



NVAO  THE NETHERLANDS

INITIAL ACCREDITATION
BACHELOR
DATA SCIENCE & ARTIFICIAL INTELLIGENCE
Leiden University

FULL REPORT
1 July 2021



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1 Peer review

The Accreditation Organisation of the Netherlands and Flanders (NVAO) determines the quality of a new programme on the basis of a peer review. This initial accreditation procedure is required when an institution wishes to award a recognised degree after the successful completion of a study programme.

The procedure for new programmes differs slightly from the approach to existing programmes that have already been accredited. Initial accreditation is in fact an ex ante assessment of a programme. Once accredited the new programme becomes subject to the regular review process.

The quality of a new programme is assessed by means of peer review. A panel of independent peers including a student reviews the plans during a site visit to the institution. A discussion amongst peer experts forms the basis for the panel's final judgement and the advisory report. The agenda for the panel visit and the documents reviewed are available from the NVAO office upon request.

The outcome of this peer review is based on the standards described and published in the limited NVAO Assessment framework for the higher education accreditation system of the Netherlands (Stcrt. 2019, nr. 3198). Each standard is judged on a three-point scale: meets, does not meet or partially meets the standard. The panel will reach a conclusion about the quality of the programme, also on a three-point scale: positive, conditionally positive or negative.

This report contains the findings, analysis and judgements of the panel resulting from the peer review. It also details the commendations as well as recommendations for follow-up actions. A summary report with the main outcomes of the peer review is also available.

NVAO takes an accreditation decision on the basis of the full report. The NVAO decision can be positive, conditionally positive or negative. Following a positive NVAO decision with or without conditions the institution can proceed to offer the new programme.

Both the full and summary reports of each peer review are published on NVAO's website www.nvao.net. There you can also find more information on NVAO and peer reviews of new programmes.

Because of COVID-19 temporary measures apply for this peer review.

2 New programme

2.1 General data

Institution	: Leiden University
Programme	: Data Science and Artificial Intelligence
Mode of study	: Full time
Degree	: Bachelor
Tracks	: -
Location	: Leiden
Study load	: 180 EC ¹
Field of study	: Nature

2.2 Profile

In the bachelor programme in Data Science and Artificial Intelligence (DSAI) students learn how to get insight from data and to build smart machines capable of performing tasks that typically require human intelligence in order to provide useful applications for society. The programme is centred on solving problems by the combination of Data Science and Artificial Intelligence and emphasizes on formal methods and technical solutions. Drawing from the fields of machine learning and data mining of large, complex data sets, Data Science provides critical support to decision makers in many professions, allowing them to make decisions based on statistically significant patterns in data. Artificial Intelligence is concerned with the theory and the development of computational systems capable of performing tasks that typically require human intelligence. The DSAI programme uses multiple approaches involving (cognitive) psychology and neuroscience, statistical science, linguistics, and philosophy. The new bachelor programme is offered by the Faculty of Science of Leiden University and delivered under the full responsibility of Leiden Institute of Advanced Computer Science (LIACS).

Panel

Peer experts

1. Prof. Dr. Willem-Jan Van den Heuvel (*chair*), Professor Information Systems at *Universiteit van Tilburg/Jheronimus Academy of Data Science (JADS)*;
2. Prof. dr. ir. Stan van Hoesel, Professor of Operations Research at *University Maastricht*;
3. Prof. dr. Lejla Batina, Professor Digital Security and Education Director Instituut Informatica en Informatiekunde at *Radboud Universiteit*;
4. Ruward Karper, (*student*), Student Joint Master Data Science & Entrepreneurship, *Universiteit van Tilburg & Technische Universiteit Eindhoven*.

Assisting staff

- Riekje de Jong, secretary;

¹ European Credits

- Frank Wamelink, NVAO policy advisor and process coordinator.

Site visit (online)

Leiden Institute of Advanced Computer Science (LIACS), May 18th 2021



3 Outcome

The NVAO approved panel reaches a positive conclusion regarding the quality of the bachelor programme Data Science and Artificial Intelligence offered by Leiden University. The programme complies with all standards of the limited NVAO framework.

The overall objective of the bachelor DSAI is that students learn how to get insight from data and how to build “intelligent” machines capable of performing tasks that typically require human intelligence in order to provide useful applications for society.

The panel is very positive about the vision and the aims of the new bachelor programme DSAI and the intended qualification profile of the graduate.

The programme defines a set of complete and concise intended learning outcomes. It is demonstrated that the intended learning outcomes meet bachelor level and expectations of the (professional) field by matching them with international reference frameworks. These goals are well thought out and further developed in discussion with envisioned teachers and the Advisory Board.

The panel recommends clarifying the emphasis on the theoretical approach of problem solving in its communication to students and the field. Although issues of security, privacy, ethics, legal aspects and soft skills are present in various courses, the panel recommends that these issues are strengthened in the curriculum and highlighted in the Intended learning outcomes.

The programme fits with the wider vision on teaching and learning of Leiden University and the existing research environment.

The programme is a thorough elaboration of the intended learning outcomes. The learning lines and the didactics of the courses contribute to the achievement of the goals of the programme by the graduate. The overall objectives of the programme are translated into six learning trajectories: computational thinking, mathematical skills, basic AI, intelligent systems, cognition and research skills. Guidance of students is properly in place on several levels and student engagement is part of the culture. The staff is well qualified and committed to the new programme. Interactions between the contributing disciplines and groups are fruitful, thus illustrating the interdisciplinary attitude of the staff.

The panel affirms English as language of teaching. The panel considers the intake level and the mandatory matching procedure of Dutch students as adequate.

The assessment policy is both formally at the level of the program, and more operationally in the courses well developed. A mixture of assessments is used. The assessment policy also promotes a steady study behaviour. The quality assurance of assessments is detailed and a strong point of the programme. Developing assessment matrices could be of added value in the quality assurance of course assessments. The assessment of the thesis is well developed and substantive.

LIACS will be fully responsible for the development and delivery of this new programme. This is a solid base of implementing the new DSAI programme. Necessary agreements about teaching are already in place with participating institutes. The panel concludes that envisioned lecturers are already collaborating in the design of the new programme that will start in September 2022.

The NVAO approved panel reaches a positive conclusion regarding the quality of the bachelor programme Data Science and Artificial Intelligence offered by Leiden University. The programme complies with all standards of the limited NVAO framework.

Standard	Judgement
1 Intended learning outcomes	meets the standard
2 Teaching-learning environment	meets the standard
3 Student assessment	meets the standard
Conclusion	positive

Given these considerations and conclusion, the panel advises NVAO to take a positive decision regarding the quality of the proposed programme wo-bachelor Digital Science and Artificial Intelligence at Leiden University.



4 Commendations

The programme is commended for the following features of good practice.

1. Integration and depth: The programme is centred on solving problems by the combination of Data Science and Artificial Intelligence with an emphasis on thorough understanding of formal methods and techniques.
2. Relevant expertise LIACS: The programme fits the existing educational activities and connects well with LIACS research with an accent on methodology rather than on industrial or public/consumer applications.
3. Graduates well qualified for master: Both the intended learning outcomes of the programme, that are elaborated in the learning tracks and the choice of minors, prepare appropriately for a faculty master or a master offered by the consortium of Leiden University, TU-Delft, and Erasmus University.
4. Decisive coordination: The full support and solid base of LIACS as host of the new programme that is taking responsibility of coordination, management and quality assurance



5 Recommendations

For further improvement to the programme, the panel recommends a number of follow-up actions.

1. Highlight the DSAI profile with its focus on theoretical foundations more clearly in the intended learning outcomes and in communication to students and the professional field.
2. Embed societal issues like cyber-security and privacy, ethics and legal aspects more broadly in the curriculum. Also soft skills like communication and cooperation can be strengthened in the programme.
3. Put structural effort in the (current ad-hoc) mentoring of young staff combining research and teaching and putting effort in the design of the new DSAI bachelor programme. Make this a structural part of the professionalisation of new staff.
4. Use assessment matrices to assure the right level of assessment and the alignment of course objectives and course assessments.



6 Assessment

6.1 Standard 1: Intended learning outcomes

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

Judgement

Meets the standard.

Findings, analysis and considerations

Intended learning outcomes of the programme

The overall objective of the bachelor DSAI is that students learn how to get insight from data and to build smart machines capable of performing tasks that typically require human intelligence in order to provide useful applications for society.

The programme matches Leiden University's general ambitions on teaching and learning that graduates can critically assess scientific and societal problems and make well-reasoned choices in finding solutions for these problems. One of the university's core values: the integration of education and research, is also explicitly visible in the bachelor programme DSAI.

The programme combines Data Science (DS) and Artificial Intelligence (AI). DS is concerned with large, complex data sets. Drawing from the fields of machine learning and data mining, it provides vital/important support to decision makers in many professions, allowing them to make decisions based on statistically significant patterns in data. AI is concerned with the theory and the development of computational systems capable of performing tasks that typically require human intelligence. AI is an interdisciplinary science with multiple approaches involving (cognitive) psychology and neuroscience, statistical science, linguistics, and philosophy.

Aims of the programme are articulated in fourteen intended learning outcomes (ilo's) at programme level: eight generic ilo's and six AI ilo's. Examples of the eight generic intended learning outcomes are: knowledge and understanding of current concepts and methods, conducting research, formulating theories and testing hypotheses, critical thinking, analysing a scientific problem, using soft skills and reflect on societal problems. The other six intended learning outcomes specifically touch on DS and AI knowledge and skills. Such as mathematics, algorithmic principles and computational theories, designing, implementing and evaluating of intelligent agents or programmes, problem analysis, understanding of models of knowledge representation and applying knowledge from key areas from DS and AI. The ilo's at programme level are elaborated in six learning trajectories in the programme: computational thinking, mathematical skills, basic AI, intelligent systems, cognition and research skills.

The panel has studied the vision of the programme and the associated intended learning outcomes. The panel appreciated the thorough and clearly formulated set of intended learning outcomes. Initially, it was not very clear what kind of problems have to be resolved as well as the kind of applications for society to be developed. Lecturers and the programme managers explained that the focus in problem solving is rather theoretical. Students will use formal methods and techniques of DS

and AI and use insights of the cognitive sciences to develop solutions that can be applied in several fields. Students learn for example how to contribute to the development of new knowledge in machine learning or software design. Further societal applications could be explored in one of the minors in the third year and on the master level.

Soft skills are included in the ilo's and issues of security, privacy, ethics and legal aspects are dealt with in various courses. This became apparent from the interview with the lecturers. The panel emphasizes the importance of soft skills and societal issues and recommends that both soft skills as well as the aforementioned issues be more broadly integrated in the curriculum and in the ilo's.

The ilo's define that graduates will have a thorough knowledge base and master a set of research skills required to successfully continue with a master programme and complete a master's degree within the discipline and related areas.

The Bachelor graduates can enrol in departmental master tracks of data science and computer science and in the master Robotics of Technical University of Delft.

Based on a thorough analysis presented in the documentation of the match between (inter)national frames of reference and the intended learning outcomes of the programme the panel decides that the ilo's define Bachelor level of the programme. Also, the disciplinary expectations as defined in the KION and the ACM frameworks² are well met.

The management presented the initiative to develop this new Bachelor DSAI programme as an effort to bring together the best of both worlds. This choice is already visible in: recent innovations in DS courses; more interest of students in AI subjects than currently provided in the CS programme and the growing cooperation of researchers in Science and Psychology. The new programme DSAI broadens the scope of the science programmes of Leiden University and it offers an English language bachelor with an international orientation.

The management has installed an Advisory Board to deliver state of the art teaching and to advise on curriculum changes. Plans for the new bachelor have been discussed with the Advisory Board and are fully supported by all the members. The panel suggests providing students with examples of careers (persona's) in data science and artificial intelligence that can be pursued by graduates: such as Machine Learning Engineer, Data Scientist, and Business Intelligence Developer.

In conclusion, the panel is very positive about the vision and the aims of the new bachelor programme DSAI and the intended qualification profile of the graduate.

The programme broadens the offer of programmes of the Faculty of Science and responds adequately to a clear demand in the working field.

LIACS will be fully responsible for the delivery of this new programme. This is a solid base of implementing the new DSAI programme. Necessary agreements about teaching are already in place

² Dutch referential framework of Artificial intelligence (KION) and the international frameworks of Computing Competencies for Undergraduate Data Science Curricula by the ACM Educational Board.

with participating institutes. The panel concludes that envisioned lecturers are already collaborating in the design of the new programme that will start September 2022.

The panel appreciates the commitment of the Advisory Board of the professional field in the design of the new DSAI programme to keep it state of the art.

The panel decides that the intended programme clearly meets standard 1. It defines complete and concise intended learning outcomes. It is demonstrated that the intended learning outcomes meet bachelor level and expectations of the (professional) field by matching them with international reference frameworks. These goals have been well thought through, and further developed in discussion with envisioned teachers and the Advisory Board. The programme fits within the vision on teaching and learning of Leiden University and the existing research environment. The programme meets the need in the working-field and clearly makes a choice for a strong theoretical foundation.

6.2 Standard 2: Teaching-learning environment

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

Judgement

Meets the standard.

Findings, analysis and considerations

Curriculum

The new bachelor DSAI is a full-time programme of three years with a study load of 180 EC. The curriculum is structured in six semesters according to the Leiden University semester structure. The ilo's at programme level are elaborated in six learning trajectories: computational thinking, mathematical skills, basic AI, intelligent systems, cognition and research skills.

The first year delivers a thorough basis: the essential aspects of the disciplines that remain unaltered in the face of technological change. Mathematical support courses provide understanding of the core concepts of modelling and algorithms used in the implementation of artificial intelligence. Students get acquainted with the foundations of logical reasoning and computational models. In the course Studying and presenting, students acquire academic skills and methodology. The course Social and ethical aspects gives special attention to social and ethical issues related to data science and artificial intelligence. The second year is focused on some of the key areas of artificial intelligence and data science, such as: searching and decision making, cognitive and behavioural data science, autonomous and multi agent systems, statistics, human-robot interaction and machine learning. Also, the methodological skills are further elaborated and students deepen their knowledge of computational models and algorithms, the limits of computations and get a solid basis in probability and statistical theory. In the second year, students are also introduced to cyber security. In the third year, students have the possibility to choose from minors, next to three mandatory courses and the concluding bachelor's project. The bachelor's project (15 EC) is an individual research project. Guidance is provided through the bachelor class.

Talented students will have the possibility to broaden their horizon via *The Honours College*,³ an extracurricular set of courses (30 EC) that starts in the second semester of the first year and continues until the end of the third year.

The panel discussed the broad choice of minors and the need of guidance for students to build a meaningful study-career. The panel understood that a minor is an obligatory part of the programmes at Leiden University. It gives students the opportunity to broaden their scope. Also, minors offered by the TUDelft or EUR are allowed. Also it is possible to combine a minor with studying abroad. To support students in their choice the programme committee has preselected a limited number of electives which prepare for the master.

Teaching-learning environment

The didactics of the bachelor tie in with the vision on teaching and learning of Leiden University. Especially with regard to the research orientation of the programme, critical thinking and a balanced mix of theory and practice.

Although the details of the first year have not yet been fully worked out, the study guide presented to the panel as 'work in progress', already provides a good overview of the objectives, content, literature, didactics and assessment of the courses.

Lecturers who currently teach in DS and CS are engaged in the development of the DSAI programme. The teaching team meets once a month and will discuss the alignment between courses and the intended learning outcomes. Lecturers enlightened the panel on the systematic way in which the principles of backwards design are used. Thus, the requirements for the programme as a whole are systematically elaborated in the learning tracks and the right level is realized in the different courses. Both, the integration of the newly developed course machine learning in the DSAI programme as well as the content of the courses on statistics and the integration of privacy security and cyber security in a new course on cyber security have been discussed.

In general, the didactics of the courses are appropriate to acquire the intended learning outcomes. Lecturers emphasize that many courses have a practical component in which students practice the knowledge acquired. This problem solving is fundamental to the approach to learning. Several convincing and concrete examples have been presented to the panel. The panel also established that the research skills are integrated in many courses.

In the subsequent years, the didactics become more and more 'advanced' giving the students an active role in their learning. Starting with exercise classes and guided lab sessions in small groups to third year group assignments that integrate working in teams on the learning objectives and the assessment. The last year bachelor class offers students proper structure and guidance in the process of their bachelor research project. Students value learning in small teams and projects. Lecturers recognize the need to include societal issues and soft skills in the courses. The panel underlines this need and recommends to firmly integrate the 21st century skills in the programme.

Language

The programme's language of instruction will be English. This is in line with the language policy of Leiden University, which sees English as the de-facto language of the scientific world. The programme aims for an international inflow of approximately 20%. The international classroom will familiarize students to cultural diversity as they will encounter in a globalized working field, and also in companies in the Netherlands. The International Classroom with a mixture of nationalities and cultures provides an

³www.universiteitleiden.nl/en/education/bachelors/why-leiden-university/extra-challenges/honours-education/honours-college

enriched learning environment. Moreover, it enables the non-Dutch speaking research and teaching staff at LIACS to participate in the DSAI programme.

The panel affirms this motivation for English as language of teaching. The panel suggests that a somewhat higher percentage of international students would strengthen an inclusive learning environment and could reduce the risk of groups of students being a minority.

Intake

Students with a Dutch VWO diploma with Mathematics B are admitted directly to the programme. The study counsellor is involved in the mandatory matching process. In this matching procedure, students will study illustrative materials and are assessed. This procedure is finalized with an interview with students to discuss their achievements and motivation. Students affirmed to the panel that this procedure offered them a clear view of the programme before the start and helped them to confirm their own choice.

International students are required to have an equivalent of the Dutch VWO with Mathematics B diploma and an adequate level of English proficiency.

Student guidance and support

The dedicated study advisor is clearly a sparring partner for students. He is helping students with problems that negatively impact their study performance, gives guidance in the design of study plans and informs students about regulations. At the start of the programme each student will have an introductory meeting with the study advisor or a lecturer. In the first year, there is a system of mentoring. Mentors are older students promoting student engagement and informing students about the programme. Mentor groups regularly meet in the first semester and might have some individual sessions later on in the first year. Also, the guidance of teaching assistants during the coursework is well appreciated. Interviews confirmed that student guidance and support was generally well considered.

An illustration was the extra guidance during the COVID crisis. While all education was online the study advisor and one of the lecturers initiated online talks with students on their well-being.

Staff

The panel has met a passionate teaching team that is highly committed to the programme. The programme management is professional and this proposal for a new programme is the result of years of discussions and deliberations. The lecturers are well qualified, they all have a relevant PhD. A relatively large part of the staff is new. This makes a mentoring system for the professionalization of this staff important. Although this seems to be informally in place the panel understood that there is need for a more formal and structural mentoring system. This wish is endorsed by the panel.

Currently all lecturers have passed the university teaching qualification (BKO) or are in the process of acquiring one. The panel discussed the differences in departmental background and cultures of the teachers. The lecturers perceive this as positive. There are differences between teaching cultures. One might emphasize writing papers, the other mathematical reasoning. This is a source of inspiration and strengthens them as interdisciplinary researchers.

Inclusiveness is an important topic in the programme. From what the panel understood there is need to pursue this in its full broadness, and also on its implications for educational policy and human resource management.

Effects of the Covid-19 measurements on teaching and learning



Teachers adapted well to the impact of the Covid-19 measurements on teaching and learning. A training on interactive online teaching was provided. They used blended learning and online collaboration spaces for students. Teachers learned from each other by mutual observation of online classes. Some online activities worked out very well, such as debating topics. Because physical interaction with a robot was not viable, the teacher developed a simulation of a robot to get the concept across. This proved to work well and certainly will remain part of the course in future. The lecturers have learned what worked well. Students agreed that after some start-up problems the online teaching was of sufficient quality. The online programming assignments for pairs of students especially were motivating and stimulated to start working.

From the documents and the interviews, the panel considers it substantiated that the programme meets the requirements in standard 2. The programme reflects a solid implementation of the intended learning outcomes. The learning lines and the didactics of the courses contribute to the achievement of the goals of the programme by the graduate. Guidance of students is properly in place on several levels and student engagement is part of the culture. The staff is well qualified and committed to the new programme. Interactions between the contributing disciplines and groups are fruitful, thus illustrating the interdisciplinary attitude of the staff. The panel affirms English as language of teaching. The panel considers the intake level and the mandatory matching procedure of Dutch students as adequate.

6.3 Standard 3: Student assessment

The programme has an adequate system of student assessment in place.

Judgement

Meets the standard.

Findings, analysis and considerations

Assessment system

Teaching and Examination regulations (TER) are a specification of the collective TER of the Faculty of Science. This specification of the TER DSI serves as the formal backbone at the start of the programme in September 2022. The collective Rules and Regulations applying to all study and minor programmes in the Faculty of Science. Since this is the first bachelor programme delivered in English a translation of the bachelor part and the specification of this programme has to be provided before the start of the international DSAI programme. This is routine for the Faculty since master programmes have already been delivered in English for years.

The assessment policy of the programme ensures validity, reliability and transparency of the assessments, while maintaining a reasonable level of efficiency (for students and staff). This policy is well developed and clear for the panel.

Although an English version still has to be provided, the panel concludes the examination regulations are sound and meet the legal requirements.

Course assessment

Most courses use a mixture of assessment methods. Most frequently used is a written exam with open-ended questions at the end of the course. In some courses, students must also give a presentation or have to write an essay as assessment.

Some courses include homework assignments on which students receive feedback. This formative assessment will guide students in their study activities towards the final exam. In some courses handing in these assignments yield a 'bonus-point' and (mostly) count for 20% in the final grade. If groupwork is part of the assessment, it in general counts for a maximum of 40% in the final grade. This is to discourage free-riding.

An exception is the course Software engineering because in this course groupwork is an intrinsic part of the course objectives.

In the first-year course on studying and presenting the students learn about citation, plagiarism and fraud and how to check their own work on plagiarism with Turnit In software.

With the policy of 'bonus-points', one resit per year, take-home exams and in between partial exams the programme fosters steady study behaviour of students.

The final research project is assessed by the supervisor and a second lecturer. The Board of Examiners explained that the research project is assessed by two assessors together using one assessment form while grading. Grading criteria are: project work, thesis, executing the project, presentation and defence. The panel suggest that objectivity of this assessment might benefit from the use of separate forms by the two assessors before agreeing on the final grade.

Quality assurance

There is a good system of quality assurance of assessments. From 2021, the four eyes principle is used to ensure the quality of written exams. The preliminary grades, course description, learning outcomes and assessment are handed to the second examiner who reviews the exam (on assessment criteria form, level and content) and grading (on criteria: transparency, consistency and feedback). In assessing written exams, assessment criteria are used. Rubrics or assessment matrices are not commonly in use. The panel suggests that professional assessment will benefit from more structural use of rubrics or assessment matrices.

Minimum or excellent works graded with a six or nine will be checked by a third examiner. Procedures dealing with complaints are clear and effective.

The panel considers the requirements of standard 3 being met by the programme.

The assessment policy is both formally at the level of the program, and more operationally in the courses well developed. The assessment policy also promotes a steady study behaviour. The quality assurance of assessments is detailed and a strong point of the programme and well-guarded by the Board of Examiners. Developing assessment matrices of course could be of added value in the quality assurance of course assessments. The assessment of the thesis is well developed and substantive. The use of separate forms by the two examiners might strengthen objectivity of the assessment.

6.4 Degree and field of study

The panel advises awarding the following degree to the new programme: Bachelor of Science.

The panel supports the programme's preference for the following field of study: Nature.

Abbreviations

ACM	Association for Computing Machinery
BKO	Basis Kwalificatie Onderwijs
CS	Computer Science
DSAI	Data Science and Artificial Intelligence
EC	European Credit points (studiepunten)
EUR	Erasmus University Rotterdam
Ilo's	Intended learning outcomes
KION	Kunstmatige Intelligentie Opleidingen Nederland
LIASC	Leiden Institute of Advanced Computer Science
NVAO	Nederlands-Vlaamse Accreditatie Organisatie
TER	Teaching and Examination Regulations
TU Delft	Technical University Delft
Turnitin	Software to check on plagiarism



The full report was written at the request of NVAO and is the outcome of the peer review of the new programme B Data Science and Artificial Intelligence | Leiden University

Application no: (AV 1033)



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