as the NWO Gravitation and NWA ORC InterSect grants. Although the NWO funding is 2.5 times as high as in the previous period, the department has not been as successful in obtaining EU project funding when compared with the previous assessment period 2009-2014. During the online visit, senior staff expressed their wish for improved support for grant proposals, especially for grants in consortia.

The committee is positive about the many large grants from private companies and other sources.

The department has a continuous strong reputation of high-quality research, including both foundational and applied research with valorisation. The work includes multi-disciplinary work in many areas. The committee has noted that this focus has been maintained and developed further to new directions, and new initiatives and networks related to, e.g., AI and medical data science, the Innovation Center for Artificial Intelligence (ICAI), and the Amsterdam Cyber Security Centre (AMsec) have been started.

Two of the strategic goals of the department were to strengthen collaboration among research groups and to form networks with key scientific and societal partners. In the eyes of the committee the department has been very successful in fostering collaborations both within the department (see also 10.7.1) as with other academic partners (see also 10.4).

10.3 Societal relevance

The department considers the making of high-impact research software, the collection and sharing of high-impact data through archives, and the becoming of a recognisable voice in the public debate as important contributions to society. The committee believes that the department has been very successful in this. A particularly strong point of CSVU is that its research covers the whole spectrum from fundamental research to applied research with a clear societal impact. Evidence of this can be found in the media presence not only in the Netherlands but also internationally in Belgium, Germany, and the U.S. The presence has covered newspapers, tech magazines, TV, TEDx talks, museums, and presentations in conferences of related research fields such as health.

In addition to the famous MINIX 3 operating system, running on a billion Intel-based devices around the world, also other new software products (DRAMMER, Triply, etc.) originating from the CSVU research have been deployed.

10.4 Viability

In terms of its future orientation and viability, the department stresses that it aims to consolidate an inspiring environment for all staff at the department, where a positive atmosphere and trust will foster creativity and high-quality output in research, teaching, and valorisation. According to the committee, the department has good cause for optimism. Funding seems stable, research production is high and competent, and societal relevance is obvious.

A major drawback of CSVU, according to experiences of the research staff, has been the annulation of the co-location and integration with the Informatics Institute (IvI) of the University of Amsterdam (UvA). However, this has not affected very seriously on the grass root level collaborations between the researchers. The Sectorplan 2019-2025, the new Hybrid Intelligence center, and the NWO program on Efficient Deep Learning, may be helpful in aligning the research agendas in overlapping areas, such as

health, AI, and Data Science, between the two major CS units in the Amsterdam area, and to avoid unnecessary competition and redundancy of research.

New planned research fields of CSVU, supported by new professor-level staff, include Quantitative Data Analytics, Assessing and Evaluating Security, Ethical Computing, Energy-efficient Computing, and Hybrid Intelligence. The new funding acquired for these should be helpful in aligning the research agendas between the CS departments in different universities. Areas that require consideration include AI and Data Science as lots of funding from different kinds of sources are now available for this rapidly emerging area in universities, companies, and public organisations. A concern for the future here is whether enough resources will be available for fundamental research where the role of the universities is particularly strong.

There has been a substantial improvement in research facilities when the department moved into a new building. In addition, there have been substantial investments in the research infrastructures.

Although the work of CSVU is deemed central from the faculty point of view, the rigid university demand for spending all annual surplus during the same fiscal year is harmful as it easily leads to overspending and hinders flexible longer-term development of the department.

10.5 PhD policy and programme

There seems to be a well-developed PhD programme in use. The new policy to demand 30 EC formal studies to be accomplished by the PhD candidate seems good as it gives the PhD candidate basic skills needed for their research work, accomplishing their thesis, and also helps in community building between the PhD candidates. PhD students are also encouraged to follow courses of the national Research Schools ASCI, BioSB, IPA and SIKS.

Typically, doctoral candidates receive job guidance from their supervisors, but can also follow career development courses as well as meetups such as Amsterdam Data Science.

Based on the interviews during the assessment, the PhD programme at CSVU seems to work well in general. However, a challenge not solved yet is that many PhD candidates need a longer time for graduating than the expected four years. There is a monitoring system for PhD candidates in order to evaluate the quality of the PhD programme but getting the data is still a challenge.

From conversations with PhD candidates, the committee gathered that administrative tasks (e.g., recording credit points) and information flow to new-comers appeared to be cumbersome. The PhD candidates the committee spoke to, appeared aware of Open Science practices.

10.6 Open science

According to the committee, open science aspects have been taken seriously and addressed actively in CSVU. To reach a wider audience, the department increasingly aims to publish articles in an open access format. In addition, the department supports researchers in practicing open science by enabling them to work according to the FAIR principles for data and in a way that adheres to the GDPR (General Data Protection Regulation).

10.7 Working environment and personnel policies

10.7.1 Academic culture

The organisational structure of CSVU has been based on traditional research groups led by full professors. The committee liked the new idea of setting up a thematic horizontal cluster-based organisation, in addition to the vertical research groups, where researchers are free to join the clusters as they like. This policy has the potential for fertilising multidisciplinary research and collaborations across research groups in the rapidly growing department. The management team the committee spoke with during the online visit, mentioned that this theme structure works well on a higher level. When the department further grows it might be good to formalise this collaborative structure.

The committee was pleased to hear that many of the researchers interviewed, affirm that they experience a collaborative culture and appreciate the informal atmosphere within the department. The committee advises to not lose this informal culture when the department grows, especially at the lower levels. The committee appreciates the coaching system in which junior staff is mentored by a mentor from another faculty.

More and more students are taken in as the department expands. There is a need in the department for hiring more programmers and people helping the staff in their increasing workloads in research and teaching, e.g., in supervision of students. One possible pool for this could be master students. There are processes for supporting the junior staff in joining the Dutch university community, preparing grant applications, writing data management plans, and budgeting, but it seems that more support and resources for this would be helpful.

10.7.2 Human resources policy

As for the staff, the number of full professors has remained the same during the evaluation period, and the number of associate professors has decreased. The increased funding has been used for hiring new assistant professors. In terms of this staff composition, the career prospects for tenure track promotions do not seem very lucrative, however, the department argues that there is a clear and uniform procedure in place for promotions now.

The starter package for new assistant professors is 50% PhD, which is less than in many other (international) universities. This is a challenge when recruiting staff in the highly competitive CS market.

As for mobility, there has been a substantial renewal of expertise: three full professors (25% out of 12) have left CSVU to other universities and research organisations, in addition to several retired ones. New full professors have been hired for replacement.

The challenges regarding gender balance reported in the previous assessment are still there: in 2015 17% of the staff was female and in in 2020 the research staff consisted of 16% women. However, the department seems to be taking the matter seriously and has been able to attract more female staff after the assessment period 2015-2020. The situation is slightly better regarding postdocs and PhD candidates: 21% of them were female in 2020.

As for diversity, there is a change in hiring more assistant professors from abroad: in 2020, 55% of the staff were from abroad while in 2015 only 36%. As for postdocs and PhD candidates, there is a slight increase to 63% foreigners in 2020 from 54% in 2015.

10.8 Conclusions and recommendations

10.8.1 Conclusion

CSVU has excellent performance regarding research quality and societal relevance. The results in acquiring new funding and in establishing new organisational infrastructures and collaborations with fellow universities as well as with industry and non-governmental organisations (NGO) are promising, indeed. However, on the other hand, this sets new challenges for the future: how to deal with the rapid growth of students, new research areas, collaborations with other universities and partners, challenges in finding staff, dealing with increased teaching load, and sustainability of temporal funding.

10.8.2 Recommendations

The committee makes the following recommendations to address the above issues in the future:

- The committee recommends that the reasons for not being as successful as previously in EU Horizon funding are investigated. Although EU projects may be more bureaucratic and difficult to administer than national projects, they are vital from an international collaboration point of view and can be of substantial size, too;
- Hiring more technicians, programmers, and administrative staff on demand, not only PhDs and postdocs, to help the staff in their research is recommended. Removing administrative obstacles for this may be needed;
- Continue the close collaborations between VU and UvA in the Amsterdam area in order to coordinate mutual research and education and to avoid unnecessary competition of students and staff in the hot CS market;
- Proving more fundamental funds so the department may establish strategic and sustained research focus that is more stable than that of responding to industry challenges;
- As more and more funding, activities, and external collaborations in CSVU are related to the applied side of CS, it would be good to support the fundamental research by, e.g., the university budget funding;
- Correcting the gender balance needs more attention and new ideas, as the situation has not improved in 2015-2020;
- The CSVU is encouraged to negotiate a fairer policy with the university, where the annual surplus made is not automatically returned to the university after the fiscal year, but can be used for longer term development;
- If staff members have money left over at the end of the year, enable them to keep these funds such that they can do their own strategic investments such as supporting PhD students or enabling conference travel;
- Increasing the starter package for new staff is recommended, say to a full PhD student instead of the current 50%. There are lots of funding and projects around to better match the fierce market situation.

11. Utrecht Research Institute of Information and Computing Sciences, Utrecht University

11.1 Organisation, strategy and targets

At the end of the evaluation period this is now a large department in a large university, with a recent hiring of many tenure-track faculty and more than 100 PhD candidates, each student with their own training programme. The research strategy which drives the department has evolved since the last evaluation period moving from a narrow although comprehensive focus on gaming to a more structured organisation into three macro-areas making three large research groups in Algorithms, Interaction and Intelligent Software and these are now firmly established. This was due on the one hand as a response to the previous evaluation concerns and on the other hand to the growth in staffing that allowed to both re-enforce existing expertise and to enlarge the scope of research in the department. Intensive actions to increase inter- and intra-department collaborations were carried out at the university and faculty levels. The mission of the university is to focus on transferring foundational results to applications and that appears to be well implemented in a set of coherent research and management actions.

While the department has research expertise in computer science topics, it also has research expertise in computer science with applications, which points to interdisciplinary work. This positive reaction to the recommendations from the last research review leaves the department with a current focus on some aspects of foundational computer science with support and encouragement for interdisciplinary research, where there are opportunities and interests in doing so in areas like digital humanities and AI in education. This interdisciplinary research is nurtured and encouraged by the department, faculty and the university, but may need future investment.

The large growth of the department within a short timeframe, almost doubling the size of its research staff within the evaluation period, was in response to the opportunity to grow the teaching mission and the challenge now is to keep the correct balance between the teaching and research missions. This also includes having an equitable and fair distribution of the teaching load. The department is now entering a period of consolidation which is necessary to allow the new staff to grow and flourish and to allow them to mature their research interests and outputs.

11.2 Research quality

The quality of research in the department is very good, with at least one division being excellent notably the work in algorithms, as was highlighted in one of the case studies. This work on algorithms and complexity has performed exceptionally well during this evaluation period and the number of top-tier publications is outstanding, in particular the number of publications at the STOC and FOCS conferences. The department can be congratulated on its successful recent recruitment to re-enforce this area, including at ERC level.

The department is well connected nationally and internationally, its funding sources are distributed among National and European sources showing good resilience and spread though there is a desire for greater success in research funding at national level. Research outputs as highlighted in the self-evaluation report are very good in terms of publications and research software/algorithm exploitation. Although the number of research staff almost doubled, external earning capacity seems steady in absolute terms for research grants, however most of the newly-recruited staff are at junior level. For

research contracts, these are growing in number although not significantly relative to the overall budget size. In this respect, the actions taken to increase the awareness and opportunity for external research grants and the support for staff to participate in research funding submissions, are important.

The recent growth has seen a growth in numbers but also diversification into new areas and the landscape of the department has now changed as a result. This growth has presented an opportunity for expansion into new research areas. It also presents a risk that this rapid growth could mask the quality of that research, because it has not yet had enough time to establish itself. It is difficult to assess research quality when there has been so much structural change and the senior leadership in the department do realise this.

11.3 Societal relevance

The department has a strong and ingrained element of collaboration across disciplines and this is present not just in the department itself but across the university. This support for collaboration exists in both formal and informal ways and creates opportunities, especially for new staff, to make an impact with their research, especially a societal impact.

The department has put in place a series of standard actions to highlight how its work has societal relevance though this could be more comprehensive. For example, the PhD-IT programme as a collaboration with public organisations, the work of the diversity committee, the many collaborations within the university both existing and planned/in development and even the valorisation of research work, have all increased during the evaluation period and these could be presented and highlighted more coherently.

11.4 Viability

This is now a large department in a large university as a result of very recent growth in student numbers and its most important work in the near future will be consolidation and integration. As a result, the department needs to maintain a focus on this in its strategic planning as described in its ICS Plan 2020-2023, its decisions on research collaborations, structural changes and research topics.

The future strategy of the department does not allude to any kind of agile shift in research areas as topics of focus if, and as, they emerge. Instead, it seems to be a “steady as she goes”, keep on this track which has just recently been established and this is a natural reaction to assume when in a consolidation phase after a large expansion. Yet the department needs to keep an open eye on emerging trends and not get locked into its own, current, self-defined research topics.

At the present time, the department is well positioned to consolidate and it builds on the building blocks it has recently put in place. As the department is at the start phase of this consolidation there is not much that the committee can assess yet, except to state that the pathway as in the ICS plan for short-term and medium-term development is known and recognised. If the department sticks to that plan it should result in a strong, resilient and successful department which can contribute meaningfully to research in Computer Science in the Dutch landscape. This will require continuing to re-enforce and strengthen the research areas the department has chosen and in parallel to nurture people to collaborate across research groups, across the faculty and across the University. It will also require the development of leadership personnel from within the department in order for this momentum to continue.

11.5 PhD policy and programme

Since 2016, UU made significant changes to their PhD programme. UU introduced a university-wide tracking system for PhDs, ensured PhD supervision by at least two people, (daily) supervisors are now partially compensated (for supervising PhD candidates), created a starting guide for newcomers, introduced a PhD council and a PhD mentor. In addition to the standard PhD track which is externally funded, UU also introduced two new PhD tracks. Both tracks have a longer contract and either a higher teaching load (PhD-TA) or a collaboration with public institutions (PhD-IT). In the PhD-IT track, PhD candidates spend only two days at the university and the remaining time working in the public sector. Unfortunately, the effects of these changes onto success rates are not fully clear yet. For one category of (PhD-TA) the student will take longer to complete and submit but has a higher teaching load than other PhDs. This suits many researchers so the range of PhD categories at the department is to be complimented and it is good to see the range of optional PhD pathways for candidates to follow with none being better or worse than others, they are just different.

The committee cannot yet judge the impact of the PhD-IT track as it is at too early a stage for this. While candidates spend two days at UU and three days per week at a public institution, it cannot be guaranteed that candidates will have sufficient time to conduct research (comparable to the four-year PhD track). While in conversation with candidates, it appeared that their public institutions allowed them to implement their research there, this is not necessarily a given. The committee recommends monitoring the time allocated for research.

Besides the changes, PhD candidates have to fulfil a Training and Supervision Agreement (TSA) with twenty credit points. Four credit points are gained by acquiring general skills, of which the Academic Integrity course is mandatory. The remaining points can be obtained from academic activities, which include research-related courses, e.g., from the national Research Schools ASCI, IPA or SIKS, summer schools; giving presentations at conferences or teaching-related activities.

Doctoral candidates typically have weekly meetings with their day-to-day supervisor. Yearly, candidates undergo an evaluation by their supervisors, whereas their first evaluation is used to make a go/no-go decision on progression of their PhD. However, there are not yet enough meetings between and among PhD candidates across the research groups, and this is a missed opportunity for identifying potential collaborations.

Teaching tends to be mandatory for PhD candidates. The teaching load of PhDs the committee interviewed is significant, especially for candidates in their earlier years of their PhD trajectory. The committee noted that PhD candidates at the institute have a lot of teaching responsibilities. In particular, they were assigned to teach full courses for BSc/MSc students, and on one occasion this was at short notice, all due to the recent growth in CS students (and CS-related courses). In the opinion of the committee, this needs to become normalised and better managed. Despite the high teaching responsibilities, 40% of PhD candidates graduate within four years and three months, and 48% within 5 years. It has to be noted that only 11% dropped out of the PhD programme which is an acceptable amount.

11.6 Open science

There is a good overall mission and strategic aims when it comes to open science for the department and for the university as a whole but on the ground, there is more varied update and embracing of this. It appears that the stated policy exists and is informed by FAIR data management and open-source software, but it is not enforced or perhaps even monitored regularly. In this area the university has a

recognised leadership role such as having, and encouraging the use of, its own open access repository and providing other support mechanisms to facilitate open access deposition.

Approximately half of the published papers from the department are available on open access on either or both the university's own repository or other publicly available ones, or both. According to the committee this is a good ratio, but the department should not rest on this and should encourage current and future scientific outputs to be made openly available where constraints such as confidentiality or intellectual property restrictions do not prevent.

At the present time it appears that the momentum for making research outputs publicly available is left to individuals rather than being systematic or institutionalised. The department might also consider ways to regularise this, perhaps to incentivise it by recognition of achievements where researchers have made the outputs of their work openly available.

11.7 Working environment and personnel policies

11.7.1 Academic culture

The department can be rightly proud of how it has managed the huge growth within the evaluation period in terms of onboarding of new research staff and welcoming and integrating them at departmental, faculty and university levels. The threat that including such a large number of new staff might have on disorienting or destabilising the department seems to have been mitigated and managed well.

The onboarding experience of new staff, especially at junior level, has been very positive and new staff have been made to feel welcome and integral quite quickly. For example, one of the ways the academic culture in the department is revealed is in the support given to junior researchers with their grant proposal writing by the more senior and experienced staff, even if this happens informally. Every junior staff member has a senior mentor and this collegiality is part of the department's academic culture. It is recognised that as a consequence of the recent growth, supporting the more junior staff is an imperative and covers their embedding, onboarding, and integration. This is more important for junior than for senior staff.

The department has taken on several new initiatives to improve the academic environment during this period of rapid growth based on proactively engaging with all members of the department. This has seen the adoption of a mixed top-down and bottom-up approach to many aspects of its operation, with input from all levels, including the PhD candidate level, sought on major issues. For example, the department now has a research support officer whose role is to assist with the development of research proposal submissions and this is appreciated by all staff levels, especially the more inexperienced junior staff.

There is a culture of being part of the department in areas such as the future areas for expansion and recruitment. One area where this could be improved is in the distribution of teaching load, which is inevitably stressful in recent times as a result of the large increase in student numbers to be taught, and the increased difficulties of remote teaching during a pandemic. The department should re-examine the model it uses for how the teaching load is assigned and take inputs from across the department as it does this.

11.7.2 Human resources policy

The department has defined and detailed a set of actions to include the underrepresented within the academic environment and within its social life. For example, it has an active diversity committee which brings in input from across the researchers and whose actions are broadly felt and well received. Diversity in the form of gender diversity, is a real strength in this department and is well done. Other aspects of diversity besides gender, e.g., nationality and ethnicity are also well represented in the department. The effort and organisation that the department puts into this is almost a model for others to follow. The department has also joined the initiative of the science-geo ethic review board and encourages its use.

These activities and others present the department as a welcoming, caring, embracing and open place to work thus making it attractive for those who work there and for those who would like to join. The department makes an effort to effectively support researchers along their career paths and is to be complimented on this.

11.8 Conclusions and recommendations

11.8.1 Conclusion

After such a short period of rapid growth, the department is entering a period of consolidation, integrating new researchers and reaffirming its research directions and strengths. That makes assessing the quality of its research a difficult task because it is still a work in progress so the judgement which the panel can make and in which it has most confidence is to continue on its current pathway.

11.8.2 Recommendations

The committee makes the following recommendations for further improvements in the future:

- The department needs to maintain its focus on the short-term aim of consolidation and integration of new research staff who have joined the department recently;
- Teaching loads are an issue, especially for some categories of PhD candidates which were perhaps a necessary action as a stopgap to react to the large increase in student numbers, but this needs to be addressed and regularised so that PhD candidates and their research does not suffer. The department should re-examine the model it uses for the assignment of teaching and related responsibilities in light of the increased demand from its teaching mission arising from its recent growth;
- Funding for interdisciplinary research often falls between different stools and the department may need to invest in this explicitly if it is to fulfil its aim of encouraging this;
- The department needs to keep an open brief on emerging research areas and not get locked into its current topics which would be a natural reaction after a phase of growth and while consolidating after that growth;
- The department should encourage the open availability of all forms of research outputs and seek to improve its current ratio, and consider recognition of this as one of its incentives. It should do this by making open access more systematic throughout the research groups rather than depending on individuals to do so.

12 Research Schools

12.1 General remarks

PhD education in computer science is of high quality in the Netherlands. The three national research schools, ASCI, IPA and SIKS, offer specialised advanced courses in computer science and provide a welcome part of PhD education in this research area. Moreover, the research schools enable students to network with fellow students and staff from other universities in the Netherlands.

When the research schools were founded 25 years ago, the distribution of the topics over the three schools was well thought-out. Since then, however, much has changed in the rapidly evolving field of computer science. At present, several parts of computer science are distributed over the different schools, and some research groups are not part of any of the three schools.

The previous review committee suggested that the three schools should meet regularly. This suggestion was taken seriously, leading to more collaborations, including the cooperation in the ICT.Open conference and "ICT with industry" workshops, and formal agreements among the three research schools enabling students from one to register in the courses of another school. The committee welcomes this increased communication between the schools. For areas that are represented in more than one research school, it may be advantageous to collaborate with other relevant organisations, such as ACCSS (security), VERSEN (software), DSPN (data sciences) and SGAI or BNVKI (artificial intelligence), in order to come to an integrated course offering across the research schools.

12.2 Advanced School for Computing and Imaging

The main mission of the Advanced School for Computing and Imaging (ASCI) is to provide specialised courses on PhD level in the broad area of design, implementation, and application of advanced computer systems and computer imaging systems. New focus areas that were added in the assessment period are deep learning, edge computing, heterogeneous computing, cybersecurity, quantum computing, blockchain, explainable AI for vision analytics, visual active learning, and 3D scene analysis.

ASCI organises multi-day courses at special locations outside universities in order to stimulate interaction and foster social contacts among participants. Reasonable measurements for quality assurance of the courses are in place.

Prior to the pandemic, course attendance was stable. The course programme consists of about eight courses, with three discontinued and one newly added course in the reporting period (and ideas for four new courses laid out as future plans). Over a period of six years and in the context of a rapidly evolving research field, the committee would have expected more adjustments. Moreover, the committee recommends striving for a better balance between courses offered in the two fields of computer systems and computer imaging.

In addition to its course programme, ASCI provides financial support for participation in some conferences in relevant fields (such as the NCCV conference series) or organises conferences such as the annual CompSys conference. The own annual conference ASCI used to organise for its members has been discontinued, in favour of the ICT.Open conference series to which all three research schools are contributing.

A speciality of ASCI is the DAS supercomputer. The sixth generation of DAS was built in the reporting period with funding from NWO, but long-term funding still could not be secured. DAS is extensively used by ASCI members, in particular by 44 PhD candidates in the reporting period.

During the assessment period, 97 PhD candidates completed ASCI's education programme. The number of accredited PhD theses was in a steady decline from 27 in 2015 to 5 in 2020 but improved to 16 in 2021. The formal requirements to graduate within the ASCI programme seem to be quite strict, as 33 of ASCI PhD candidates graduated without the ASCI certification in the reporting period. The committee recommends lowering some requirements, to limit the loss and increase the number of PhD graduations.

ASCI has comparatively low membership fees, partly thanks to financial support from TU Delft.

The career prospects of ASCI's PhD candidates are excellent. Among ASCI's alumni, about half work in industry and half in academia, both in the Netherlands and abroad.

ASCI has recently revamped its website for increased visibility. ASCI also plans to create an annual PhD thesis prize and to foster collaboration within ASCI to help community building. The committee supports these plans.

12.3 Institute for Programming research and Algorithmics

The mission of the Institute for Programming research and Algorithmics (IPA) is to educate researchers—in particular, PhD candidates—in the field of programming research and algorithmics, with specific focus on: Algorithmics & Complexity, Formal Methods, and Software Technology & Engineering. Secondary goals are networking, community building, stimulating collaboration in strategically chosen research areas, and act as the representative for its research community.

The strategic areas are chosen every five to seven years by the scientific council. During the evaluation period, the topics were: Real World Algorithmics and Models, Cyber Physical Systems, Security, Model-Driven Software Engineering, and Software Analytics. Recently, IPA's management team and board, with input from the IPA member groups, have jointly drafted new interest areas for the period 2021–2026: domain-specific approaches for diverse and omni-present software and data, scalable efficient and reliable software engineering, algorithmic data analysis, software sustainability and software engineering for AI. These themes appear to be very relevant and reflect trends in the international community. The committee appreciates that one of these topics is chosen as the theme for the event(s) organised by the school. Advanced courses are chosen in one of the three research areas of the school and complement the offerings of the local graduate schools.

The school appears in good health with 100 students enrolled per year. They follow the three mandatory courses and attend four events. Quality of the programme is monitored by a quality manager and the PhD council. The outcomes received by the PhD candidates through surveys and interviews provides useful feedback for the teachers and for the IPA management. This structure is adequate to monitor the quality of the IPA activities.

The career prospect for IPA alumni is excellent. Data referring to the period 2015-2020 reported that 40% have a position in academia (ranging from postdoc to associate professor level) and 60% in industry (software engineering, architect, consultant, analyst positions often at senior level). Few are CTO, CEO or freelancer. Many positions are in the Netherlands, including many Dutch universities, and large companies such as Philips, ASML, TomTom. Some graduates return to their country or work abroad (Apple, ETH Zürich, TU Wien, Virginia Tech).

The number of theses published in the IPA dissertation series appear low with respect to the number of PhD candidates, part of it is due to the pandemic and to research groups leaving IPA, and part is because PhD candidates forget to apply for IPA certification. The committee recommends taking action to avoid losing track of this data.

The pandemic has of course produced effects in the last two years. On the positive side, the committee was informed that attendance on online courses was higher. For full day events, where interaction and socialising is a critical component, the school is considering to organise hybrid events to keep both benefits.

The school has experienced a cut of funding that has been compensated thanks to the pandemic and to existent savings. In the longer term this may result in an increase of the fees or a scale down of the activities.

The school is well aware of the challenges ahead, it has provided clear indications of how to restructure the educational offer exploiting the experience matured during the pandemic. It recognises the need and the opportunity of a closer cooperation with the other schools and other sectorial initiatives.

12.4 Netherlands Research School for Information and Knowledge Systems

The Netherlands Research School for Information and Knowledge Systems (SIKS) covers the fields of Artificial Intelligence, Databases & Information Systems and Software Engineering. Its research areas are knowledge representation and reasoning, machine learning, multi-agent systems, natural language processing, human machine interaction, data management, storage and retrieval, process mining / business process management, and information systems, which were extended by human-centred AI and data science during the reporting period. SIKS is not restricted to studying computing machinery, but also considers its use by humans and organisations. Therefore, SIKS incorporates many PhD candidates in the social sciences and the humanities (predominantly in computational linguistics or natural language processing), which is a unique feature compared to other research schools.

SIKS organises a broad spectrum of activities: courses, master classes, seminars, research colloquia, doctoral consortia and lectures/tutorials given by visiting professors from abroad or senior staff members. This allows to address the heterogeneous background of SIKS PhD candidates by offering broader as well as more specialised courses. These activities are adequate to fulfil SIKS' main missions. The attractiveness of this programme is indicated by courses being nearly always overbooked.

SIKS offers about eight courses regularly. Reacting to recent trends, the new courses Explainable AI and Social AI were added in the reporting period. These courses are held in a conference centre. Despite the overburdened lecturers at many Dutch universities, SIKS easily finds lecturers, which shows its importance and relevance in the research landscape.

In addition to the course programme, SIKS (co-)organises scientific events such as 4TU.NIRICT, and annual SIKS days. SIKS also cooperates with top conferences that are organised in the Netherlands, allowing SIKS PhD candidates to participate in tutorial programmes, workshops, or doctoral consortia for free. Moreover, SIKS provides financial support for participation in some conferences in relevant fields. This range of activities enriches the course programme and contributes to the fulfilment of SIKS' mission.

The number of PhD defenses within SIKS is steady, with 30-50 defenses per year and 236 defenses in total in the reporting period. Each PhD candidate entering the school must provide SIKS with a detailed supervision and teaching programme. In addition to the PhD candidates, about 400 research fellows are associated with SIKS. This shows that SIKS has become very large in terms of membership as well as scope, which may raise scalability issues in terms of management and balance issues among the three research schools SIKS, ASIC and IPA.

The career prospects of SIKS PhD candidates are excellent as many of SIKS graduates have already accepted a new position long before the public defense of their thesis, and unemployment is virtually non-existent. The majority take jobs in industry both in the Netherlands and abroad.

The PhD students' yearly fee of 630 euros is comparatively high. Partially, this is justified as it provides access to all of SIKS' activities for free (accommodation included). All paying members have recently continued their support, indicating the importance of the research school.

SIKS is planning new courses in the two newly added research areas. The committee recommends creating an annual thesis award as it exists in other research schools.

Appendix A - Programme of the visit

Sunday January 23

Time	Part
16.30 - 18.00	Committee meeting

Monday January 24

Time	Part
08.30 - 09.00	preparation programme TU/e
09.00 - 09.45	management
09.45 - 10.00	break
10.00- 10.30	PhD candidates
10.30 - 11.05	senior staff
11.05 - 11.15	break
11.15 - 11.50	junior staff
11.50 - 12.15	preparing questions for 2nd meeting management
12.15 - 12.35	2nd meeting management (additional questions)
12.35 - 13.45	lunch and reflecting programme TU/e
14.00 - 14.30	preparation programme OU
14.30 - 15.15	management
15.15 - 15.30	break
15.30 - 16.00	PhD candidates
16.00 - 16.35	senior staff
16.35 - 16.45	break
16.45 - 17.20	junior staff
17.20 - 17.45	preparing questions for 2nd meeting management
17.45 - 18.05	2nd meeting management (additional questions)
18.05 - 18.30	reflecting programme OU

Tuesday January 25

Time	Part
08.30 - 09.00	preparation programme UL
09.00 - 09.45	management
09.45 - 10.00	break
10.00- 10.30	PhD candidates
10.30 - 11.05	senior staff
11.05 - 11.15	break
11.15 - 11.50	junior staff
11.50 - 12.15	preparing questions for 2nd meeting management

12.15 - 12.35	2nd meeting management (additional questions)
12.35 - 13.45	lunch and reflecting programme UL
14.00 - 14.30	preparation programme UM
14.30 - 15.15	management
15.15 - 15.30	break
15.30 - 16.00	PhD candidates
16.00 - 16.35	senior staff
16.35 - 16.45	break
16.45 - 17.20	junior staff
17.20 - 17.45	preparing questions for 2nd meeting management
17.45 - 18.05	2nd meeting management (additional questions)
18.05 - 18.30	reflecting programme UM

Wednesday January 26

Time	Part
08.30 - 09.00	preparation programme RU
09.00 - 09.45	management
09.45 - 10.00	break
10.00- 10.30	PhD candidates
10.30 - 11.05	senior staff
11.05 - 11.15	break
11.15 - 11.50	junior staff
11.50 - 12.15	preparing questions for 2nd meeting management
12.15 - 12.35	2nd meeting management (additional questions)
12.35 - 13.45	lunch and reflecting programme RU
14.00 - 14.30	preparation programme UT
14.30 - 15.15	management
15.15 - 15.30	break
15.30 - 16.00	PhD candidates
16.00 - 16.35	senior staff
16.35 - 16.45	break
16.45 - 17.20	junior staff
17.20 - 17.45	preparing questions for 2nd meeting management
17.45 - 18.05	2nd meeting management (additional questions)
18.05 - 18.30	reflecting programme UT

Thursday January 27

Time	Part
08.30 - 09.00	preparation programme UvA
09.00 - 09.45	management
09.45 - 10.00	break

10.00- 10.30	PhD candidates
10.30 - 11.05	senior staff
11.05 - 11.15	break
11.15 - 11.50	junior staff
11.50 - 12.15	preparing questions for 2nd meeting management
12.15 - 12.35	2nd meeting management (additional questions)
12.35 - 13.45	lunch and reflecting programme UvA
14.00 - 14.30	preparation programme VU
14.30 - 15.15	management
15.15 - 15.30	break
15.30 - 16.00	PhD candidates
16.00 - 16.35	senior staff
16.35 - 16.45	break
16.45 - 17.20	junior staff
17.20 - 17.45	preparing questions for 2nd meeting management
17.45 - 18.05	2nd meeting management (additional questions)
18.05 - 18.30	reflecting programme VU

Friday January 28

Time	Part
08.30 - 09.00	preparation programme UU
09.00 - 09.45	management
09.45 - 10.00	break
10.00- 10.30	PhD candidates
10.30 - 11.05	senior staff
11.05 - 11.15	break
11.15 - 11.50	junior staff
11.50 - 12.15	preparing questions for 2nd meeting management
12.15 - 12.35	2nd meeting management (additional questions)
12.35 - 13.45	lunch and reflecting programme UU
14:00 - 14:30	ASCI (staff and PhD's)
14:40 - 15:10	IPA (staff and PhD's)
15:20 - 15:50	SIKS (Staff and PhD's)

Appendix B- Quantitative data

Subdepartment of Computer Science, Eindhoven University of Technology

Table 1.1 Research staff in # and fte – TU/e

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	8	7.6	9	8.6	9	8.6	10	9.6	11	9.9	14	12.0
associate prof	5	4.7	8	5.4	11	10.0	10	9.8	13	11.2	12	11.2
assistant prof	30	28.3	34	29.7	37	33.3	36	34.9	33	33.0	35	32.0
all prof	**43**	**40.6**	**51**	**43.7**	**57**	**51.9**	**56**	**54.3**	**57**	**54.1**	**61**	**55.2**
PD	10	7.8	10	7.1	10	10.0	9	9.0	9	7.9	16	14.1
PhD	74	63.7	81	65.9	88	77.0	85	79.0	95	81.0	101	92.0
all PD + PhD	**84**	**71.5**	**91**	**73**	**98**	**87.0**	**94**	**88.0**	**105**	**88.9**	**117**	**106.1**

Table 1.2 Funding – TU/e

	2015		2016		2017		2018		2019		2020	
Funding in FTE/%	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*
Direct funding	70.0	48	78.8	54	84.0	52	83.2	52	88.7	55	104.1	54
Research grants	30.8	21	26.5	18	29.0	18	27.3	17	23.7	15	28.1	15
Contract research	33.5	23	31.0	21	36.5	23	36.9	23	35.3	22	42.1	22
Other	12.0	8	10.7	7	11.2	7	12.1	8	13.6	8	17.6	9
Total funding	**146.3**		**146.9**		**160.7**		**159.4**		**161.3**		**191.8**	
Expenditure in M€/%												
Personnel costs	10.1	90	10.9	85	12.3	84	12.9	83	13.7	85	16.1	94
Other costs	1.1	10	1.0	15	2.3	16	2.7	17	2.4	15	1.0	6
Total expenditure	**11.2**		**12.8**		**14.6**		**15.6**		**16.1**		**17.1**	

Table 1.3 PhD completion – TU/e

Enrollment				**Cumulative success rates**											
Starting year				≤ 4 yr + 3 mo		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	8	5	13	5		8		9		9		2		2	
2013	9	2	11	6		10		10		10		0		1	
2014	24	4	28	9		14		17		17		6		5	
2015	18	7	25	8		14		–		14		5		6	
2016	20	2	22	3		–		–		3		14		5	
2017	18	3	21	(2)		–		–		2		17		2	
2018	21	4	25	(1)		–		–		1		20		4	
2019	23	9	32	–		–		–		–		31		1	
2020	14	9	23	–		–		–		–		23		0	
Total															

Department of Computer Science and Department of Information Science, Open University

Table 2.1 Research staff in # and fte – OU

	2015	2016	2017	2018	2019	2020
	fte	fte	fte	fte	fte	fte
full prof	2.80	3.20	3.20	3.20	3.20	2.50
associate prof	2.00	2.00	3.00	4.00	6.60	6.60
assistant prof	15.25	20.65	18.65	24.65	25.90	27.90
all prof	**20.05**	**25.85**	**24.85**	**31.85**	**35.70**	**37.00**
PD	0.40	0.40	3.00	4.00	4.50	5.00
PhD	0.50	0	2.00	2.00	3.50	4.50
all PD + PhD	**0.90**	**0.40**	**5.00**	**6.00**	**8.00**	**9.50**

Table 2.2 Funding – OU

	2015		2016		2017		2018		2019		2020	
Funding	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*
Direct funding	0.567	92.8	0.630	89.7	0.622	70.5	0.562	39.9	0.806	52.4	0.582	45.3
Research grants	0.015	2.5	0.018	2.6	0.161	18.2	0.239	17	0.238	15.5	0.273	21.3
Contract research	0.029	4.8	0.054	7.7	0.100	11.3	0.609	43.2	0.494	32.1	0.430	33.5
Other	-		-		-		-		-		-	
Total funding	**0.611**	**100**	**0.702**	**100**	**0.883**	**100**	**1.410**	**100**	**1.538**	**100**	**1.286**	**100**
Expenditure in	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*
Personnel costs	0.591	96.8	0.696	99.1	0.880	99.6	1.369	97.1	1.507	98	1.267	98.5
Other costs	0.019	3.2	0.006	0.9	0.004	0.4	0.041	2.9	0.030	2.0	0.019	1.5
Total expenditure	**0.611**	**100**	**0.702**	**100**	**0.883**	**100**	**1.410**	**100**	**1.538**	**100**	**1.286**	**100**

Table 2.3 PhD completion – OU, employed PhDs and PhDs with a scholarship

Enrolment				**Cumulative success rates**					
Starting year				≤ 4 yr + 3 mo	≤ 5 yr	≤6 yr	7 years but until 31Dec 2020	Ongoing on dec 31 2020	Discontinued
	M	F	M+F	#	#	#	#	#	#
2012	1	0	1		1			0	0
2013	0	0	0					0	0
2014	1	1	2	1			1	0	0
2015	0	1	1		1			0	0
2016	0	0	0					0	0
2017	1	1	2					2	0
2018	0	0	0					0	0
2019	1	1	2					2	0
2020	1	0	1					1	0
Total	**5**	**4**	**9**	**1**	**2**		**1**	**5**	**0**

The Leiden Institute of Advanced Computer Science (LIACS), Leiden University

Table 3.1 Research staff in # and fte – Leiden University

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	8	3.7	11	6.5	15	8.9	15	8.9	16	8.7	20	11.9
associate prof	7	6.6	8	7.6	7	7	7	7	9	8.8	9	8.6
assistant prof	5	4.4	9	8	16	14.6	19	17.7	28	25.5	30	27.9
all prof	**20**	**14.7**	**28**	**22.1**	**38**	**30.5**	**39**	**33.6**	**53**	**43**	**59**	**48.4**
Postdocs/researcher	7	7	6	6	10	8.9	14	12.6	18	17.3	21	20.3
PhD regular	15	14.5	18	16.8	26	25	35	34	34	33.1	55	54.1
PhD external*	6		6		14		15		19		24	
PhD scholarship**	21	21	29	29	32	32	34	34	36	36	31	31
all PD + PhD	**49**		**59**		**82**		**98**		**107**		**131**	

* External PhD candidates have their own time schedule, it's not feasible to state any number of fte

** PhD candidates on a scholarship all work 1.0 fte

Table 3.2 Funding – Leiden University

	2015		2016		2017		2018		2019		2020	
Funding in K€/%	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*
Direct funding	5.061	88	5.129	85	5.705	81	6.150	78	7.230	71	9.047	73
Research grants NL	320	6	575	10	753	11	1.067	14	1.655	16	1.591	13
Research grants EU	113	2	70	1	69	1	90	1	184	2	502	4
Contract research	136	2	63	1	363	5	454	6	975	10	1.237	10
Other	131	2	173	3	121	2	131	2	82	1	66	1
Research funding	**5.761**	**100**	**6.010**	**100**	**7.011**	**100**	**7.892**	**100**	**10.126**	**100**	**12.443**	**100**
Expenditure in K€/%	4.532	81	4.640	*80*	5.837	85	6.496	84	7.960	81	11.232	90
Personnel costs	1.051	19	1.080	19	930	14	1.118	14	1.678	18	1.124	9
Other costs	17	0.3	84	1	114	2%	146	2	186	2	110	1
Total expenditure	5.600	100	5.804	100	6.881	100	7.760	100	9.824	100	12.466	100

Table 3.3 PhD completion – Leiden University

Enrolment				**Cumulative success rates**											
Starting year				≤ 4 yr + 6 mo*		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	9	2	11	9	82	9	82	9	82	10	91	0	0	0	0
2013	13	2	15	10	67	10	67	10	67	12	80	3	21	0	0
2014	11	2	13	4	41	5	38	6	46	8	62	5	25	1	7
2015	6	3	9	2	22	6	67	8	89	8	89	1	13	0	0
2016	8	2	10	2	20	3	30	5	50	-	-	5	50	0	0
Total	**47**	**11**	**58**	**27**	**47**	**33**	**57**	**38**	**67**	**38**	**81**	**18**	**27**	**1**	**2**

*The average time of administrative PhD procedures in Leiden is close to 6 months

Department of Data Science and Knowledge Engineering, Maastricht University

Table 4.1 Research staff in # and fte – UM

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	2	0.7	3	0.9	3	1.1	3	1.1	4	1.1	6	1.6
associate prof	4	1.8	3	1.4	4	1.5	8	3	10	3.5	11	4.7
assistant prof	15	7.2	16	7.3	17	7.6	17	7.3	14	6.4	16	7.2
all prof	**21**	**9.7**	**22**	**9.6**	**24**	**10.2**	**28**	**11.4**	**28**	**11**	**33**	**13.5**
PD	2	1.8	4	2.7	3	2.7	4	3	7	3.8	10	6.4
PhD	14	12.4	14	13.5	15	14.5	17	16	13	12	11	10.5
all PD + PhD	16	14.2	18	16.2	18	17.2	21	19	20	15.8	21	16.9

Table 4.2 Funding – UM

	2015		2016		2017		2018		2019		2020	
Funding in K€/%	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*	*K€*	*%*
Direct funding			279	7	403	10	430	8	432	8	420	6
Research grants	419	10.8	508	13	484	12	681	13	616	11	790	11
Contract research	13	0.3									66	0.9
Other	74	1.9	65	2	56	1	61	1	38	1	4	0.1
Research funding	**506**	**13**	**852**	**22**	**943**	**24**	**1171**	**23**	**1086**	**20**	**1279**	**18**
Educational funding	**3372**	**87**	**2985**	**78**	**3061**	**76**	**3914**	**77**	**4293**	**80**	**5997**	**82**
Expenditure in K€/%												
Personnel costs	2654	77	2897	77	3284	78	3874	77	4573	75	5265	72
Other costs	813	23	878	23	913	22	1187	23	1551	25	2005	28
Total expenditure	**3467**		**3775**		**4197**		**5061**		**6124**		**7270**	

Table 4.3 PhD completion – UM

Enrollment				**Cumulative success rates**											
Starting year				≤ 4 yr + 3 mo		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	2	2	4			2	50	1	25	1	25				
2013															
2014		1	1					1	100						
2015	2	2	4			1	25					3	75		
2016	3	1	4									4	100		
2017	1	1	2									2	100		
2018	4		4									4	100		
2019		1	1									1	100		
2020	2	2	4									4	100		
Total	**14**	**10**	**24**			**3**	**23**	**2**	**15**	**1**	**8**	**18**			

Institute for Computing and Information Sciences, Radboud University

Table 5.1 Research staff in # and fte – RU

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	12	7.7	14	9.2	16	11.1	16	10.8	17	10.0	17	11.1
associate prof	8	5.6	8	4.4	6	2.4	5	2.3	5	2.9	6	2.4
assistant prof	11	9.7	13	10.9	15	12.8	16	15.6	19	13.9	22	17.9
all prof	**31**	**23**	**35**	**24.5**	**37**	**26.3**	**37**	**28.7**	**41**	**26.8**	**45**	**31.4**
PD	30	18.7	26	14.3	22	16.1	25	12.0	21	10.6	18	8.0
PhD	44	34.2	46	36.8	43	35.2	39	28.9	52	33.0	64	40.6
all PD + PhD	**74**	**52.9**	**72**	**51.1**	**65**	**51.3**	**64**	**40.9**	73	**43.6**	**82**	**48.6**

Table 5.2 Funding – RU

	2015		2016		2017		2018		2019		2020	
Funding in M€/%	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*
Direct funding	2.9	43.0	3.6	49.2	3.5	47.6	3.8	50.5	4.4	59.8	5.6	65.7
Research grants	2.0	29.5	2.1	28.3	2.1	28.1	1.6	21.4	1.9	25.3	1.7	20.3
Contract research	1.3	18.8	1.1	14.4	1.1	14.3	0.9	11.9	0.9	11.6	0.8	9.1
Other	0.6	8.7	0.6	8.0	0,7	10.0	1.2	16.2	0.2	3.3	0.4	4.9
Total funding	**6.786**		**7.315**		**7.424**		**7.448**		**7.384**		**8.501**	
Expenditure in M€/%												
Personnel costs	5.9	90.1	6.1	87.1	6.5	88.5	6.7	86.8	6.7	89.8	7.7	93.8
Other costs	0.6	9.9	0.9	12.9	0.8	11.5	1.0	13.2	0.8	10.2	0.5	6.2
Total expenditure	**6.508**		**7.045**		**7.353**		**7.707**		**7.432**		**8.218**	

Table 5.3 PhD completion – RU

Enrolment				**Cumulative success rates**											
Starting year				≤ 4 yr + 3 mo		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	2	2	4	1	25	2	75	0	75	0	75	1	25	0	
2013	12	1	13	3	23	3	46	6	92	0	92	1	8	0	
2014	3	1	4	0	0	2	50	1	75	1	100	0	0	0	
2015	14	2	16	4	25	4	50	0	50			6	38	2	
2016	8	0	8	2	25	1	38					5	62	0	
2017	3	0	3									3	100	0	
2018	6	1	7									7	100	0	
2019	15	4	19									19	100	0	
2020	16	7	23									23	100	0	
Total	79	19	98	**10**		**12**		**7**		**1**		**65**		**2**	

Department of Computer Science, University of Twente

Table 6.1 Research staff in # and fte – UT

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	20	14.8	19	14.0	20	13.4	19	13.8	17	10.7	16	9.3
associate prof	11	9.7	13	11.1	13	9.9	10	9.0	14	10.9	16	11.7
assistant prof	18	13.7	20	14.1	25	18.5	27	23.8	32	25.9	38	31.0
all prof	**49**	**38.2**	**52**	**39.2**	**58**	**41.8**	**56**	**46.6**	**63**	**47.5**	**70**	**52.0**
PD	52	29.5	42	28.5	37	19.3	36	20.4	33	21.8	39	22.3
PhD	101	76.8	82	67.0	72	55.6	75	51.0	72	55.4	71	53.3
all PD + PhD	**153**	**106.3**	**124**	**95.6**	**109**	**75.0**	**111**	**71.4**	**105**	**77.2**	**110**	**75.8**

Table 6.2 Funding – UT

	2015		2016		2017		2018		2019		2020	
Funding	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*
Direct funding	8.119	52	9.545	61	10.006	69	11.150	71	11.982	70	14.456	77
Research grants	5.579	36	4.579	29	3.202	22	3.354	21	3.251	19	2.737	14
Contract research	1.821	12	1.487	10	1.325	9	1.661	10	1.898	11	1.641	9
Other	0	0	0	0	0	0	0	0	0	0	0	0
Total funding	**15.519**	**100**	**15.611**	**100**	**14.534**	**100**	**16.165**	**100**	**17.131**	**100**	**18.834**	**100**
Expenditure												
Personnel costs	11.193	74	10.924	73	9.603	70	10.427	73	11.113	75	12.153	79
Other costs	4.039	27	3.986	27	4.147	30	3.856	27	3.656	25	3.160	20
Total Expenditure	**15.231**	**100**	**14.910**	**100**	**13.750**	**100**	**14.283**	**100**	**14.769**	**100**	**15.313**	**100**

Table 6.3 PhD completion – UT

Enrolment				**Success rates**											
Starting year				≤ 4 yr + 3 months		≤ 5 yr		≤6 yr		Until Dec. 2020		Not yet finished		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	32	3	35	7	20%	14	40%	19	54%	22	63%	2	6%	11	31%
2013	26	3	29	2	7%	16	55%	23	79%	23	79%	0	0%	6	21%
2014	24	5	29	7	24%	14	48%	18	62%	19	66%	6	21%	4	14%
2015	17	8	25	1	4%	7	28%	10	40%	-	-	8	32%	7	28%
2016	14	2	16	3	19%	3	19%	-	-	-	-	11	69%	2	13%
2017	17	3	20	3	15%	-	-	-	-	-	-	14	70%	3	15%
2018	23	12	35	-	-	-	-	-	-	-	-	-	-	-	-
2019	17	9	26	-	-	-	-	-	-	-	-	-	-	-	-
2020	17	12	29	-	-	-	-	-	-	-	-	-	-	-	-
Total	**187**	**57**	**244**	**23**	**15%**	**54**	**40%**	**70**	**59%**	**64**	**69%**	**41**	**27%**	**33**	**21%**

Informatics Institute, University of Amsterdam

Table 7.1 Research staff in # and fte – UvA

	2015	2016	2017	2018	2019	2020
full prof	9.7	9.5	8.0	8.8	9.9	11.4
associate prof	7.0	7.2	9.2	9.2	10.2	10.2
assistant prof	12.2	13.0	14.0	15.5	15.0	23.4
all prof	**28.9**	**29.7**	**31.2**	**33.5**	**35.1**	**45.1**
PD	32.6	36.5	31.2	25.9	22.5	23.8
PhD	57.1	66.7	74.5	88.6	109.7	125.9
all PD + PhD	**89.7**	**103.2**	**105.7**	**114.5**	**132.2**	**149.7**

Table 7.2 Funding – UvA

	2015	2016	2017	2018	2019	2020
Funding	*M€*	*M€*	*M€*	*M€*	*M€*	*M€*
Direct funding	4.152	4.535	4.783	4.610	6.471	8.221
Research grants	3.420	3.891	3.699	3.019	3.204	3.686
Contract research	5.042	5.577	5.972	7.536	6.558	6.972
Other	47	161	718	205	90	43
Total funding	**15.244**	**17.013**	**18.220**	**18.674**	**19.810**	**22.542**
Expenditure						
Personnel costs	10.689	11.461	12.256	12.553	12.620	15.051
Other costs	4.757	5.289	5.267	4.880	4.476	4.588
Total Expenditure	**15.446**	**16.749**	**17.523**	**17.433**	**17.096**	**19.639**

Table 7.3 PhD completion – UvA

Enrolment				Success rates											
Starting year				≤ 4 yr + 3 months		≤ 5 yr		≤6 yr		7 years but Until Dec. 2020		Not yet finished		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	12	2	14	4		1		4						5	
2013	21	5	26	7		5		2		1		5		6	
2014	14	2	16	4		2		3		1		2		4	
2015	22	3	25	4		5		4				8		4	
2016	22	7	29	9		3		1				11		5	
2017	21	7	28	3								17		8	
2018	26	10	36									29		7	
2019	25	13	38	2								34		2	
2020	32	16	48									48			
Total	**195**	**65**	**260**	**33**		**16**		**14**		**2**		**153**		**41**	

Department of Computer Science, Vrije Universiteit Amsterdam

Table 8.1 Research staff in # and fte – VU

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	12	10.6	12	10.6	11	9.7	11	10.1	10	9.1	12	10.9
associate prof	8	5.4	5	3.5	4	3.2	5	4.3	6	5.3	6	5.3
assistant prof	16	15.6	15	14.6	15	14.6	16	15.2	24	23	26	24.6
all prof	**36**	**31.6**	**32**	**28.7**	**30**	**27.5**	**32**	**29.6**	**40**	**37.4**	**44**	**40.8**
PD	28	25.7	30	27.7	23	21.35	25	22.5	17	15	17	16.4
PhD	77	58.27	73	55.79	75	58.37	77	62.24	93	79.52	101	89.36
all PD + PhD	105	83.97	103	83.49	98	79.72	102	84.74	110	94.52	118	105.76

Table 8.2 Funding – VU

	2015		2016		2017		2018		2019		2020	
Funding in FTE/%	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*	*fte*	*%*
Direct funding	5.7	66	6.9	78	7.0	61	7.8	61	9.5	53	11.0	55
Research grants	2.7	31	1.3	15	3.3	29	4.7	37	8.1	45	4.5	23
Contract research	0.3	3	0.7	8	1.2	11	0.2	2	0.3	2	4.3	22
Other												
Total funding	**8.7**		**8.8**		**11.4**		**12.7**		**17.9**		**19.9**	
Expenditure in M€/%												
Personnel costs	6.0	95	6.6	94	6.6	94	6.3	95	6.1	94	7.7	94
Other costs	0.4	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	5
Total expenditure	**6.3**		**7.0**		**7.0**		**6.6**		**6.5**		**8.2**	

Table 8.3 PhD completion – VU

Enrollment				**Cumulative success rates**											
Starting year				≤ 4 yr + 3 mo		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	20	3	23	6	26	11	48	18	78	20	87	1	4	2	9
2013	9	3	12	2	17	4	33	6	50	7	58	2	17	3	25
2014	12	1	13	2	15	3	23	5	38	5	38	7	54	1	8
2015	12	1	13	1	8	4	31	7	54			4	31	2	15
2016	8	3	11	0	0	1	9					9	82	1	9
2017	18	4	22	1	5							19	86	2	9
2018	9	4	13												
2019	20	6	26												
2020	16	5	21												
Total	124	30	154	12	13	23	32	36	59	32	67	42	45	11	12

Utrecht Research Institute of Information and Computing Sciences, Utrecht University

Table 9.1 Research staff in # and fte – UU

	2015		2016		2017		2018		2019		2020	
	#	fte	#	fte	#	fte	#	fte	#	fte	#	fte
full prof	8	7.75	9	8.25	9	8.25	13	11.85	15	13.75	15	14.15
associate prof	5	4.9	5	4.7	6	5.7	8	7.5	8	6.6	8	7.2
assistant prof	31	28.7	31	28.8	37	34.55	47	42.89	55	51.39	60	56.74
all prof	**44**	**41.35**	**45**	**41.75**	**52**	**48.5**	**68**	**62.24**	**78**	**71.74**	**83**	**78.09**
PD	8	6.75	10	8.15	6	4.8	9	6.5	7	5.7	8	7.5
PhD	30	29.2	29	27.96	34	33.7	36	35.7	39	38.4	52	51.56
all PD + PhD	**38**	**35.95**	**39**	**36.11**	**40**	**38.5**	**45**	**42.2**	**46**	**44.1**	**60**	**59.06**

Table 9.2 Funding – UU

	2015		2016		2017		2018		2019		2020	
Funding in M€/%	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*	*M€*	*%*
Direct funding	1.9	44	1.9	39	2.3	46	2.1	43	2.7	48	3.0	52
Research grants	1.4	33	1.4	29	1.1	22	1.1	22	1.3	23	1.3	22
Contract research	1.0	23	1.6	33	1.6	32	1.7	35	1.6	29	1.5	26
Other												
Total funding	**4.3**		**4.9**		**5.0**		**4.9**		**5.6**		**5.8**	
Expenditure in M€/%												
Personnel costs	4.2	92	4.4	89	4.8	91	4.4	88	5.1	90	5.3	92
Other costs	0.4	8	0..5	11	0.5	9	0.6	12	0.6	10	0.5	8
Total expenditure	**4.6**		**4.9**		**5.3**		**5.0**		**5.7**		**5.8**	

Table 9.3 PhD completion – UU

Enrollment				**Cumulative success rates**											
Starting year				≤ 4 yr + 3 mo		≤ 5 yr		≤6 yr		Until Dec 2020		Ongoing		Discontinued	
	M	F	M+F	#	%	#	%	#	%	#	%	#	%	#	%
2012	15	1	16	5	31	10	63	10	63	13	81	2	13	1	6
2013	9	2	11	10	91	10	91	11	100	11	100	0	0	0	0
2014	7	2	9	3	33	3	33	3	33	3	33	4	44	2	22
2015	13	2	15	5	33	6	40	6	40			5	33	4	27
2016	11	3	14	7	50	8	57					4	29	2	14
2017	11	5	16	2	13							14	88	0	0
2018	18	4	22	1	5							21	95		
2019	13	11	24	1	4							22	92		
2020	15	9	24									24	100		
Total	**66**	**15**	**81**	**32**	**40**	**39**	**48**	**40**	**49**	**43**	**53**	**29**	**36**	**9**	**11**

Research schools

ASCI

Number of PhD candidates, postdocs, and staff on 31 December 2020- ASCI

	Male	Female	total
PhD	79	16	95
Postdoc	2	1	3
Staff	75	6	81
Total	**156**	**23**	**179**

Number of PhD theses officially accredited by ASCI per year

Year	Number of accredited PhD theses
2015	27
2016	24
2017	20
2018	15
2019	6
2020	5
Total	**97**

IPA

Composition of the research school per ultimo 2020- IPA

	Male	Female	total
Scientific staff	152	24	176
PhD candidates	85	17	102
Total	**237**	**41**	**278**

Number of PhD published in the IPA dissertation series per year

Year	Number of PhD theses
2015	23
2016	14
2017	11
2018	21
2019	13
2020	8
Total	**90**

SIKS

PhD defenses per year SIKS

Year	Number of PhD defenses
2015	35
2016	50
2017	48
2018	30
2019	38
2020	35
Total	**236**