Assessment report
Limited Framework Programme Assessment

Master Chemical Engineering

Delft University of Technology

Contents of the report

1. Executive summary

In this executive summary, the panel presents the main considerations, which led to the assessment of the quality of the Master Chemical Engineering programme of Delft University of Technology. The programme was assessed according to the standards of the limited framework, as laid down in the NVAO Assessment framework for the higher education accreditation system of the Netherlands, published on 20 December 2016 (Staatscourant nr. 69458).

The panel considers the programme objectives to be sound and appreciates the breadth of the programme. Students are educated comprehensively in the chemical engineering discipline. The panel welcomes the programme addressing the research and more practical, industry-related dimensions as well as the chemistry and chemical engineering dimensions of the discipline. The panel feels that these dimensions are well-balanced, but endorses programme management's intentions to emphasise the chemical engineering somewhat more, compared to the chemistry and research dimensions. The panel regards the programme profile to be well-delineated, but suggests to clarify this profile further in relation to other Dutch and foreign programmes.

The objectives of the programme are within the boundaries of the domain-specific reference framework for academic chemical sciences programmes. The panel appreciates the efforts by the joint programmes in chemical sciences in the Netherlands to draft this framework and regards this as a sound and up-to-date description of this domain. The profile of this Delft University of Technology programme may be clearly distinguished within the framework. The panel appreciates the programme meeting international domain-specific standards in chemical engineering.

The programme is well-aligned with the chemical engineering industry and programme management keeps adequately of current trends in the professional field. Students are educated for a wide range of positions on the labour market.

The intended learning outcomes of the programme are aligned with the objectives, are well-articulated and conform to the master level.

The panel is positive about the substantial number of incoming students in the programme and notes the number being within programme capacity limits. The panel advises to be pro-active in adjusting facilities and lecturers' numbers to further increasing student numbers.

The curriculum matches the programme intended learning outcomes. The contents of the curriculum are appreciated by the panel, the courses being solid and up-to-date. The curriculum is coherent, the courses and other curriculum components being balanced. The coherence especially balances the study load in the first part of the curriculum. The specialisations are well-chosen and have been well-integrated in the curriculum. The panel appreciates the Design Project and the internship, allowing students to become acquainted with the professional field. The panel suggests to give students opportunities to do more extensive internships to meet industry demands. Although the academic skills are appropriately addressed in the curriculum, the panel advises to bring them together in one teaching-learning trajectory to optimise academic skills training. The panel proposes to add industry-related subjects to emphasise the chemical engineering profile, as programme management intends to do.

The lecturers in the programme are well-reputed researchers. Their motivation and educational capabilities are definitely up to standard. The support staff of the programme is very effective.

The entry requirements and admission procedures are adequate. Incoming students are well-informed about the programme. The panel finds the international students to be integrated well in the programme.

The study methods of the programme are appropriate, promoting student-active learning processes. The students-to-staff ratio and the number of hours of face-to-face education in the programme meet the standards. The study guidance by the academic counsellor is appreciated by the panel. Although the programme is challenging, the panel regards the programme to be feasible and the study load to be evenly distributed. The student success rates are favourable.

The panel regards the examination and assessment regulations for the programme to be appropriate. The panel approves of the examination methods adopted in the programme, noting these to be consistent with the goals and the contents of the courses. The panel is positive about measures being taken to counter free-riding in group assignments and to prevent fraud and plagiarism. The supervision and assessment processes for the Master thesis projects are well-organised. The panel welcomes the rubrics scoring form and the academic skills being assessed in the project. The panel considers the measures which have been taken to ensure the validity, reliability and transparency of examinations and assessments to be adequate. The Board of Examiners is active in enforcing these.

The panel supports the grades awarded to the Master thesis projects by the programme examiners. These projects are regarded by the panel to be solid and to be well-elaborated.

The panel is convinced that students having completed the programme reached the intended learning outcomes. The panel is especially very positive about the labour market prospects of the programme graduates and regards their career perspectives to be very favourable.

The panel which conducted the assessment of the Master Chemical Engineering programme of Delft University of Technology assesses this programme to meet the standards of the limited framework, as laid down in the NVAO Assessment framework for the higher education accreditation system of the Netherlands, judging the programme to be good. Therefore, the panel recommends NVAO to accredit this programme.

Rotterdam, 7 March 2019

Prof. dr. M.A. Cohen Stuart
(panel chair)

drs. W. Vercouteren
(panel secretary)

2. Assessment process

The evaluation agency Certiked VBI received the request by Delft University of Technology to support the limited framework programme assessment process for the joint-degree Master Chemical Engineering programme of this University. The objective of the programme assessment process was to assess whether the programme would conform to the standards of the limited framework, as laid down in the NVAO Assessment framework for the higher education accreditation system of the Netherlands, published on 20 December 2016 (Staatscourant nr. 69458).

Management of the programmes in the assessment cluster WO Scheikunde convened to discuss the composition of the assessment panel and to draft the list of candidates.

Having conferred with management of the Master Chemical Engineering programme of Delft University of Technology, Certiked invited candidate panel members to sit on the assessment panel. The panel members agreed to do so. The panel composition was as follows:

- Prof. dr. M.A. Cohen Stuart, professor emeritus, chair of Physical Chemistry & Colloid Chemistry, Wageningen University, professor emeritus of Physical Surface Chemistry, University of Twente, professor East China University of Science and Technology, Shanghai, China (panel chair);
- Prof. dr. A.H.T. Boyen, associate professor emeritus, Faculty of Sciences and Bio-engineering Sciences, Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel (panel member);
- Prof. dr. ir. G.B. Marin, professor of Chemical Reaction Engineering, head Laboratory for Chemical Technology, Ghent University (panel member);
- Prof. dr. R.M.J. Liskamp, professor, chair Chemical Biology and Medicinal Chemistry, School of Chemistry, University of Glasgow, United Kingdom, professor of Molecular Medicinal Chemistry, Utrecht University (panel member);
- Drs. O. de Vreede, head Innovation and Human Capital, VNCI, Association of the Dutch Chemical Industry (panel member);
- A.E.M. Melcherts BSc, student Master in Nanomaterials Science, Utrecht University (student member).

On behalf of Certiked, drs. W. Vercouteren served as the process coordinator and secretary in the assessment process.

All panel members and the secretary confirmed in writing being impartial with regard to the programme to be assessed and observing the rules of confidentiality. Having obtained the authorisation by the University, Certiked requested the approval of NVAO of the proposed panel to conduct the assessment. NVAO have given their approval.

To prepare the assessment process, the process coordinator convened with management of the programme to discuss the outline of the self-assessment report, the subjects to be addressed in this report and the site visit schedule. In addition, the planning of the activities in preparation of the site visit were discussed. In the course of the process preparing for the site visit, programme management and the Certiked process coordinator regularly had contact to fine-tune the process. The activities prior to the site visit have been performed as planned. Programme management approved of the site visit schedule.

Well in advance of the site visit date, programme management sent the list of final projects of graduates of the programme of the most recent years. Acting on behalf of the assessment panel, the process coordinator selected the theses of 15 graduates from the last few years. The grade distribution in the selection was ensured to conform to the grade distribution in the list, sent by programme management.

The panel chair and the panel members were sent the self-assessment report of the programme, including appendices. In the self-assessment report, the student chapter was included. In addition, the expert panel members were forwarded a number of theses of the programme graduates, these theses being part of the selection made by the process coordinator.

Several weeks before the site visit date, the assessment panel chair and the process coordinator met to discuss the self-assessment report provided by programme management, the procedures regarding the assessment process and the site visit schedule. In this meeting, the profile of panel chairs of NVAO was discussed as well. The panel chair was informed about the competencies, listed in the profile. Documents pertaining to a number of these competencies were presented to the panel chair. The meeting between the panel chair and the process coordinator served as the briefing for panel chairs, as meant in the NVAO profile of panel chairs.

Prior to the date of the site visit, all panel members sent in their preliminary findings, based on the self-assessment report and the final projects studied, and a number of questions to be put to the programme representatives on the day of the site visit. The panel secretary summarised this information, compiling a list of questions, which served as a starting point for the discussions with the programme representatives during the site visit.

Shortly before the site visit date, the complete panel met to go over the preliminary findings concerning the quality of the programme. During this preliminary meeting, the preliminary findings of the panel members, including those about the theses were discussed. The procedures to be adopted during the site visit, including the questions to be put to the programme representatives on the basis of the list compiled, were discussed as well.

On 26 September 2018, the panel conducted the site visit on the Delft University of Technology campus. The site visit schedule was as planned. In a number of separate sessions, the panel was given the opportunity to meet with Faculty Board representatives, programme management, Board of Examiners members, lecturers and final projects examiners, and students and alumni.

In a closed session at the end of the site visit, the panel considered every one of the findings, weighed the considerations and arrived at conclusions with regard to the quality of the programme. At the end of the site visit, the panel chair presented a broad outline of the considerations and conclusions to programme representatives.

The assessment draft report was finalised by the secretary, having taken into account the findings and considerations of the panel. The draft report was sent to the panel members, who studied it and made a number of changes. Thereupon, the secretary edited the final report. This report was presented to programme management to be corrected for factual inaccuracies. Programme management were given two weeks to respond. Having been corrected for these factual inaccuracies, the Certiked bureau sent the report to the Board of Delft University of Technology, to accompany their request for re-accreditation of this programme.

3. Programme administrative information

Name programme in CROHO:	M Chemical Engineering
Orientation, level programme:	Academic Master
Grade:	MSc
Number of credits:	120 EC
Specialisations:	Chemical Product Engineering Chemical Process Engineering
Location:	Delft
Mode of study:	Full-time (language of instruction English)
Registration in CROHO:	21PF-60437
Name of institution:	Delft University of Technology
Status of institution:	Government-funded University
Institutions' quality assurance:	Approved

4. Findings, considerations and assessments per standard

4.1 Standard 1: Intended learning outcomes

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

Findings
The Master Chemical Engineering programme is offered by the Faculty of Applied Sciences of Delft University of Technology. The dean of the Faculty has the responsibility for all bachelor, master and PDEng programmes of the Faculty. Research of the Faculty is organised in seven departments, one of which is the Department of Chemical Engineering, contributing the most to this programme. Being assisted by the programme coordinator and the academic counsellor, the director of studies takes care of programme management. The Board of Studies, consisting of an equal number of lecturers and students, advises programme management on quality issues. Students views are collected by means of written surveys and quarterly evaluation lunches. The programme Board of Examiners, acting on behalf of the Faculty Board of Examiners is responsible for ensuring the quality of examinations and assessments of the programme.

The Master Chemical Engineering is a two-year, research-based, academic master programme in chemical engineering. Students in the programme are educated to be responsible researchers or engineers in the discipline of chemical engineering at academic level and to make original contributions to recognising, analysing and solving chemical engineering problems. The programme is positioned at the interface of the chemistry, mathematics, physics and engineering disciplines. The students may select one of the two specialisations offered, being Chemical Process Engineering or Chemical Product Engineering.

The objectives of the programme are conform to the domain-specific reference framework for the chemical sciences in the Netherlands, which has been drafted by the joint programmes of this assessment cluster in the Netherlands. In this domain-specific framework, reference has been made to international frameworks and benchmark statements. This Delft University of Technology programme may be regarded to be positioned in the chemical engineering sub-domain of chemical sciences.

The programme has been accredited by the international Institution of Chemical Engineers (IChemE). The intended learning outcomes of the programme meet the requirements of the European Federation of Chemical Engineering (EFCE).

The programme aims to prepare students for a wide range of industries. Traditionally, graduates were mainly employed by companies in the petroleum industry. Now, they find positions in, among others, the medicine, biomedical, advanced materials, energy, consumer products and environment industries.

The programme maintains intensive contacts with industry, both on the national level and in interaction with chemical engineering companies. Companies are involved in internships and Master thesis projects and part-time professors from industry lecture in the programme.

The programme objectives have been translated into intended learning outcomes. These specify, among others, knowledge and understanding of fundamental principles of the chemical engineering discipline, profound knowledge and understanding in the field of specialisation, knowledge and skills to analyse chemical engineering problems, to solve problems and to design solutions or new products or processes. The intended learning outcomes also include scientific research knowledge and skills in this domain, academic skills, such as communication and collaboration skills, professional and ethical behaviour and competences for continuing education.

Although programme management is content with the current objectives and intended learning outcomes of the programme, they plan to shift the balance somewhat more to the chemical engineering dimensions of the programme vis-à-vis the chemistry and research dimensions of the programme.

Considerations
The panel considers the programme objectives to be sound. The panel appreciates the breadth of the programme, educating students comprehensively in the chemical engineering discipline. The panel welcomes the programme addressing the research and more practical, industry-related dimensions as well as the chemistry and chemical engineering dimensions of the discipline. The panel feels these dimensions to be well-balanced, but endorses programme management's intentions to give the chemical engineering somewhat more emphasis, compared to the chemistry and research dimensions. The panel regards the programme profile to be well-delineated, but suggests to clarify this profile further in relation to other Dutch and foreign programmes.

The objectives of the programme are within the boundaries of the domain-specific reference framework for academic chemical sciences programmes. The panel appreciates the efforts by the joint programmes in chemical sciences in the Netherlands to draft this framework and regards this to be a sound and up-to-date description of this domain. The profile of this Delft University of Technology programme may be clearly distinguished within the framework.

The panel appreciates that the programme is meeting international domain-specific standards in chemical engineering.

Students are educated for a wide range of positions on the labour market. The programme is well-aligned with the chemical engineering industry, allowing programme management to keep track of current trends in the professional field.

The objectives meet the intended learning outcomes of the programme. The panel regards the intended learning outcomes as well-articulated. The intended learning outcomes are conform to the master level.

Assessment of this standard
These considerations have led the assessment panel to assess standard 1, Intended learning outcomes, to be satisfactory.

4.2 Standard 2: Teaching-learning environment

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

Findings
Over the last ten years, the number of incoming students in the programme grew substantially from 22 students in 2008 to 70 students in 2013 to 112 students in 2017. The proportion of female students is about 30 %. About 50 % of the students come from the Delft University of Technology and Leiden University joint-degree Bachelor Molecular Science and Technology programme. The proportion of international students is 45 % to 50 % of total inflow. Programme management wants to keep the proportion of international students at the current level. About 10 % of the students come from other Dutch universities or originate from higher vocational education institutes.

The curriculum has a study load of 120 EC and takes two years to complete. Programme management presented a table, mapping the intended learning outcomes to the curriculum components. The curriculum is scheduled in four quarters in the first year. The first quarter is composed of three advanced core courses for all students (15 EC). In the second quarter, students take three specialisation-specific courses (15 EC). In the second semester, students take courses about ethics and engineering and about product and process design. The latter course includes methodological and safety dimensions of design and prepares them for the Design Project (12 EC). These projects are real-life projects, mostly proposed by companies and some by research groups. Students work in small, diverse groups of 4 to 6 students and present their results at the end in a one-day symposium. In the Scientific and Social Orientation module (30 EC), students may tailor the curriculum to their preferences. About 90 % of the students take the Research and Development variant, being composed of three deepening or broadening electives (12 EC) and an internship (18 EC). The internships are meant to introduce students to the professional field. Other variants are Study Abroad at one of the partner universities of the programme, Education, preparing students to become teachers in secondary education or Management of Technology, teaching students to explore and understand technology as corporate resource. The final component of the curriculum is the Master thesis project (40 EC), taking up the major part of the second year and requiring students to conduct an individual research project. New trends, such as Industry 4.0, filter via research through to the programme curriculum. In the courses, Design Project, internship and Master thesis project, students are taught academic skills, such as academic writing, presentation, problem-solving and collaboration skills. In the courses, these skills are incorporated in the course contents. In the curriculum, career events are scheduled.

About 45 lecturers are involved in the programme. All lecturers have PhDs and are actively engaged in current, international research in their fields, working at the research groups of the Department of Chemical Engineering. The proportion of lecturers being BKO-certified is 72 %, another 15 % of the lecturers being exempt on account of their teaching track records. In addition to the permanent staff, postdocs and PhD students act as teaching assistants in tutorials and research projects. The programme coordinator and academic counsellor comprise the support staff of the programme. As has been indicated, part-time lecturers from industry are involved in the courses. The coming years, several lecturers will retire. New staff will, however, be recruited to fill the gaps.

Applicants who have completed the Delft-Leiden Bachelor Molecular Science and Technology programme or Bachelor Chemical Engineering programmes of Dutch universities are admitted unconditionally. The applications of students with other backgrounds are screened by the admission committee of the programme. Students with Dutch bachelor degrees in, among others, chemistry, mechanical engineering, life sciences and earth sciences or bachelor degrees from higher vocational education institutes are admitted, provided they take pre-defined bridging programmes. International students may be admitted, if they have a grade point average of at least 7.5 (out of 10) in their prior education, are proficient in English and can submit reference letters and a motivation letter.

The educational concept of the programme is research-based learning. The number of hours of face-to-face education in the cursory parts of the curriculum (50 EC) is at least 680 hours, implying about 19 to 20 hours per week of face-to-face education. Study methods adopted in the courses are lectures, tutorials, computer-assisted tasks, group work, site visits and lab work. In most courses, two lecturers are involved. Lecturers adopt ICT-based study methods to some extent. The students-to-staff ratio is 14 : 1. New facilities are available for the programme. The programme academic counsellor interviews all students, monitors their study pace and advises them in case of study problems. The study association is active in scheduling activities for students in the programme. Students experience the first quarters of the curriculum as challenging. The student success rates after two years are on average about 37 % and after three years on average 84 % (figures for last three cohorts).

Considerations
The panel is positive about the substantial number of incoming students in the programme and notes that the number is within programme capacity limits. The panel advises to be pro-active in adjusting facilities and lecturers' numbers to further increasing student numbers.

The curriculum matches the intended learning outcomes of the programme. The panel appreciates the contents of the curriculum, the courses being solid and up-to-date. The curriculum is coherent and the courses and other curriculum components are balanced. The coherence especially balances the study load in the first part of the curriculum. The specialisations are well-chosen and have been well-integrated in the curriculum. The panel appreciates the Design Project and the internship, allowing students to become acquainted with the professional field. The panel suggests to give students opportunities to do more extensive internships to meet industry demands. Although the academic skills are appropriately addressed in the curriculum, the panel advises to bring them together in one teaching-learning trajectory to optimise academic skills training. The panel proposes to add industry-related subjects to emphasise the chemical engineering profile, as programme management intends to do.

The lecturers in the programme are very strongly research-oriented teachers. The panel regards the lecturers' motivation and educational capabilities to be definitely up to standard. The support staff of the programme is very effective.

The entry requirements and admission procedures of the programme are appropriate. Incoming students are well-informed about the programme. The panel finds the international students well-integrated in the programme.

The panel considers the study methods of the programme to be appropriate, promoting student-active learning processes. The students-to-staff ratio and the number of hours of face-to-face education in the programme meet the standards. The study guidance by the academic counsellor is appreciated by the panel. Although the programme is challenging, the panel regards the programme to be feasible and the study load to be evenly distributed. The student success rates are favourable.

Assessment of this standard
These considerations have led the assessment panel to assess standard 2, Teaching-learning environment, to be good.

4.3 Standard 3: Student assessment

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

Findings
The examinations and assessments in the programme are governed by the Teaching and Examination Regulations for the programme and the rules and guidelines of the Board of Examiners. The Faculty Board of Examiners sets the rules, whereas on behalf of the Faculty Board the programme Board of Examiners has the authority to ensure the quality of examinations and assessments of the programme.

The examination methods in the courses are predominantly written examinations, individual and group assignments, reports and essays, oral examinations, presentations and homework assignments. In most of the courses, multiple examinations are scheduled, both during and at the end of courses. In case of group projects, peer review among students is adopted to counter free-riding. No more than 20 % of the grades of courses may consist of group work. In design projects, internships and Master thesis projects, examination methods are performance in the projects, progress meetings, presentations, written reports and oral defence of the work. Written assignments and theses are checked for plagiarism and fraud. Cases are dealt with by the Board of Examiners. A few cases have been reported.

The final Master thesis projects are individual research projects. The projects are usually done at one of the research groups of the Department of Chemical Engineering and, most of the time, are part of ongoing research projects. Rarely, projects are conducted in industry. Very often however, companies participate in these ongoing research projects. The projects are supervised by supervisors of one of the research groups of the Department of Chemical Engineering. Day-to-day supervisors may be PhD students, acting under the responsibility of supervisors. Weekly meetings between the students and their supervisor as well as about three presentations by students are scheduled in this process. At completion of the project, students submit the written report and have to present and defend their results. The project is assessed by at least three staff members, one of whom comes from another research group. They use an extensive rubrics scoring form for their assessment, which includes as assessment criteria theoretical knowledge and understanding, scientific methods and approach, research work, report, presentation and defence and academic skills.

In the programme, measures have been taken to ensure the validity, reliability and transparency of examinations and assessments. Examinations drafts are peer-reviewed by fellow examiners, this being checked by the Board of Examiners. The Board inspects whether examinations drafted meet the rules and regulations. Test matrices are included. In case of deviant grade distributions, examinations may be analysed. The Board of Examiners inspects on a regular basis samples of Master thesis projects. Students are presented with previous examinations for exercises. Students are provided with feedback on examinations they have taken.

Considerations
The panel regards the examination and assessment regulations for the programme to be appropriate.

The panel approves of the examination methods adopted by the programme, noting these to be consistent with the goals and the contents of the courses. The panel is positive about measures being taken to counter free-riding and to prevent fraud and plagiarism.

The supervision and assessment processes for the Master thesis projects are well-organised. Students are offered appropriate supervision. The assessment procedures are up to standard. The panel welcomes the rubrics scoring form and the academic skills being assessed in the project.

Measures have been taken in the programme to ensure the validity, reliability and transparency of examinations and assessments. The panel considers these measures to be adequate and the Board of Examiners being active in enforcing these.

Assessment of this standard
The considerations have led the assessment panel to assess standard 3, Student assessment, to be satisfactory.

4.4 Standard 4: Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings
The panel reviewed the Master thesis projects of fifteen graduates of the programme with different grades. Students are expected to demonstrate specialist knowledge and skills in these projects and self-reliance in executing their project within the domain of the programme. The average grade of the Master thesis projects of the last five years is 7.8. The proportion of cum laude is 5 % to 10 %. About 50 % of the thesis projects contribute to scientific publications.

Programme graduates find positions quite easily. About 90 % of the programme graduates found suitable jobs within six months after graduation. About three quarters of the alumni are employed in the private sector, whereas also three quarters of them have found positions at large companies. The vast majority of the programme alumni (about 90 %) consider the programme to be a good preparation for their careers.

Considerations
The panel supports the grades awarded to the Master thesis projects by the programme examiners. These projects are considered by the panel to be solid and to be well-elaborated.

The panel is convinced that students having completed the programme reached the intended learning outcomes. The panel is especially very positive about the labour market prospects of the programme graduates and regards their career perspectives to be very favourable.

Assessment of this standard
The considerations have led the assessment panel to assess standard 4, Achieved learning outcomes, to be good.

5. Overview of assessments

Standard	Assessment
Standard 1. Intended learning outcomes	Satisfactory
Standard 2: Teaching-learning environment	Good
Standard 3: Student assessment	Satisfactory
Standard 4: Achieved learning outcomes	Good
Programme	Good

6. Recommendations

In this report, a number of recommendations by the panel have been listed. For the sake of clarity, these have been brought together below.

- To further clarify the programme profile in relation to other Dutch and foreign programmes.
- To be pro-active in adjusting facilities and lecturers numbers to further increasing student inflow numbers.
- To give students opportunities to do more extensive internships to meet industry demands.
- To bring academic skills together in one teaching-learning trajectory to optimise academic skills training.
- To add industry-related subjects to the courses to emphasise the chemical engineering profile, as programme management intends to do.