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M Nanoscience

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Project code P2302

Contents

Summary

Standard 1. Intended learning outcomes

The Nanoscience programme of the University of Groningen is a highly challenging and ambitious programme, aiming to prepare excellent students for a PhD in nanoscience. It inquires deep into physics, chemistry, and select biology topics, and is tailored for talented and motivated students from the Netherlands and abroad. International students receive scholarships to be able to participate in the programme. The rigorous selection process ensures students are prepared for this demanding curriculum. Only a maximum of 15 students are admitted each year, ensuring close interaction with experienced researchers. The programme's emphasis on creating well-rounded scientists is praised by the panel. It stands out in the Netherlands and Europe for its academic focus and interdisciplinarity, as well as its attention to student diversity, both in terms of student background and gender. The main goal of the programme is to prepare students for research careers in top Nanoscience institutes. The panel commends the strong academic orientation of the programme and 13 well-defined ILOs, aligned with the Dublin descriptors in terms of level and orientation, emphasizing both knowledge and skills.

Standard 2. Teaching-learning environment

The panel appreciates small-scale, intensive didactic approach of the programme, which fosters close interaction between students and leading researchers. The small cohorts of 15 students per year ensure diverse interactions while avoiding fragmentation. The programme targets students with backgrounds in physics, chemistry, or materials science. The panel found the curriculum to be well adapted to this diverse intake. Initial weeks of guided self-study help level students' knowledge. The coherence of the curriculum is given shape by core modules emphasizing practical and theoretical training structured around the research cycle. The wet-lab courses and additional electives which are well-balanced between physics and chemistry further enhance the curriculum. Individual projects and master's theses deepen research engagement, with students gaining multidisciplinary exposure. The panel commends the programme's diverse educational methods, emphasis on practical techniques, and small-scale teaching, viewing it as conducive to achieving programme goals. Despite its intensity, student support mechanisms, including mentorship and academic advising, contribute to student success, evidenced by favourable success rates. The panel feels that the use of English as the language of instruction aligns with the international orientation and academic focus of the programme. The panel views the teaching staff positively, noting their expertise, motivation, and dedication to student success. The programme benefits from new state-of-the-art facilities, addressing previous concerns about limited lab resources. Overall, the panel praises the programme's comprehensive approach. If anything, it recommends continued emphasis on student well-being, and keep working on the perception of the programme as multidisciplinary rather than nanophysics.

Standard 3. Student assessment

The panel found that the Nanoscience programme emphasizes a comprehensive assessment system designed to prepare students for a career in nanoscience research. A diverse range of assessment modes, including exams, practical work, reports, papers, and presentations, ensure comprehensive evaluation. Midterm assessments were introduced to provide ongoing feedback to students, enhancing student progress and performance. The panel concludes that the programme has a very solid assessment policy in place. The assessment plan ensures that all intended learning outcomes are properly assessed throughout the programme. The Board of Examiners oversees assessment quality, compliance, and student requests. The Board's effective management, procedures, and checks garner praise from the panel: the panel has an excellent impression of the role of the Board of Examiners within the programme, even calling it a ‘best practice example’ for other programmes.

Standard 4. Achieved learning outcomes

Students of the Nanoscience master's programme show exceptional research skills, surpassing the minimum level for a master's programme and demonstrating work nearly at a PhD-level quality. Students are integral to the research at the Zernike Institute NCR, with their projects and theses often leading to publications or grant proposals. Alumni expressed high satisfaction with the programme and felt well-prepared for their PhD. The panel was very impressed by the level of graduates from the Nanoscience programme, particularly praising the exceptional percentage of graduates pursuing PhDs and the success of graduates in academia and R&D in industry.

Score table

The panel assesses the programme as follows:

Master's programme Nanoscience

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

Prof. dr. J. (Johan) Hofkens
Chair

P. (Peter) Hildering MSc.
Secretary

Date: 14 June 2024

Introduction

Procedure

Assessment

On 4 and 5 April 2024, the master's programme Nanoscience of the University of Groningen was assessed by an independent peer review panel. The assessment followed the procedure and standards of the NVAO Assessment Framework for the Higher Education Accreditation System of the Netherlands (September 2018).

Quality assurance agency Academion coordinated the assessment upon request of the University of Groningen. Peter Hildering acted as coordinator and secretary. He is certified and registered by the NVAO. Yannick Slagter of Academion was present during the site visit as an observer.

Preparation

Academion composed the peer review panel in cooperation with the institutions and taking into account the expertise and independence of the members. On 12 January 2024, the NVAO approved the composition of the panel. The coordinator instructed the panel chair on his role in the site visit according to the Panel chair profile (NVAO 2016).

The programme composed a site visit schedule in consultation with the coordinator (see appendix 3). The programme selected representative partners for the various interviews. It also determined that the development dialogue would be made part of the site visit. A separate development report was made based on this dialogue.

The programme provided the coordinator with a list of graduates over the period July 2021 – October 2023. In consultation with the coordinator, the panel chair selected 15 theses per programme. They took the diversity of final grades and examiners into account. Prior to the site visit, the programme provided the panel with the theses and the accompanying assessment forms. They also provided the panel with the self evaluation report(s) and additional materials (see appendix 4).

The panel members studied the information and sent their findings to the secretary. The secretary collected the panel's questions and remarks in a document and shared this with the panel members. In a preliminary meeting, the panel discussed the initial findings on the self-evaluation report and the theses, as well as the division of tasks during the site visit. The panel was also informed on the assessment framework, the working method and the planning of the site visits and reports.

Site visit

During the site visit, the panel interviewed various programme representatives (see appendix 3). The panel also offered students and staff members an opportunity for confidential discussion during a consultation hour. No consultation was requested. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the preliminary findings.

Report

The secretary wrote a draft report based on the panel's findings and submitted it to an Academion colleague for peer assessment. Subsequently, the secretary sent the report to the panel for feedback. After processing this feedback, the secretary sent the draft report to the programme in order to have it checked for factual irregularities. The secretary discussed the ensuing comments with the panel chair and changes were

implemented accordingly. The panel then finalised the report, and the coordinator sent it to the Faculty of Science and Engineering and the University of Groningen.

Panel

The panel assessing the master's programme Nanoscience at the University of Groningen consisted of the following members:

- Prof. dr. J. (Johan) Hofkens, professor at the Unit Molecular Imaging and Photonics Division of the Department of Chemistry of the KU Leuven (Belgium) [panel chair];
- Prof. dr. L.D.A. (Laurens) Siebbeles, professor at the department of Chemical Engineering at the Faculty of Applied Sciences of Delft University of Technology;
- Prof. dr. I. (Irene) D'Amico, professor at the School of Physics, Engineering and Technology at the University of York (United Kingdom);
- Drs. E.M. (Lisa) Gommer, programme director at the Faculty of Engineering Technology of the University of Twente;
- M. (Maarten) van Os BSc., master's student Nanotechnology at the University of Twente [student member].

Information on the programme

Name of the institution:	University of Groningen
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive
Programme name:	Nanoscience
CROHO number:	60618
Level:	Master
Orientation:	Academic
Number of credits:	120 EC
Location:	Groningen
Mode(s) of study:	Fulltime
Language of instruction:	English
Submission date NVAO:	1 November 2024

Description of the assessment

Previous accreditation panel's recommendations

The documentation provided by the programme prior to the site visit outlined the recommendations provided by the previous accreditation panel in 2018 and the measures undertaken to address these recommendations. The recommendations and their follow-up actions were also discussed in the interviews during the site visit. The panel concludes that the programme management demonstrates an impressive commitment to continuous improvement across all levels, effectively addressing previous external review recommendations. Overall, the panel expresses satisfaction with the implemented improvement strategies, acknowledging their significant contribution to elevating the quality of the programme.

Standard 1. Intended learning outcomes

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

Findings

Profile of the programme

The University of Groningen's master's programme in Nanoscience, offered by the Faculty of Science and Engineering (FSE) is an internationally oriented, two-year selective programme aimed at preparing excellent students for a PhD in the field of Nanoscience. It was originally developed by teaching and research staff of the Zernike Institute National Research Centre (Zernike Institute NRC), a collaboration between the Zernike Institute for Advanced Materials, the Stratingh Institute for Chemistry, and the Groningen Biomolecular Sciences and Biotechnology Institute. The programme aims to give students a high-level and uniquely dedicated master's training to convey to the students the knowledge, skills and attitude needed for an independent research career in the field of Nanoscience. The programme maintains strong ties with the Zernike Institute NRC as well as the Groningen Cognitive Systems and Materials Centre (CogniGron).

Nanoscience is a multidisciplinary field, combining insights primarily from physics and chemistry, and to a lesser extent biology. To be prepared for a successful research career in nanoscience, students need to become experts in each of these fields. Since few universities provide interdisciplinary programmes like Nanoscience at the University of Groningen, no universally agreed standard set of competences has been defined. However, the strong collaborations with the field through the Zernike Institute and other institutes in the field of Nanoscience puts the programme in a good position to keep its programme aligned with the requirements of the field.

The aim to equip exceptional students with the skills needed for advanced research, particularly for pursuing a PhD, indicates high requirements with respect to both the scope and the level of the programme. Although the field of Nanoscience combines topics traditionally taught in physics and chemistry, its multidisciplinary nature implies that neither of these traditional curricula alone fully prepare a student for a career in Nanoscience at a top institution. In order to excel in leading-edge research, students must explore physics, chemistry, and select topics in biology in great depth. The programme thus offers a very challenging curriculum in terms of depth and width, which is specifically aimed towards very talented and highly motivated students from the Netherlands and abroad. International students receive a scholarship and their tuition fee is covered by CogniGron and the Zernike Institute, enabling students from various backgrounds to

apply. The programme uses a strict and selective selection procedure to make sure that students are properly equipped to undertake this challenge. Each year, a maximum of 15 students are admitted to the programme and students have frequent personal interaction with experienced researchers in the field, who help and guide them to become experts in nanoscience.

The panel is very positive about the focus of the programme on creating well-rounded young scientists in the field of Nanoscience and applauds the excellent emphasis in developing independence and critical thinking. The strict selection procedure combined with the small-scale, intensive didactic approach gives the programme the tools to achieve this very ambitious goal. According to the panel, the University of Groningen's master's programme in Nanoscience has a unique profile within the Netherlands and is very competitive within Europe. What sets the programme apart is the strong academic orientation and the interdisciplinarity. The panel is also very pleased with the programme's strong attention to diversity in students. Not only are (international) students from different backgrounds given equal opportunity, but from the interview with the programme management it also became clear that there is quite a good balance in terms of gender. From the last two cohorts, 50% of the applicants were female. An achievement that the programme management thinks may have been inspired by the fact that the Zernike institute has many female PI's, which the panel commends.

Learning outcomes

The main objective of the Nanoscience master's degree programme is to equip students for a research career within top-tier institutes in the rapidly developing field of Nanoscience. The programme's goals are summarized in thirteen intended learning outcomes (ILOs), which are listed in Appendix 1. The panel studied these in terms of level, orientation and content. It concludes that the ILOs are clear and well-defined, up-to-date and encompass a good mix of knowledge and skills. The ILOs are clearly tied to the Dublin descriptors, making the master's level and academic orientation clearly visible.

Considerations

The Nanoscience programme of the University of Groningen is a highly challenging and ambitious programme, aiming to prepare excellent students for a PhD in nanoscience. It inquires deep into physics, chemistry, and select biology topics, and is tailored for talented and motivated students from the Netherlands and abroad. International students receive scholarships to be able to participate in the programme. The rigorous selection process ensures students are prepared for this demanding curriculum. Only a maximum of 15 students are admitted each year, ensuring close interaction with experienced researchers. The programme's emphasis on creating well-rounded scientists is praised by the panel. It stands out in the Netherlands and Europe for its academic focus and interdisciplinarity, as well as its attention to student diversity, both in terms of student background and gender. The main goal of the programme is to prepare students for research careers in top Nanoscience institutes. The panel commends the strong academic orientation of the programme and 13 well-defined ILOs, aligned with the Dublin descriptors in terms of level and orientation, emphasizing both knowledge and skills.

Conclusion

The panel concludes that the programme meets standard 1.

Standard 2. Teaching-learning environment

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

Findings

Curriculum and didactics

The teaching-learning environment of the master's programme Nanoscience is designed around the didactic philosophy of small-scale, intensive teaching. Throughout the curriculum, students work in small cohorts of maximum 15 students for the core modules, where they are trained to do research through one-on-one interaction with leading researchers from the associated research institutes. The programme has settled on a group size of 15 students per year as optimal. According to the programme management and the teachers, 15 students is small enough to prevent splitting into smaller groups, and large enough for diversity in interactions. The programme is designed for students with a bachelor's degree in Physics, Chemistry or Materials Science. Equivalent bachelor's degrees can be considered after assessment by the programme's Admissions Board. Next to their CV, prospective students are also required to write a motivation letter and provide letters of recommendations by experts in the field. The Admissions Board reviews all applications and invites students that meet the requirements for an interview. After these interviews the programme invites the most promising candidates to enrol in the programme.

The students start off their first year with approximately four weeks (6 EC) of guided self-study aimed at levelling their background knowledge. The gaps in knowledge are ascertained from the intake interview, after which students are advised what topics to study in the guided self-study. For instance, students with a bachelor's degree in Physics acquire knowledge in organic and inorganic chemistry, and those with a bachelor's degree in Chemistry study solid-state physics and quantum physics. This activity is guided in the sense that for each area of study, a tutor is available for guidance and help. A mentor (who remains associated with the student throughout the programme) and a number of tutorial sessions are available for each student, usually about once a week. Students with different backgrounds help and train each other. Second year students often also help first year students. At the end of the self-study period, students are tested on bachelor's level knowledge of the topics in an exam. Students describe the self-study weeks as challenging yet fulfilling. In the end, they are all successful in their exams and feel like they are adequately equipped for the rest of the programme. In addition, the period spent studying together and helping each other out creates a strong group feeling that lasts throughout the programme.

The panel is very positive about this start-up phase of the programme. Equalizing the background knowledge of students is a challenge for multidisciplinary master's programmes, and the programme has found a very successful way of doing so, as confirmed by both students and teachers. The panel is very impressed that students master relevant topics outside their undergraduate field in such a short amount of time with almost no drop-outs. It provides a solid starting point for the rest of the curriculum, with the building of 'cohort-spirit' as a nice added bonus. The panel also approves assigning a mentor to each of the students, who helps and advises them throughout the programme.

After finishing the guided self-study, typically lasting about four weeks, students proceed to the core modules. These modules offer practical experimental training and theoretical understanding structured around the research cycle. Since the previous accreditation in 2018, the programme changed the structure of the curriculum to 5 core modules instead of 3, adding the courses 'Nanomaterial Design' and 'Functional Properties of Nanomaterials and Devices' to the already existing courses. The introduction of a wet-lab

course was also part of this restructuring. The core modules are now smaller in terms of EC, but they define the elements of the research cycle even more. In the discussion with the panel, students said that they feel that the small-scale education, with a lot of interaction with the teaching staff, and the many options to do lab work is really valuable for their development as scientists and it's also what sets the Nanoscience programme apart from other programmes. The panel is very positive about the fact that the curriculum is now even more closely based on the research cycle, and applauds the adjustments to the curriculum. They feel that students are given a great opportunity to learn about and experience the whole research cycle, including all synthesis, design, fabrication and characterization, giving them a good base for future research projects.

Beginning in the second semester of the first year, individual projects provide opportunities for students to apply their knowledge and skills while honing additional academic and research abilities. Additionally, students engage in elective courses to deepen their understanding of specific topics relevant to their master thesis project. Extra electives have been added to the curriculum, for instance on machine learning and nano medicine, in order to align the curriculum with the current state of the field of Nanoscience. The panel appreciates that, following up on the 2018 accreditation committee's feedback, the programme eliminated the practice of rewarding students of the Nanoscience programme with fewer ECs for electives followed in other programmes with the reasoning that they are more talented than the average master's student. Nanoscience students now receive the same number of ECs for an elective course as students of other programmes.

The master thesis occupies a large part of the second year, alongside the PhD Research Proposal course, where students learn how grant proposals work, how to structure a research plan, and how to come up with and define research ideas. The master thesis project, worth 45 ECs, allows students thoroughly investigate a research project, gain extensive exposure to research group activities, and experience academia firsthand. Students are required to perform their three main individual projects (the review paper and the small research project in the first year, and the master thesis in the second year) in different research groups at the Zernike Institute NRC and on different topics. The reasoning behind this, as explained by the programme management in their interview, is that by doing their project in different groups and on different topics (physics and chemistry), students step out of their comfort zone. It also ensures that students with a physics background learn to speak with and understand chemists and vice versa. In the interview with the students, they confirmed that this is indeed how it works out in practice and they felt it was very valuable to their development as a multidisciplinary researcher.

The panel is very positive about the curriculum of the Nanoscience programme. The panel appreciates the variety in educational methods, including self-study, courses, projects and a symposium, and compliments the programme at having courses with a well-rounded compendium of skill, from theoretical basis, to hands-on experience, to transferable skills like keeping a lab book and writing a proposal. Students have also expressed the value of these academic skills, which they believe they would not have learned in regular physics or chemistry masters. The panel especially appreciates the emphasis on a lot of practical techniques in the core modules, which the panel deems unique and very valuable. The small scale of the programme, with a lot of student-teacher contact is also valued highly by the panel. The panel considers this an excellent learning environment to achieve its goals.

The Nanoscience programme is equally balanced between physics and chemistry. Several years ago, the scale was tipped more to physics, but especially with the addition of the wet-lab and the extra electives, it is much more in balance, as is shown by a curriculum analysis in the documentation provided by the programme and also articulated by the teaching staff. The panel appreciates the Nanoscience programme

for the truly multidisciplinary programme that it is. All aspects of the field of nanoscience are represented, also in terms of teachers. However, there is a perception of the programme being biased towards physics. The panel recommends improving the perception of the programme as multidisciplinary rather than nanophysics. This means, for example, always being very explicit about the different fields that make up the programme, avoiding any bias toward physics in all communications, both internal and external, and mentioning the other fields even more explicitly.

Feasibility

The Nanoscience programme is intense and demanding for students. During the interview with students and alumni, students expressed that it can be challenging and that workload can be high. At the same time, sometimes students set the bar too high for themselves. One student mentioned for example the pressure students can experience to produce a peer reviewed paper from their research projects, because they have seen other students manage this, even though it is not a requirement of the programme. But the students also noted that there is a lot of support by the programme along the way and that the small number of students is beneficial to them in overcoming difficulties, because there can be very close interaction with both the programme staff and with peers. Throughout the programme, students receive support from an academic advisor, an individual staff mentor, and a student buddy. The academic advisor assists students in selecting elective courses and offers support if any challenges arise during the entire master's programme. A mentor, a senior staff member of the Zernike Institute, acts as a personal guide regarding the study programme's content and meets with the student in the first year. The student buddy, a peer one year ahead in the programme, provides practical advice on life in Groningen and the programme, such as managing workload and understanding how the different research groups work. Additionally, students engage with programme management through regular lunch meetings, occurring about once per quarter, with the programme coordinator and director. These meetings are to inform students about important aspects of the programme, upcoming events, excursions, and career information.

The panel appreciates the close interaction with and guidance from the programme's staff as well as the buddy-mentor system, facilitated by the small cohort size of the programme. The panel therefore supports the ambition of the programme management to keep small cohorts, because there are clear benefits to it, substantive to the success of the programme and its students. Although there is already a good support system in place, the panel also noted the students express their concerns about having to juggle a lot of things, especially international students who also still need to get used to the Netherlands. Therefore, the panel recommends introducing a workshop on life-work balance, a suggestion from one of the students, to help students even more in coping with the pressure to perform. The panel also noted with appreciation that the admission procedure (see description earlier under this Standard) has ample personal attention, including an interview with potential candidates, which the panel deems a good tool to select students who know what they are signing up for and who are properly equipped to undertake this challenge, adding to the probability of the students being able to successfully completing the programme. The documentation shows that in the years 2017–2021, students graduated within 2 years, with very few dropouts (0-2 per year), further demonstrating the feasibility of the programme.

The panel also commends the openness to student feedback in the programme. Students told the panel that they feel that their experience and wellbeing is really being taken into account. There is a feedback moment for students after the core courses to share their experience and students fill in surveys from the programme committee for the programme to improve. Small improvements are made every year. Changes that are introduced based on the evaluations are discussed with the students at lunch meetings. The small cohort also offers a lot of flexibility to the programme management and the teaching staff. For example, resits in case of illness or some other reason, is easier to arrange because of the small cohort.

Language and internationalization

During the site visit, the panel discussed the use of English as the language of instruction and the programme name with the programme management. Because research environments are highly international, the panel considers English an appropriate choice given the international orientation and academic focus of the programme, with the main purpose to produce PhD candidates. The aim for diversity that the programme management expressed during the interview furthermore justifies the choice for English. All staff at FSE is used to communicating in English; in daily practice, scientifically, orally, and in writing. If necessary, the University of Groningen Language Centre offers a wide range of English courses and coaching on the job for personnel that might feel uncomfortable using the English language. For new scientific staff, proficiency in English is one of the criteria on which candidates are selected. This also applies to support staff involved with students. Proficiency in English is also a requirement for students, as was explained by the programme management when discussing the selection procedure for students. The panel considers the way in which a suitable level is ensured appropriate.

Teaching staff

Courses in the Nanoscience programme are taught by a large international staff, all of whom are researchers in fields related to nanoscience. For the first-year courses, there are about 23 staff members involved. The documentation provided by the programme shows that the majority of the staff, regardless of whether from the Zernike Institute or one of the associate research groups, has acquired the University Teaching Qualification (UTQ). Those members of staff who do not have it yet, are either exempt or in the process of obtaining it. Students have expressed themselves very positively about the quality of the teachers during the interview.

The teaching staff expressed a high motivation for teaching in the programme: they enjoy close collaborations with very interactive and highly motivated students. In the small and large projects in the programme, they feel it is possible to go much deeper into research with the students than in other programmes. Therefore, it is also beneficial for the research activities of the teaching staff members to be visible in the programme.

The panel looks very favourably on the teaching staff within the programme. Not only is the student-teacher ratio excellent, but the teachers are all well-qualified experts in the field. The panel also observed that the teachers are very dedicated to the programme and the students, because they are happy to contribute to the programme. During the interview with the teaching staff, the panel noted that the teachers seemed proud to be contributing to the success of the programme, which the panel finds commendable.

Programme-specific services

During the site visit the panel was given a tour of the new Feringa Building that will be housing part of the Faculty of Science and Engineering from 2024 onwards. The panel was impressed by the building with state-of-the-art facilities for research in chemical engineering, nanotechnology, material research and astronomy. Even though parts of the building are still under construction, several of its facilities are already in use, including the labs for the Nanoscience programme. In the report from the 2018 accreditation committee, it was noted that opportunities for students to work in the labs could be limited due to high demand for lab resources within the institute. With the new building and the increase in lab space, the panel expects this should no longer be a problem.

Considerations

The panel appreciates small-scale, intensive didactic approach of the programme, which fosters close interaction between students and leading researchers. The small cohorts of 15 students per year ensure

diverse interactions while avoiding fragmentation. The programme targets students with backgrounds in physics, chemistry, or materials science. The panel found the curriculum to be well adapted to this diverse intake. Initial weeks of guided self-study help level students' knowledge. The coherence of the curriculum is given shape by core modules emphasizing practical and theoretical training structured around the research cycle. The wet-lab courses and additional electives which are well-balanced between physics and chemistry further enhance the curriculum. Individual projects and master's theses deepen research engagement, with students gaining multidisciplinary exposure. The panel commends the programme's diverse educational methods, emphasis on practical techniques, and small-scale teaching, viewing it as conducive to achieving programme goals. Despite its intensity, student support mechanisms, including mentorship and academic advising, contribute to student success, evidenced by favourable success rates. The panel feels that the use of English as the language of instruction aligns with the international orientation and academic focus of the programme. The panel views the teaching staff positively, noting their expertise, motivation, and dedication to student success. The programme benefits from new state-of-the-art facilities, addressing previous concerns about limited lab resources. Overall, the panel praises the programme's comprehensive approach. If anything, it recommends continued emphasis on student well-being, and keep working on the perception of the programme as multidisciplinary rather than nanophysics.

Conclusion

The panel concludes that the programme meets standard 2.

Standard 3. Student assessment

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

Findings

Assessment system

The vision of the Nanoscience programme is that assessment guides and evaluates student learning in a multidisciplinary and international context to prepare them for a research career in Nanoscience. Individual assessment is essential and valued for all courses part of the Nanoscience programme. The assessment plan is annually drawn up by the programme director and programme coordinator, and formally approved by the Programme Board and Faculty Board after the advice of the Board of Examiners. Formal regulations about registering for examinations, terms of assessment, and terms of validity of results are set out in the Teaching and Examination Regulations (TER) of FSE for the master’s degree programmes. Following up on the recommendations from the 2018 accreditation committee, midterm assessments have been introduced for all individual projects, as a non-formal formative assessment to ensure ongoing feedback and improvement. This involves supervisors discussing student performance and progress, as well as providing written feedback, making points of potential improvement explicit to the students. This process is supported by the use of a midterm assessment form resembling the final grading criteria. According to the teachers and students interviewed, this mid-term assessment is beneficial for students, as they see significant improvements between assessments.

The panel has studied the programme's assessment plan and interviewed the Board of Examiners, the programme management, the teaching staff and students on the topic of assessment. It concludes that the programme has a very solid assessment policy in place. The assessment plan ensures that all intended learning outcomes are properly assessed throughout the programme. The modes of assessment are varied, including written exams, practical work, reports, papers and presentations. The panel appreciates the

implementation of formative, midterm assessments for the thesis and individual projects, making the process more transparent and adding to the learning cycle and the professional development of students.

Board of Examiners

The Board of Examiners used to be exclusively dedicated to the Nanoscience programme, but has recently merged with a broader Board of Examiners within the faculty. The Nanoscience programme now falls under the Board of Examiners of the cluster Physics, overseeing the Applied Physics, Astronomy, Nanoscience and Physics programmes. While in name it may seem like a Physics focussed Board, there are representatives from different disciplines on board, also including Chemistry to safeguard the ties of Nanoscience to Chemistry. The Board, among other things, is responsible for assessing the quality of examinations and final assessments, monitoring compliance with the Faculty's TER, checking compliance of the students' study programme with the learning outcomes, issuing diplomas and assessing individual student requests. The nine members of the Board are appointed by the Faculty Board. The Board is composed of a chair, two vice chairs, one of which is assigned for Nanoscience, four general members, and one external member. One member is staff of the Nanoscience programme, and three other members of the Board are also appointed as examiner for the Nanoscience programme specifically. The role of the external member, with a PhD in assessment as a research subject, is to provide a comparative perspective with other faculties and programmes. The Board's workload is alleviated by support from a formal secretary, who has a full-time position on the Board and is mandated to answer all standard requests. This takes a lot of work off the Board's hands, having to convene only for specific cases.

The Board has implemented several measures in recent years, including the introduction of the rubrics and the mid-term assessment, which were based on feedback and recommendations from the previous accreditation committee. These measures mitigate the risks the previous accreditation committee warned about concerning too close involvement of students and teachers in the sort of small-scale environment that Nanoscience programme represents. The use of rubrics promotes that close contact with students does not affect grading, because it is clear from the rubric what a specific grade constitutes. The panel appreciates the effective addressing of the issues put forward by the previous accreditation committee by the Board of Examiners. Based on the assessment policies and procedures, and the interviews during the site visit, the panel has an excellent impression of the role of the Board of Examiners within the programme, even calling it a 'best practice example' for other programmes. The panel feels the Board is clearly in control, with good procedures for exams and master's theses, and all the necessary checks and balances in place.

Considerations

The panel found that the Nanoscience programme emphasizes a comprehensive assessment system designed to prepare students for a career in nanoscience research. A diverse range of assessment modes, including exams, practical work, reports, papers, and presentations, ensure comprehensive evaluation. Midterm assessments were introduced to provide ongoing feedback to students, enhancing student progress and performance. The panel concludes that the programme has a very solid assessment policy in place. The assessment plan ensures that all intended learning outcomes are properly assessed throughout the programme. The Board of Examiners oversees assessment quality, compliance, and student requests. The Board's effective management, procedures, and checks garner praise from the panel: the panel has an excellent impression of the role of the Board of Examiners within the programme, even calling it a 'best practice example' for other programmes.

Conclusion

The panel concludes that the programme meets standard 3.

Standard 4. Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

Quality of theses

To assess the achieved learning outcomes of the programme, the panel (excluding the student member) studied a sample of 15 theses.

Students of the Nanoscience master programme apply the knowledge gained in their first-year courses to their master thesis project by doing research in one of the research groups at the Zernike Institute NCR. The panel was very impressed by the quality of the theses. In all cases, the students demonstrated that they far surpass the minimum level required for a master's programme. The theses show high-quality, independent work and a powerful demonstration of a wide variety of research skills that might be considered almost PhD-level quality. From the interview with the teaching staff, the panel also found that students are actually central to much of the research that is happening at the institute, with students' work from their projects and their theses leading to publications or grant proposals more often than with students from other programmes.

Alumni success

To determine alumni success, the panel reviewed the documentation presented by the programme and interviewed several alumni of the programme. In the documentation provided by the programme, an analysis of first jobs after graduation for graduates from 2019 to 2022 shows that 81% of graduates went on to do a PhD and that the majority of these graduates started their new position within four months from graduating. In the interview with the students and alumni of the programme, the alumni said that they were very satisfied with the programme and felt well-prepared for their PhD. After finishing a PhD about 75% of the graduates continue their career in high-tech companies such as ASML, Photonis, Apple, or QDI Systems. Of all 180 Nanoscience graduates since 2005 at least nine work at a university at assistant professor level or higher. This shows that graduates from the Nanoscience programme are highly qualified and trained for a career in academia, which is the main goal of the programme, but also for R&D in industry. The panel is very impressed by the level of the programme's graduates, praising the exceptional percentage going on to do a PhD.

Considerations

Students of the Nanoscience master's programme show exceptional research skills, surpassing the minimum level for a master's programme and demonstrating work nearly at a PhD-level quality. Students are integral to the research at the Zernike Institute NCR, with their projects and theses often leading to publications or grant proposals. Alumni expressed high satisfaction with the programme and felt well-prepared for their PhD. The panel was very impressed by the level of graduates from the Nanoscience programme, particularly praising the exceptional percentage of graduates pursuing PhDs and the success of graduates in academia and R&D in industry.

Conclusion

The panel concludes that the programme meets standard 4.

General conclusion

The panel's assessment of the master's programme Nanoscience is positive.

Development points

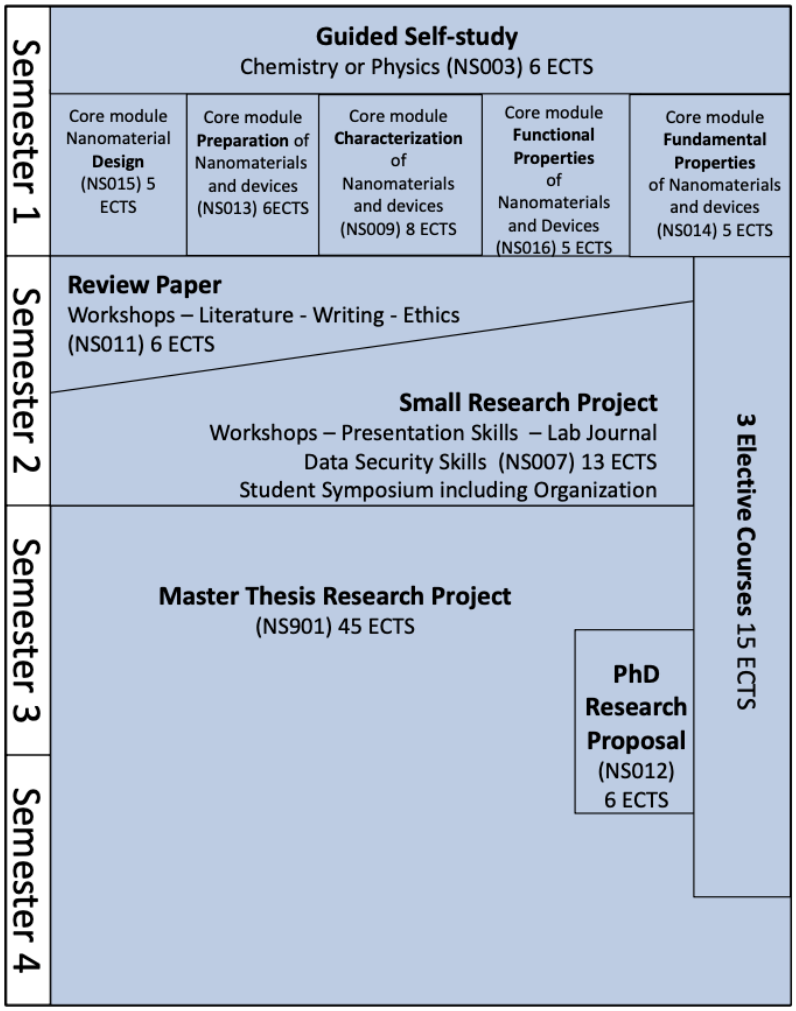
1. Emphasize the multidisciplinary character of the programme even more in the (official and unofficial) communication about the programme, to oppose the perceived bias of the programme being predominantly physics oriented.

2. Continued emphasis on student well-being and attention to experienced pressure to perform in a demanding environment.

Appendix 1. Intended learning outcomes

The graduate of the Top Master Programme in Nanoscience:
1. is able to perform Nanoscience research in the international and interdisciplinary environment of a world-leading institute;
2. has the knowledge, skills, and attitude that are needed for successful entrance and participation in a PhD programme;
3. understands the importance of proper scientific conduct and responsible behaviour when performing research, and is aware of the social and ethical ramifications of scientific research and its applications;
4. can apply knowledge of those parts of the disciplines of physics, chemistry, and mathematics that are relevant to Nanoscience, as well as knowledge of a selection of topics within molecular biology and medicine that are relevant to Nanoscience;
5. is able to solve realistic scientific problems in the interdisciplinary field of Nanoscience, even on the basis of a rudimentary problem specification;
6. is capable of acquiring sufficient knowledge within a limited time span to work in a different speciality within Nanoscience;
7. is capable of critically using the scientific literature in his/her/their chosen speciality;
8. is capable of both performing scientific research, analysing the data, and of interpreting the results;
9. can effectively convey and discuss results of scientific research, orally and in written form, to specialists as well as non-specialists;
10. is able to plan and conduct research independently;
11. is able to perform research in a research team and work together with fellow students;
12. can formulate and defend a realistic and well-argued research plan on the basis of a rudimentary problem specification;
13. is able to adapt to the rapid changes occurring in the field of Nanoscience.

Appendix 2. Programme curriculum



Course Unit	Course Code	Topics	ECTS	Practical	Entry requirements
FIRST YEAR					
Guided Self-study in Nanoscience	WMNS003-06	Two topics from the following list will be assigned on an individual basis on advice from the Admission Board: -Solid-state Physics -Quantum Physics -Organic Chemistry -Inorganic Chemistry -Mathematics	6	No	None
CORE MODULES					
Preparation of Nanomaterials and Devices	WMNS013-06	-Thin-film growth -Preparation of inorganic devices -Preparation of solution processable devices	6	Yes	Guided Self-study in Nanoscience*1
Nanomaterial Design	WMNS015-05	-Design of biomimetic materials -Ordered molecular structures -Nanomedicine	5	No	Guided Self-study in Nanoscience*1
Characterization of Nanomaterials and Devices	WMNS009-08	-Surface and Single Molecule Techniques -X-ray Diffraction -Spectroscopy -Electron Microscopy and Diffraction	8	Yes	Guided Self-study in Nanoscience*1
Fundamental Properties of Nanomaterials and Devices	WMNS014-05	-Electronic Structure Properties -Optical Properties -Magnetic Properties -TV-lectures in collaboration with Osaka University	5	Yes	Guided Self-study in Nanoscience*1

Functional Properties of Nanomaterials and Devices	WMNS016-05	-Surfaces and Interfaces -Electronic Transport Properties of Organic and Hybrid Materials and Devices -Electronic Transport Properties of Inorganic Materials and Devices	5	No	Guided Self-study in Nanoscience*1
INDIVIDUALLY SUPERVISED PROJECTS					
Review Paper*2	WMNS011-06	Including workshops academic skills: -literature search -scientific writing -ethics and scientific integrity	6	No	Guided Self-study in Nanoscience
Small Research Project and Symposium*2	WMNS007-13	Including workshops academic skills: -lab-journal keeping -oral presentation skills -organization scientific symposium	13	Yes	Guided Self-study in Nanoscience
SECOND YEAR					
PhD Research Proposal	WMNS012-06	Including workshops academic skills: - writing and presenting proposal	6	No	Review Paper, Small Research Project and Symposium, and a maximum of one resit for one part of the core modules.
Master Thesis*2	WMNS901-45	Including workshops academic skills: - planning and time-management of a research project - Zernike colloquia - Zernike workshops	45	Yes	Review Paper, Small Research Project and Symposium, and a maximum of one resit for one part of the core modules.

*1: The Guided Self-study (WMNS003-06) has to be completed prior to participating in the remainder of the programme. Students must participate in the first-offered partial exams on their tasks in the Guided Self-study before the first lectures of the core modules. When a re-exam is needed for passing a part of the Guided Self-study, the re-exam must be held and passed before the first partial exams of the core modules.

*2: Note on having sufficient diversity in the topics of the individually supervised projects, and the choice of electives: The Review Paper (WMNS011-06), the Small Research Project and Symposium (WMNS007-13) and the Master Thesis (WMNS901-45) cannot be on the same topic nor in the same research group. The three topics must be a diverse choice from the research topics that are present in the Zernike Institute National Research Centre (incl. associate members). The choice of electives (see Appendix IV) must support the choice of topics for the individually supervised projects, in particular the Master Thesis. The choice of the topics and electives requires consultation with the mentor.

Appendix 3. Programme of the site visit

Day 1	**Thursday 4 April 2024**
15.30 – 15.45	**Arrival and welcome**
15.45 – 16.30	**Panel preparation & consultation hour**
16.30 – 17.30	**Interview programme management**

Day 2	**Friday 5 April 2024**
08.45 – 09.00	**Arrival at Feringa building**
09.00 – 10.30	**Interview with students and tour of facilities** Three from each cohort and two recent alumni
10.45 – 11.30	**Interview teaching staff**
11.45 – 12.15	**Interview Board of Examiners**
12.15 – 13.00	**Lunch break**
13.00 – 15.00	**Thematic sessions** ● *Recruiting + Future without Scholarships* ● *Curriculum*
15.00 – 15.45	**Internal panel session**
15.45 – 16.00	**Final interview formal programme management**
16.00 – 17.00	**Composing preliminary findings and oral report**
17.00 – 17.30	**Oral report and conclusion**

Appendix 4. Materials

Prior to the site visit, the panel studied 15 theses of the master's programme Nanoscience. Information on the theses is available from Academion upon request.
The panel also studied other materials, which included:

- Panel report Audit 2018
- Mid-term report Nanoscience 2022
- TER MSc Nanoscience 2023-2024
- Meetings with External Advisory Panel 2019 to 2023
- Annual reports Admissions Board 2019-2022
- Assessment Plans 2022 to 2024
- Thesis and Internship Guide
- Education Monitors 2021 to 2022
- Annual Reports Programme Committee 2020 to 2022
- Annual Reports Board of Examiners 2020 to 2022
- Report Curriculum Committee
- UG assessment policy 2022
- Presentation PB liaisons new UG assessment policy
- Assessment mission and vision guidelines
- Performing quality controls
- Assessment forms research projects
- Labor Market Search for graduates of the past 5 years