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M Mechanical Engineering
University of Groningen

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Project code P2321

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Summary

Standard 1. Intended learning outcomes

The MSc Mechanical Engineering has a unique profile as an engineering programme, being able to connect to other disciplines in a comprehensive university, and being embedded in a regional and national ecosystem of companies that supports the programme. This profile is translated into elaborate intended learning outcomes that are formulated on an academic master's level and aligned with the academic and professional field. The panel encourages the programme to use its strengths to formulate a strong vision on the programme and connect this to a unique selling proposition for prospective students and to further development of the programme. Regarding the learning outcome on business and management, the panel advises to broaden this to a general learning outcome on connecting mechanical engineering to solutions for grand societal challenges.

Standard 2. Teaching-learning environment

The panel concludes that the programme has a coherent curriculum with relevant tracks linked to core courses and projects. Theoretical courses are balanced with individual design and research projects where students apply their knowledge and develop their academic and professional skills. The choice of English as the language of instruction and in the programme name is well justified given the international nature of mechanical engineering, and sufficient attention is paid to the English language skills of the staff. The admission criteria are valid, and the programme is aware of the challenges associated with a diverse student intake. The programme provides appropriate support, facilities, and guidance to all students, including students with functional disabilities. Students praise the personal attention and support due to the small size of the programme. The curriculum is feasible, with issues of requirements and scheduling due to the number of courses shared with other programmes adequately addressed by the programme management.

Possible improvements to the curriculum include more attention to design skills in the preparation of the design project and better embedding of the ILO on business and management in the curriculum. This ILO could be more explicitly linked to grand societal challenges, for example through integration into courses and projects. The panel also recommends working on the ME identity, both in terms of course content and the sense of community among ME students. Students are spread across different tracks, often taking courses with students from other programmes, and the panel found that they would benefit from a stronger sense of belonging. This could take the form of more ME-specific projects and challenges in courses, a stronger narrative for the tracks, and encouraging community building among students. It may also be part of a broader reflection on the programme's curriculum in light of the programme's identity. The teaching staff is well qualified, with sufficient attention paid to teaching professionalization. Students often feel free to ask teaching staff members for help in making curriculum choices, although the panel suggests formalizing this in a system of staff mentors.

Standard 3. Student assessment

The panel found that the programme has a good assessment system, with proper assessment policies and a well-structured set-up with the Course Unit Assessment Overviews. The programme has varied and appropriate assessment methods and a well functioning Board of Examiners that monitors the quality of assessment. To add to this system, the panel suggests setting up a structure of formative assessment in the courses. The final products are graded in an insightful way and are in line with the content of the work. The panel advises to keep paying attention to the substantiation of the grades on the assessment forms.

Standard 4. Achieved learning outcomes

The quality of the final products and the employability of the students in industry and academia are good and show that the graduates achieve the intended learning outcomes of the programme.

Score table

The panel assesses the programme as follows:

Master's programme Mechanical Engineering	
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. ir. Tine Baelmans, chair
Date: 22 January 2025

Peter Hildering MSc., panel secretary

Introduction

Procedure

Assessment

On 18 October 2024, the master's programme Mechanical Engineering of the University of Groningen was assessed by an independent peer review panel as part of the cluster assessment Mechanical Engineering. The assessment cluster consisted of 12 programmes, offered by the University of Twente, the University of Groningen, the TU Delft and the TU Eindhoven. The assessment followed the procedure and standards of the NVAO Assessment Framework for the Higher Education Accreditation System of the Netherlands (April 2024).

Quality assurance agency Academion coordinated the assessment upon request of the cluster Mechanical Engineering. Peter Hildering acted as coordinator and panel secretary. Yannick Slagter and Carlijn Braam also acted as secretaries in the cluster assessment. They have been certified and registered by the NVAO. Peter Hildering acted as panel secretary in the site visit of the University of Groningen.

Preparation

Academion composed the peer review panel in cooperation with the institutions and taking into account the expertise and independence of the members as well as consistency within the cluster. On 28 June 2024, the NVAO approved the composition of the panel. The coordinator instructed the panel chair on her 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 all graduates since the start of the programme. In consultation with the coordinator, the panel chair selected the design and research projects of 15 students. She took the diversity of final grades and examiners into account, as well as the three tracks. Ten theses were selected from the Smart Factories track, four from the Advanced Instrumentation track and one from the Smart and Green Energy Systems track, which is representative of the number of graduates in each track. Prior to the site visit, the programme provided the panel with the project reports and the accompanying assessment forms. It also provided the panel with an information file 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 documentation and the final products, 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 finalized the report, and the coordinator sent it to the Faculty of Science and Engineering and the University of Groningen.

Panel

The following panel members were involved in the cluster assessment:

- Prof. dr. ir. M. (Tine) Baelmans, full professor at the Department of Mechanical Engineering of the KU Leuven (Belgium) [chair];
- Prof. dr. S. (Sören) Östlund, professor of Packaging Technology at the KTH Royal Institute of Technology (Sweden);
- Drs. J.J. (Jan) Steen, independent educational consultant;
- Prof. dr. A. (Atul) Bhaskar, professor in Applied Mechanics at the Faculty of Engineering and Physical Sciences of the University of Southampton (UK);
- Prof. dr. E. (Eilif) Pedersen, professor in Marine Technology at the Department of Marine Technology of the Norwegian University of Science and Technology (Norway);
- Prof. dr. D.J. (Daniel) Rixen, professor in Applied Mechanics at the Technische Universität München (Germany);
- Prof. dr. K. (Kari) Tammi D.Sc., Lic.Sc., M.Sc., professor in Design of Mechatronic Machines at Aalto University (Finland);
- T.W.C. (Thijs) Haartmans BSc., master's student Mechanical Engineering at the TU Eindhoven [student member];
- M. (Maartje) Janszen BSc., master's student Mechanical Engineering at the TU Delft [student member].
- Prof. dr. A.S.J. (Akke) Suiker, professor in Applied Mechanics at the Department of the Built Environment of the TU Eindhoven [referent for TU Delft].

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

- Prof. dr. ir. M. (Tine) Baelmans, full professor at the Department of Mechanical Engineering of the KU Leuven (Belgium) [chair];
- Prof. dr. S. (Sören) Östlund, professor of Packaging Technology at the KTH Royal Institute of Technology (Sweden);
- Drs. J.J. (Jan) Steen, independent educational consultant;
- Prof. dr. A. (Atul) Bhaskar, professor in Applied Mechanics at the Faculty of Engineering and Physical Sciences of the University of Southampton (UK);
- T.W.C. (Thijs) Haartmans BSc., master's student Mechanical Engineering at the TU Eindhoven [student member].

All panel members, the secretary and the institution have signed a statement on impartiality and can confirm that the assessment was carried out in complete independence.

Information on the programme

Name of the institution:	University of Groningen
BRIN-number:	21PC
Address:	Postbus 72, 9700 AB Groningen
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive
Programme name:	M Mechanical Engineering
ISAT number:	60439
Level:	Master
Orientation:	Academic
Number of credits:	120 EC
Specializations or tracks:	Advanced Instrumentation Smart Factories Smart and Green Energy Systems
Location:	Groningen
Mode(s) of study:	Fulltime
Language of instruction:	English
Awarded degree:	MSc.
Submission date NVAO:	1 May 2025

Description of the assessment

Recommendations previous accreditation panel

The panel for the initial accreditation of the programme in 2018 provided several suggestions for improvement, such as making the intended learning outcomes more specific and refining the admission requirements. The panel found that these suggestions have been considered carefully, leading to further improvement of the programme. See for further discussion the respective sections in the report on these topics.

Standard 1. Intended learning outcomes

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

Findings

Profile
The master's programme Mechanical Engineering (ME) at the Faculty of Science and Engineering (FSE) of the University of Groningen (UG) is a two-year master's programme that was launched in 2019-2020. It is part of the Engineering cluster within the faculty, together with the bachelor's and master's programmes in Industrial Engineering & Management and Biomedical Engineering. These five programmes are managed by the Programme Board, consisting amongst others of the five programme directors, and share a Board of Examiners, whereas ME has its own Programme Committee. The programme currently attracts approximately 20-30 students per year, and aims for further growth.

The mission of the programme is to train students in the principles of engineering, science and mathematics, and to teach them to use these principles in the modelling, analysis, design and realization of engineering systems, components and processes. The MSc ME is part of the increased investments in engineering programmes at FSE, and directly aligns with demands from industry and society. It is financially supported by the Sectorplan Techniek as well as the province of Friesland, with the goal of increasing the number of academically trained engineers in the northern part of the Netherlands. This aligns with regional investments that require highly skilled-technical experts, such as those in hydrogen technology and autonomous systems.

Students choose one out of three tracks to further develop their knowledge and skills. These three tracks reflect the industrial and societal relevance in the (northern) Netherlands and are offered in collaboration with academic partners within and outside the UG, as well as local and regional industrial partners.

- *Advanced Instrumentation* focuses on two major themes. The first is radiation instrumentation for science and healthcare, where students study advanced instrumentation for various fields of scientific research and healthcare, for instance for use in proton therapy. This theme is offered in collaboration with the University Medical Center Groningen (UMCG). The second theme is astronomical and space instrumentation, which is offered together with researchers based at the Netherlands Institute for Space Research (SRON) in Groningen and the FSE Kapteyn Institute.
- *Smart Factories* is developed together with companies in the Innovation Cluster Drachten (ICD). ICD brings together multiple smaller and larger companies to develop the factory of the future:

intelligent, connected and customized products. The track focuses on two specialization areas: material engineering (materials for mechanical engineering) and production and automation technologies (mechatronics, robotics and smart systems). The track is offered by FSE researchers based at the Engineering and Technology Institute Groningen (ENTEG) and the Zernike Institute for Advanced Materials (ZIAM).

- *Smart and Green Energy Systems* covers technologies for the production, storage and distribution of energy from renewable sources, with special focus on electrochemical systems for a hydrogen-based economy and renewable energy systems such as wind and wave energy. Education is provided by researchers from the Energy and Sustainability Research Institute Groningen (ESRIG), with contributions from ENTEG. This track aligns with the Energy focal point of the UG, and is associated with the Energy Academy Europe, an international centre of excellence on the energy transition in which the university participates.

The panel commends the programme for its unique profile as an engineering programme in a comprehensive university. This means that the programme can relatively easily connect to fields such as medicine, environmental science and astronomy, which is demonstrated in the specialization opportunities. The panel also found the programme to be well embedded in regional and national industry, with participation and funding from multiple companies in the northern part of the Netherlands as well as the national sector plan. This provides the programme with natural partners in the further development of the programme.

During the site visit, the panel spoke with several programme representatives about the vision and growth strategy of the programme. Over the past five years, the programme has increasingly carved out its own identity within the faculty, giving shape to its own engineering courses and developing the Smart and Green Energy Systems track. Due to the relatively low student numbers this is a steady but slow process, as the programme is still reliant on the course offering and expertise available within other programmes at FSE for part of its curriculum. The panel was pleased to learn that the programme has been able to hire additional staff specific for mechanical engineering and research, which it considers to be an important step in the further development of the programme's identity. The panel encourages the programme to use this opportunity to reflect on its vision for the programme and translate this in a unique selling proposition for prospective students. According to the panel, the embedding in a comprehensive university and focus on societal challenges could be elements in this unique selling proposition.

Intended learning outcomes

The programme goals have been translated into a set of 18 intended learning outcomes (ILOs), grouped under the five Dublin descriptors. The learning outcomes are formulated in such a way that students gain the required skills, knowledge and attitudes and values necessary to realize the overall programme goals. The ILOs are the same for each track, with the exception of a track-specific learning outcome that describes the knowledge related to the content of the track.

The panel has reviewed the ILOs and concludes that they provide a sophisticated overview of the knowledge and skills required of an ME graduate. The alignment with the Dublin descriptors demonstrates the academic orientation and master's level of the programme. The initial accreditation panel recommended that the ILOs be made more specific to the programme, which the panel notes with appreciation has been taken up, resulting in a programme-specific set of ILOs that reflect the nature of the field of mechanical engineering. For future development, the panel believes that reflection on the programme's vision, as discussed under "Profile," could provide an opportunity to further sharpen the ILOs to reflect that vision. If formulated in a concise manner, these ILOs could be used to support decisions on how to develop the curriculum.

During the site visit, the panel spoke with management, staff and students about ILO 1.5 (knowledge about business and management), as students mentioned in the student chapter that this part of the programme felt disconnected with the rest of the programme (see also 'Curriculum' under standard 2). The panel suggests expanding the content of this ILO to a wider goal of being able to connect mechanical engineering to societal challenges. This would then include not only knowledge on business and management, but also on for instance 21st century skills, sustainable and inclusive design and contribution of solutions towards grand societal challenges. Examples of relevant skills are for instance cross-cultural communication, innovative and creative thinking, and social responsibility. This should be accompanied by an integration of these aspects into the curriculum, which will be further discussed under standard 2.

The panel learnt that the programme keeps its ILOs aligned to the field through the domain-specific framework of reference, as well as an external advisory board with representatives from industry. The panel concludes that the connection the programme maintains with the academic and professional field keeps the programme well aligned with international conventions in mechanical engineering.

Considerations

The MSc Mechanical Engineering has a unique profile as an engineering programme, being able to connect to other disciplines in a comprehensive university, and being embedded in a regional and national ecosystem of companies that supports the programme. This profile is translated into elaborate intended learning outcomes that are formulated on an academic master's level and aligned with the academic and professional field. The panel encourages the programme to use its strengths to formulate a strong vision on the programme and connect this to a unique selling proposition for prospective students and to further development of the programme. Regarding the learning outcome on business and management, the panel advises to broaden this to a general learning outcome on connecting mechanical engineering to solutions for grand societal challenges.

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

The curriculum consists of core courses (30 EC), electives (30 EC), a research project (40 EC) and a design project (20 EC). In their first year, students take core courses and electives. The *core courses* are divided into three ME core courses taken by all students (Introduction to Data Science, Computational Solid Mechanics and Experimental Design), and three track-specific core courses dependent on the track of choice. The core courses are built up around fundamental research, and provide a theoretical basis as well as computer lab experience, such as simulations, algorithms and computer coding. Students complement this with six *electives*, five of which are selected within the context of the track, and one is required to be a broadening elective related to business, management and society. In the Smart Factories track, students can use the electives to further specialize in either Materials for Mechanical Engineering or Robotics, Mechatronics & Smart Systems, each through a package of three electives.

In the second year, students execute a research project and the design project. Both are considered to be final products of the programme. The *design project* is usually executed at a company in the form of an internship, and requires students to develop their practical skills in a project in the industrial sector that requires the design of a new process, system or component. The programme organizes a matchmaking event twice a year where ME students can meet companies at the Innovation Cluster Drachten to explore possibilities for design projects. Students are supervised by a daily supervisor at the internship company, and an internal supervisor from within the programme, who is also responsible for grading. The *research project* is executed in one of the engineering research groups at FSE associated with the track of the student, and consists of an academic research project supervised by an FSE researcher. Parallel to the research projects, students follow a trajectory with training in literature research, scientific writing, ethics, data management and presenting.

The panel studied the set-up and content of the curriculum. It appreciates the design of the curriculum, with a common core and tracks related to the research expertise of the faculty. Two of the three core courses are unique to ME students, as are the track core courses. The other courses are taken from other MSc programmes, such as Chemical Engineering for some of the Smart and Green Energy Systems courses, and Astronomy and Applied Physics for the Advanced Instrumentation track. The panel found that the design and research projects complement the core courses, allowing students to apply their knowledge and skills to a relevant topic, thus linking the curriculum components into a coherent unit.

Following the discussion in standard 1 on the vision and identity of the programme, the panel believes that the programme is entering a phase of its development where there is an opportunity to revisit the original design of the curriculum. This means determining how the curriculum can be modified to better align with the programme's intended identity. This reflection should include the content of the core courses as well as the choice of specializations and electives. Some students commented that they sometimes miss a clear ME identity in their track courses, as they are often a minority in courses that are mostly tailored to other MSc programmes. The panel believes that a stronger track narrative and identity could help students to see the bigger picture for their track, which is greater than the sum of the individual courses. The discussion below mentions several other possible elements of such changes, for instance more ME-specific projects and integration of societal challenges into courses.

The curriculum balances theoretical and practical content, with application most visible in the design and research project in the second year. The panel appreciates the attention given to large individual projects in the curriculum, which allow students to develop both their design skills in an external context and their research skills in a research environment. During a tour as part of the site visit, the panel had the opportunity to visit some of the labs that host student projects. The panel was positive on these research facilities, which provided ample opportunities for students to work on engineering projects. The panel also welcomes the attention to academic and professional skills that students learn in parallel with these projects. Regarding design skills, the panel heard that the programme assumes that students have learned design methodology in their BSc programme. The panel considers this to be valid in principle, although students could benefit from a review and elaboration of their design skills before they engage in the design project. The panel suggests that this be introduced earlier in the curriculum in one of the courses or in the early stages of the design project. The panel noted that some students would prefer more engineering projects within the courses. The teaching staff and programme management explained that they agree that more projects would be desirable, but that this is not always feasible because several courses are taken with students from other, sometimes non-engineering, master's programmes. The panel understands this limitation, but believes that there are ways around it, such as adding ME-specific projects to broader courses. This could

also help to improve the identity of the programme as a whole and its specializations, as well as the sense of belonging of ME students (see 'Feasibility and guidance').

As discussed under standard 1, some students feel that the business and management learning objective is disconnected from the rest of the curriculum. This is currently implemented as a restricted elective where students choose one of five courses related to business, management, environment or sustainability. The panel suggests that this element be integrated more throughout the curriculum, rather than being confined to a specific course. Consistent with its recommendation in standard 1 to expand this ILO to include attention to societal grand challenges, the panel believes that this could be accomplished, for example, by linking existing courses and projects more closely to global challenges. The proposed additional attention to projects in courses could provide even more opportunities to do this.

Language of instruction
The language of instruction, as well as the name of the programme, is English. The programme is designed to prepare students for careers in research/design in academia or industry, both of which often operate in an international context. Even the smaller regional companies involved in the programme operate in a global world via supply chains, customer relations and international staff, and therefore expect their employees to be proficient in English. For new scientific staff, proficiency in English is one of the selection criteria. Existing staff are supported through English courses and coaching on the job if this is deemed necessary by the teacher or the programme director. The panel approves of the choice of English language education for the programme. It confirms the programme's rationale that this corresponds to the nature of mechanical engineering as an internationally oriented field. It appreciates the attention to and monitoring of English level proficiency of the teaching staff.

Admission
The programme admits students from multiple engineering bachelor's degrees, including (Applied) Physics, Astronomy, (Applied) Mathematics and Industrial Engineering & Management (IEM). Students with a hbo bachelor's degree are required to follow a pre-master. Depending on the content of the bachelor's, demonstrable pre-knowledge on specific knowledge and skills is applicable, which is checked by an Admissions Committee consisting of staff members of the programme. The entry requirements were updated in 2023, based on a reflection of the admission criteria advised by the panel of the initial accreditation. It was concluded that several groups of students would benefit from a better preparation for the content of the curriculum. This resulted in extra requirements for several bachelor's backgrounds, an expansion of the pre-master for hbo-graduates and the introduction of a minor for bachelor's students IEM in which they can follow several fundamental courses in mechanical engineering to better prepare them for the programme.

The panel concludes that the admission requirements are appropriate, and that the adaptations made in response to the recommendations during the initial accreditation are an improvement, particularly the check on specific knowledge and skills by the Admissions Committee, the introduction of a broader premaster for hbo students and a minor for IEM students. In discussing the heterogeneity of the intake with students and staff, the panel noted with appreciation that the programme addresses this by providing additional literature and tutorials for students in the early stages of the first semester courses. To ensure that students have the opportunity to address any remaining gaps in their knowledge. The panel advises to keep this topic on the agenda, as this remains a continuous point of attention given the heterogeneous intake of the programme.

Feasibility and guidance

The programme aims for a curriculum that spreads workload evenly, and avoids excessive workload peaks. Students have control over their own workload by scheduling their elective courses in a way that suits their ambitions and planning. In the past cohorts, approximately one-third of the students graduates within two years, and 80% of all students within three years. Students are generally satisfied with the feasibility of the programme, although the student chapter mentioned that the scheduling of electives can be complex, leading to either less elective options or an extended study duration. The panel was happy to learn that both issues were already being addressed at the time of the site visit. A recent 'heidag' was organized by the programme management, where staff members aligned the content and requirements of their courses. Overall, the panel is positive on the feasibility of the programme, although still being in an early phase in its development, the programme should keep monitoring this to ensure that new issues do not arise.

Students are supported and guided through several measures throughout the curriculum. The study advisor organizes information sessions to help students to select electives in the first year and to choose a research and design project in the second year. The study advisor is also the first point of contact for students with a functional impairment. The UG has various arrangements and facilities available, such as extra studying and examination facilities, which are implemented based on student needs. After its conversations with staff and students, the panel learnt that students feel that they are well guided and supported by the programme, most prominently due to the small-scale of the programme. Also, there is proper support and facilities in place for students with a functional impairment. Students report that they are very satisfied with the personal attention and support in the programme, mentioning that their teaching staff and the programme management knows students by name. They feel that they can easily give feedback, both informal as through formal channels, which is used for continuous improvement of the programme. The abovementioned addressing of issues concerning scheduling of electives and prerequisites for courses is a good example of this.

Next to the support by the study advisor, the panel considers that students might benefit from a strengthening of the mentoring programme. The panel understood that the programme has a student mentor that provides information to new student in the first weeks of the programme, and can be approached for further support. The panel suggests that the role of student mentors could be strengthened to include mentoring at an individual level, for example in a buddy system. Furthermore, this could also promote a stronger community of ME students (see below). A staff mentor could be used for helping students with making curriculum choices in relation to their interests and career ambitions. The panel learnt from students that they often approach a staff member on their own initiative for advice. The panel finds this commendable, but considers that embedding this in a formal structure would be helpful, especially for students that are more hesitant to approach a teaching staff member on their own.

Another point raised by students during the site visit is that they sometimes lack a sense of belonging to the programme. Students come from a variety of bachelor's programmes and only meet as a cohort for a handful of core and track courses and sometimes for informal events. The rest of the curriculum is either individual or shared with a variety of other MSc programmes, where ME students are often a minority in the classroom. The panel believes that it would be advisable for the programme to invest in creating a stronger community of ME students. This could be approached by creating more shared ME curriculum elements wherever possible, and by the above-mentioned reflection on the identity of the programme. The panel also recommends that attention be paid to the deliberate composition of project groups. By deliberately mixing different groups of ME students such as Dutch and international students and students with different BSc backgrounds, they have more opportunities to meet and work with their fellow ME students. Finally, the panel suggests providing a common space in the building for ME students, especially for those working on

their individual projects. It understands that other programmes have such spaces, but that ME has not been able to secure this due to space constraints. The panel hopes that the planned move to a new building in the near future will provide new opportunities for this.

Teaching staff

The programme is taught by teaching staff associated with various science and engineering institutes of FSE. At the start of the programme, new staff was appointed specifically to strengthen research and teaching associated with the master's programme, for instance in the field of hydrogen technology. This new staff is mainly involved in electives and project supervision, and will increasingly be involved in the teaching of core courses. All teaching staff members hold a University Teaching Qualification (UTQ) or are in the process of obtaining this, in line with the requirement by the UG. The panel is positive on the quality of the teaching staff. It noted from the interviews that the staff is very committed, and proud of the programme and its students. The staff members have relevant research expertise, allowing them to connect research and teaching in their courses. The panel appreciates the attention to teacher professionalization, both the compulsory UTQ for new teaching staff members and voluntary professionalization activities on for instance teaching methods and innovations for more experienced staff members.

Considerations

The panel concludes that the programme has a coherent curriculum with relevant tracks linked to core courses and projects. Theoretical courses are balanced with individual design and research projects where students apply their knowledge and develop their academic and professional skills. The choice of English as the language of instruction and in the programme name is well justified given the international nature of mechanical engineering, and sufficient attention is paid to the English language skills of the staff. The admission criteria are valid, and the programme is aware of the challenges associated with a diverse student intake. The programme provides appropriate support, facilities, and guidance to all students, including students with functional disabilities. Students praise the personal attention and support due to the small size of the programme. The curriculum is feasible, with issues of requirements and scheduling due to the number of courses shared with other programmes adequately addressed by the programme management.

Possible improvements to the curriculum include more attention to design skills in the preparation of the design project and better embedding of the ILO on business and management in the curriculum. This ILO could be more explicitly linked to grand societal challenges, for example through integration into courses and projects. The panel also recommends working on the ME identity, both in terms of course content and the sense of community among ME students. Students are spread across different tracks, often taking courses with students from other programmes, and the panel found that they would benefit from a stronger sense of belonging. This could take the form of more ME-specific projects and challenges in courses, a stronger narrative for the tracks, and encouraging community building among students. It may also be part of a broader reflection on the programme's curriculum in light of the programme's identity. The teaching staff is well qualified, with sufficient attention paid to teaching professionalization. Students often feel free to ask teaching staff members for help in making curriculum choices, although the panel suggests formalizing this in a system of staff mentors.

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

System of assessment

Assessment in the MSc ME is described in the annual assessment plan that the programme director and coordinator compose each year. This plan describes which learning outcomes are assessed in which courses, detailed for each of the three tracks. Coordinators of individual courses compose a Course Unit Assessment Overview (CUAO) that describes the course learning goals and how all learning goals are assessed with the various assessment moments in the course. The programme has a variety of assessment methods, such as written exams, oral exams, reports, presentations and practical work, which are used dependent on the specific learning outcomes that are being assessed. To ensure the quality of course assessment, each course has two examiners assigned that can implement the four-eyes principle on all tests and assignments. Other quality assurance policies include the clear communication of requirements to students prior to an exam or assignment, and attention to individual grading in the case of group projects to prevent freeriding.

The programme shares a Board of Examiners with the other programmes in the Engineering cluster at FSE. It advises the programme management on the quality of assessment and has several checks in place to monitor assessment quality. Its activities include advising the programme management on the annual assessment plan, checking the CUAO's of every course, and verifying the quality of tests as well as the final works based on an annual sample.

Based on the review of the assessment system and related documents, as well as interviews with staff, students, and the Board of Examiners, the panel concludes that the programme has a good assessment system. The system is well structured by the CUAOs and the assessment methods are varied and appropriate to the learning objectives of the course. The programme uses appropriate quality assurance measures, such as peer review of tests and a mix of group and individual assessments. From the interview with the Board of Examiners, the panel noted that the Board monitors the quality of assessment in the programme well and performs its duties in a professional manner. During the site visit, the panel discussed a comment made in the student chapter that more formative assessment and feedback would be welcome. The panel was assured that teaching staff members often provide informal feedback to students, but believes that this could be more structured as it is now often based on student requests. The panel therefore recommends that more attention be paid to the implementation of formative practice aimed at providing all students with timely and concrete feedback during the learning process throughout the courses. This could be organized, for example, by explicitly scheduling mid-term formative assessment or feedback moments in courses.

Assessment design and research project

The design and research project are the final products of the MSc ME. Both are assessed through similar procedures. Two examiners, one of which is the student's internal supervisor, independently grade the project report, and give a grade on each of the criteria. The weighted average of these grades forms the final grade of the student. For the design project, the criteria are split between design plan (35%), design analysis (35%), the final presentation (10%), the final report (10%) and project management (10%). For the research project, these are research quality (50%), project management (25%), the final presentation (12.5%) and the final report (12.5%) . Each of the criteria is split into several sub-criteria to help examiners to determine their score for that aspect, and examiners are required to substantiate their grade per criterium with a written justification. If the grades differ more than 1 point, the examiners discuss the result to come to a consensus.

In the case of persisting disagreement, a third party assigned by the Board of Examiners determines the final grade. For external projects, most prominently the design project, the daily supervisor from the internship organization advises the examiners on the performance of the student on daily practice. The same procedure applies for internal projects when the daily supervisor is no formal examiner, but for instance a PhD student.

The panel concludes that the grading of the final products is set up in a valid, reliable and transparent way. Using two different products, students can demonstrate both their design and research skills. The panel appreciates that two RUG examiners are always involved in grading and that there are clear criteria for both products. These measures, along with the aforementioned check on thesis quality by the Board of Examiners, contribute to the calibration of grades. Prior to the site visit, the panel examined the assessment of the design and research products of 15 students and found the grades to be appropriate and generally consistent with the content of the work and the comments on the assessment form. For a small number of products, the panel found that the justification for the grades on the assessment forms was rather short. It was pleased to learn that the Board of Examiners recognized this from its sample of dissertation evaluations and that the programme management is already working on refining the rubrics to make them more fit for purpose in helping examiners provide rationale for their grading.

Considerations

The panel found that the programme has a good assessment system, with proper assessment policies and a well-structured set-up with the Course Unit Assessment Overviews. The programme has varied and appropriate assessment methods and a well functioning Board of Examiners that monitors the quality of assessment. To add to this system, the panel suggests setting up a structure of formative assessment in the courses. The final products are graded in an insightful way and are in line with the content of the work. The panel advises to keep paying attention to the substantiation of the grades on the assessment forms.

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

As part of the preparation for the site visit, the panel studied the design and research projects of 15 graduates. It concludes that all products are of a good quality and clearly reflect the required master's level in all three master's tracks. The panel appreciated the interesting engineering challenges that students have worked on.

The first indication of the employment of graduates after education is that most graduates end up in industry, often at one of the regional companies they encountered during their internship or at the matchmaking events with industry organized by the programme. Examples of positions are (mechanical) engineer, consultant or r&d scientist. Approximately 10% of the first three cohorts continued as PhD or EngD researcher. The panel was happy to see the high demand for graduates from industry, which shows that the programme delivers qualified engineers and fulfils an important need in the region. It also appreciated the relatively high number of students interested in PhD and EngD programmes, which also shows the research competencies of students.

Considerations

The quality of the final products and the employability of the students in industry and academia are good and show that the graduates achieve the intended learning outcomes of the programme.

Conclusion

The panel concludes that the programme meets standard 4.

General conclusion

The panel's assessment of master's programme Mechanical Engineering is positive.

Recommendations

1. Further develop the vision of the programme and use it to formulate a unique selling proposition to prospective students and to guide programme development.

2. Expand the business and management learning outcome to connect engineering to solutions for grand societal challenges, and better integrate this in the curriculum, for instance through programme-specific projects.

3. Introduce design skills earlier in the curriculum, in one of the courses or in the early stages of the design project.

4. Work on the ME identity and sense of community, for instance by creating more ME-specific projects, a stronger narrative for the tracks and by encouraging community building among students.

Appendix 1. Intended learning outcomes

After the completion of a master's degree programme in Mechanical Engineering, the graduate is expected to attain the following learning outcomes.

1. On knowledge and understanding the graduate:
1.1. Has knowledge of the underlying concepts of mechanical engineering, including the necessary physics, mathematics and computer science, at a level that permits admission to a higher level post-graduate programme.
1.2. Is familiar with the quantitative character of mechanical engineering and with the relevant research methods.
1.3. Has operational knowledge and design skills in the field of mechanical engineering.
1.4. Has a thorough understanding of:
a. advanced instrumentation (For Advanced Instrumentation Track).
b. smart processes, engineering materials and products (For Smart Factories Track).
c. process design for energy systems (For Smart and Green Energy Systems Track).
1.5. Has knowledge in the field of business and management.

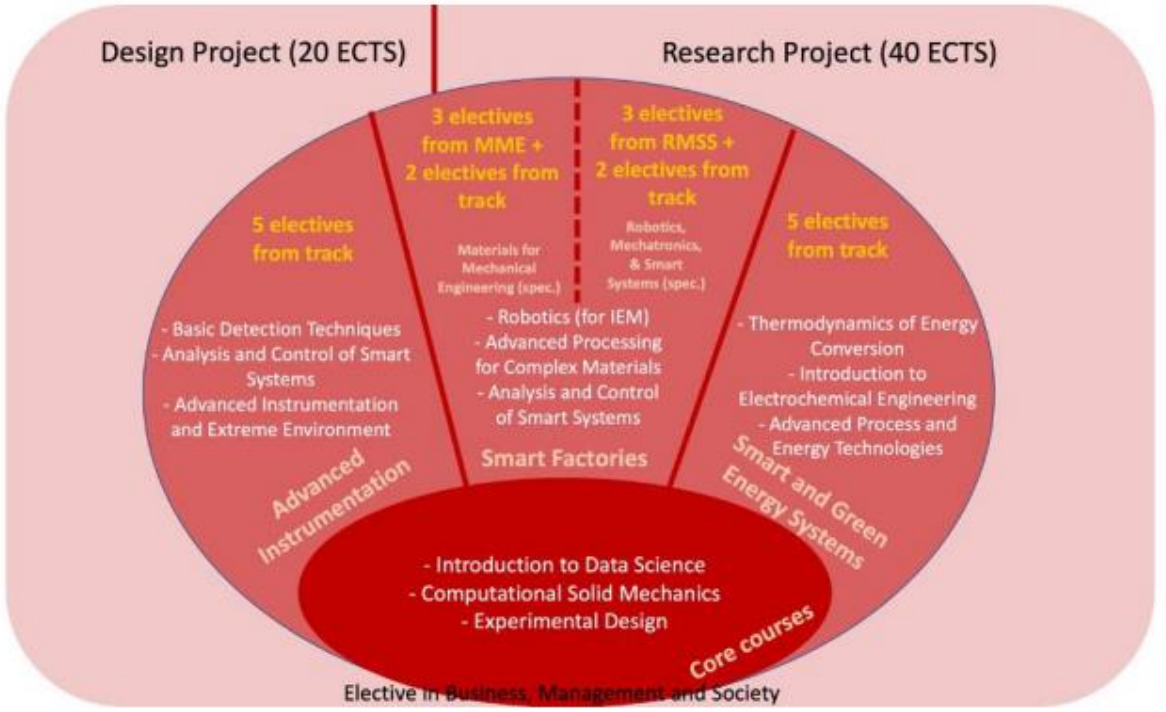
2. On the synthesis and application of knowledge and understanding the graduate:
2.1. Is able to carry out research in order to understand phenomena that are usable in developing mechanical engineering applications.
2.2. Is able to analyse a (new) complex applied problem, and develop a structured and well-planned approach to search for a solution.
2.3. Is able to apply his/her mechanical engineering knowledge and skills in his/her own and related subject areas.
2.4. Is able to seek new applications for mechanical engineering concepts.
2.5. Is able to use advanced instrumentation and/or advanced programming tools.
2.6. Is able to apply mechanical engineering concepts in an industrial environment or in an international mechanical engineering research environment.
2.7. Is able to collaborate in a (multi-disciplinary) international research and design team.

3. On reasoning and judgement the graduate:
3.1. Is able to obtain relevant information using modern information channels, and interprets this information critically for specific use in mechanical engineering research.
3.2. Judges his/her and others' actions within a scientific context, taking societal and ethical aspects into account.
3.3. Is able to draw conclusions on the basis of limited or incomplete information, and realizes and formulates the limitations of such conclusions.

4. On communication skills the graduate:
4.1. Is able to communicate clearly, verbally and in writing, on his/her subject and relevant applications, at different levels understandable to experts and non-experts using relevant communication tools.

5. On learning skills the graduate:
5.1. Is able to address issues inside as well as outside his/her main subject area, therefore and thereby gaining new knowledge and skills.
5.2. Is able to familiarize him/herself with recent advances in science and engineering and use them in mechanical engineering applications.

Appendix 2. Programme curriculum



Track Advanced Instrumentation

Ia	Ib	IIa	IIb
Introduction to Data Science (WMME027-05)	Computational Solid Mechanics (WMME028-05)	Analysis and control of smart systems (WMIE015-05)	Experimental Design (WMME012-05)
Basic Detection Techniques (WMAS002-05)	Microfluidics (WMME020-05)	Advanced Instrumentation and Extreme Environments (WMME006-05)	Medical Imaging Instrumentation (WMME014-05)
Bio-signal processing for human machine interaction (WMBE026-05)	MEMS, NEMS and Nanofabrication (WMIE010-05)	Product design by the Finite Element Method (WMIE003-05)	Opto-Mechatronics (WMME015-05)
Robotics for IEM (WMIE005-05)	Advanced Detection Techniques (WMME005-05)	Advanced Vibration (WMME030-05)	Systems Engineering (WMIE021-05)
Space Mission Technology (WBAS003-05)	Fitting Dynamical Models to Data (WMIE007-05)	Applied Optics (WMME010-05)	Data-driven optimization (WMME011-05)
Multibody and Non-Linear Dynamics (WMME009-05)	Surface Engineering and Coating Technology (WMIE013-05)	Modeling and Control of Complex Nonlinear Engineering System (WMMA020-05)	Sustainable Industrial Practice (WMIE027-05)
Scientific Visualization (WMCS018-05)	Multiscale Contact Mechanics and Tribology (WMIE011-05)	Finite Element Methods for Fluid Dynamics (WMMA016-05)	
Technology based entrepreneurship (WMIE006-05)	Engineering Design Integration (WMIE029-05)	Coupled Problems (WMMA052-05)	
		Global Change (WMEE008-05)	

Compulsory courses for all tracks
Track-specific mandatory courses
Processes and Electrochemical Systems
Renewable Energy Systems
Business, Management and Society

Track Smart Factories - Materials for Mechanical Engineering specialization

Ia	Ib	IIa	IIb
Introduction to Data Science (WMME027-05)	Computational Solid Mechanics (WMME017-05)	Analysis and control of smart systems (WMIE015-05)	Experimental Design (WMME012-05)
Robotics for IEM (WMIE005-05)	Advanced Processing for Complex Materials (WMME007-05)	Smart Materials for Engineering (WMME021-05)	Fracture of Materials (WMME023-05)
Multibody and Non-Linear Dynamics (WMME009-05)	Multiscale Contact Mechanics and Tribology (WMIE011-05)	Advanced Vibration (WMME030-05)	Composites and Metamaterials (WMME031-05)
Basic Detection Techniques (WMAS002-05)	Surface Engineering and Coating Technology (WMIE013-05)	Coupled Problems (22/23) (WMMA052-05)	Polymer Physics (WMCH025-05)
Convex Optimization (WMMA006-05)	Engineering Design Integration (WMIE029-05)	Product design by the Finite Element Method (WMIE003-05)	Opto-Mechatronics (WMME015-05)
Bio-signal processing for human machine interaction (WMBE026-05)	Microfluidics (WMME020-05)	Modeling and Control of Complex Nonlinear Engineering System (WMMA020-05)	Systems Engineering (WMIE021-05)
Scientific Visualization (WMCS018-05)	MEMS, NEMS and Nanofabrication (WMIE010-05)	Convex Analysis (WMMA060-05)	Data-driven optimization (WMME011-05)
Technology based entrepreneurship (WMIE006-05)	Fitting Dynamical Models to Data (WMIE007-05)	Global Change (WMEE008-05)	Sustainable Industrial Practice (WMIE027-05)
	Robotics for AI (WMAI011-05)		

Track Smart Factories - Robotics, Mechatronics and Smart Systems specialization

Ia	Ib	IIa	IIb
Introduction to Data Science (WMME027-05)	Computational Solid Mechanics (WMME017-05)	Analysis and control of smart systems (WMIE015-05)	Experimental Design (WMME012-05)
Robotics for IEM (WMIE005-05)	Advanced Processing for Complex Materials (WMME007-05)	Modeling and Control of Complex Nonlinear Engineering System (WMMA020-05)	Systems Engineering (WMIE021-05)
Multibody and Non-Linear Dynamics (WMME009-05)	MEMS, NEMS and Nanofabrication (WMIE010-05)	Smart Materials for Engineering (WMME021-05)	Data-driven optimization (WMME011-05)
Bio-signal processing for human machine interaction (WMBE026-05)	Fitting Dynamical Models to Data (WMIE007-05)	Advanced Vibration (WMME030-05)	Opto-Mechatronics (WMME015-05)
Basic Detection Techniques (WMAS002-05)	Robotics for AI (WMAI011-05)	Product design by the Finite Element Method (WMIE003-05)	Polymer Physics (WMCH025-05)
Convex Optimization (WMMA006-05)	Microfluidics (WMME020-05)	Convex Analysis (WMMA060-05)	Composites and Metamaterials (WMME031-05)
Scientific Visualization (WMCS018-05)	Multiscale Contact Mechanics and Tribology (WMIE011-05)	Coupled Problems (22/23) (WMMA052-05)	Fracture of Materials (WMME023-05)
Technology based entrepreneurship (WMIE006-05)	Surface Engineering and Coating Technology (WMIE013-05)	Global Change (WMEE008-05)	Sustainable Industrial Practice (WMIE027-05)
	Finite Elements Methods and Applications (WMMA051-05		
	Engineering Design Integration (WMIE029-05)		

Track Smart and Green Energy Systems

Ia	Ib	IIa	IIb
Introduction to Data Science (WMME027-05)	Computational Solid Mechanics (WMME017-05)	Hydrogen, Fuels and Electrolysers (WMME019-05)	Experimental Design (WMME012-05)
Electrochemical Systems and Engineering (WMME029-05)	Thermodynamics of Energy Conversion (WMME018-05)	Sustainable Electric Energy Storage (WMCH029-05)	Advanced Process and Energy Technologies (WMCE012-05)
Interfacial Engineering (WMCE003-05)	Microfluidics (WMME020-05)	Processes, Energy and Materials Modelling (WMEE016-05)	Fuel Cell Systems (WMEE015-05)
Multibody and Non-Linear Dynamics (WMME009-05)	Photovoltaics Science and Energy (WMCH011-05)	Analysis and control of smart systems (WMIE015-05)	Fracture of Materials (WMME023-05)
Technology based entrepreneurship (WMIE006-05)	Surface Engineering and Coating Technology (WMIE013-05)	Modeling and Control of Complex Nonlinear Engineering System (WMMA020-05)	Systems Engineering (WMIE021-05)
	Finite Element Methods and Applications (WMMA051-05)	Advanced Vibration (WMME030-05)	Capita Selecta in Ocean Energy (WMME033-05)
	Engineering Design Integration (WMIE029-05)	Coupled Problems (22/23) (WMMA052-05)	Sustainable Industrial Practice (WMIE027-05)
		Global Change (WMEE008-05)	

Appendix 3. Programme of the site visit

Friday 18 October 2024

08.30 - 09.00	Arrival and panel preparation
09.00 - 09.45	Interview management
10.00 – 10.45	Interview teaching staff
10.45 – 11.00	Break
11.00 – 12.30	Tour of the facilities (45 min) followed by student interview (45 min)
12.30 – 13.15	Lunch break
13.15 – 13.45	Interview Board of Examiners
14.00 – 15.00	Thematic session
15.00 - 16.00	Internal panel meeting
16.00 - 16.15	Final interview management
16.15 - 17.00	Finalizing panel conclusions and preparing oral feedback
17.00 - 17.15	Oral feedback and conclusion

Appendix 4. Materials

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

- Initial accreditation report
- Curriculum committee report
- ME curriculum
- Design Project companies
- Admissions checklist ME
- Student intake data and statistics
- Pre-masters programme for HBO Mechanical Engineering
- Entry requirements
- Education monitor
- Annual report Programme Committee
- Annual report Board of Examiners
- Mid-term report
- Assessment methods
- UG assessment policy
- Implementation process assessment policy
- Assessment plan 2023-2024
- Teaching and Examination Regulations (TER) 2024-2025
- Assessment form Research Project
- Assessment form Design Project
- Draft assessment form first and second examiner
- Draft rubric research project
- Outcomes of the degree programme
- NSE results
- Vision on AI in education