NOKUT's evaluations

EUROMA – critical factors for achieving high quality in Molecular Biology master programmes

Comparisons between programmes from Norway, Sweden, the Netherlands and Flanders

November 2017

NOKUT's work shall contribute to public confidence in the quality of both Norwegian higher and vocational education, as well as certified higher education from abroad. In the EUROMA project, this goal extends beyond Norwegian higher education. «NOKUT's evaluations» are expert assessments describing the state of affairs within academic disciplines and fields, as well as central common aspects of education relevant for different disciplines and fields.

We hope that the results will prove useful for higher education institutions in their programme-related quality assurance and development work.

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Preface

In September 2014, the Norwegian Ministry of Education and Research commissioned NOKUT to develop and carry out a pilot project to compare the quality of Norwegian master degree programmes with similar programmes in other European countries. NOKUT has carried out the pilot project in collaboration with NOKUT's sister organisations in the Netherlands and Flanders (NVAO) and Sweden (UKÄ), international expert panels, and participating programmes in two subject fields, Economics and Molecular Biology, from universities in the Netherlands and Flanders, Sweden, and Norway. The project was termed EUROMA – master programme education in a European context.

The project had two overarching goals: first, to develop and test a methodology to identify subject-specific critical factors ("what matters") for achieving high quality in education at the master programme level; second, to facilitate quality enhancement through discussions and sharing of knowledge, experiences and good practice between participating programmes. The methodology was developed with the purpose of identifying subject-specific quality factors, but at the same time be applicable for all subject fields and educational levels. A characteristic feature of the methodology is that it promotes a programme-driven process in the identification of quality factors and discussions of quality development. The methodology is not connected to existing external and formal quality assurance processes in any of the participating countries, and it has not been an aim to assess or rank the programmes individually.

This report describes the methodology and results from the project. The methodology is described in detail with the purpose of making it possible for any programme to use the methodology for quality development. The feedback we have received from the participating programmes and expert teams strongly suggests that the methodology and process constitutes a valuable supplement to traditional programme evaluations, because it provides a programme-driven platform for discussions and sharing of experiences, self-reflections, practices and ideas among the participants. The results include analyses of major differences between countries and programmes, discussions of strengths and weaknesses of different strategies, scopes and practices related to the critical quality factors, as well as examples of good practices and relevant indicators. We believe that the report is relevant and provides inspiration for quality development for all stakeholders involved in higher education, including higher education institutions and programmes, students, employers, quality assurance agencies and governing authorities.

The process and analyses has been carried out separately for Economics and Molecular Biology, and the results for the two subject fields are presented in separate reports. At the overall level, the factors viewed by the programmes as the most important for achieving high quality are to a large degree the same for both subject fields. This indicates that the results from this project are relevant for quality development in different subject fields. However, there are major differences between the subject fields when it comes to what matters for quality development at the detailed level, for example related to the programmes structure and organisation, their scope and content, as well as other factors where strategies and practices are influenced by the different academic cultures and characteristics. Thus, while the discussion of what matters for achieving high quality has both generic and subject-specific components, the analyses indicate that efforts to enhance quality may be most effective when they are directed at the subject-specific and programme level. Ultimately, quality in higher education and the students' learning outcome is developed through the interaction between students and academic staff at the programme level.

NVAO, UKÄ and NOKUT would like to thank the participating programmes and experts for their contributions to the project.

Contents

1 Introduction

1.1 Background

In September 2014, the Norwegian Ministry of Education and Research commissioned NOKUT to develop and carry out a pilot project to compare the quality of Norwegian master degree programmes with similar programmes in other European countries. NOKUT developed and carried out the pilot project in collaboration with NOKUT's sister organisations in the Netherlands and Flanders (NVAO) and Sweden (UKÄ), subject specific international expert panels, and participating programmes from the Netherlands and Flanders, Sweden, and Norway.

The project had two overarching goals[1]: first, to develop and test a methodology to identify subject-specific critical factors ("what matters") for achieving high quality in education at the master programme level (see box 1 below); second, to facilitate quality enhancement through discussions and sharing of knowledge, experiences and good practice between participating programmes. Since this was a pilot project, it was important to ensure that the methodology allowed identifying subject specific quality factors, while at the same time be generic, i.e., to be applicable for all subject fields and educational levels. Neither the methodology nor the output of the project overlaps with, or is connected to existing external and formal quality assurance processes in any of the participating countries. Thus, the project and its methodology were developed with the purpose of promoting quality enhancement by identifying and comparing national characteristics, strengths and challenges, sharing experiences in general and good practices in particular. The aim was not to assess or rank the programmes individually on specific aspects or as whole entities[2].

Box 1

The term "critical quality factors" used in this report is the answer provided by the programmes on the following question: *"What elements (practices, resources, etc.) do you consider particularly important for achieving high quality in master programmes in your subject?"*

Throughout the project, it has been emphasized that critical quality factors should be considered both in general terms ("*what are the critically important factors for high quality in an MA programme in your discipline?")* and in a programme specific context (e.g. related to the programmes strategy, goals, scope, size, etc.), in order to capture differences and similarities between countries and individual programmes.

What constitutes high quality in education, and what matters for achieving it, depends on who is asked. Different stakeholders may emphasise different quality areas and factors. This report discusses the participating programmes views. Moreover, the output from the project presented in this report is a discussion around important factors for *achieving* high quality, but does not seek to establish benchmarks for what constitutes high quality.

[1] See Appendix 1 for the full project plan.
[2] Reflective comments on the goals, process and methodology of the project are given in Appendix 2.

1.2 Participants

1.2.1 Programmes

The Norwegian Ministry of Education and Research left it up to NOKUT to decide which fields of study NOKUT should include in the project. NOKUT, in cooperation with its sister organisations in the Netherlands and Sweden, decided to include master programs in Molecular Biology and Economics in the project. The main reason for this selection is that MSc programmes within these subject fields are mainly internationally oriented and have a sufficient degree of similarity to allow comparisons. At the same time, the programmes exhibit variation, both between and within countries, which has made it possible to compare strengths, challenges, and sharing of experiences and good practice with respect to quality in education. In order to include comparable Economics and Molecular Biology programmes from Sweden, the Netherlands/Flanders and Norway, UKÄ, NVAO and NOKUT decided to approach programmes from traditional universities and not university colleges or universities of applied science. This report describes the output of the project for Molecular Biology. Table 1 gives an overview of participating programmes and universities in Molecular Biology.

Table 1. Participating institutions and programmes, Molecular Biology.

Institution	MSc programme
VU Amsterdam	Biomolecular Science – Specialisations Molecular Cell Biology; Biological Chemistry
VU Brussel, University of Leuven and University of Antwerp (joint program)	MSc in Molecular Biology
Wageningen University	Molecular Life Science
Lund University	MSc in in Molecular Biology
Uppsala University	Master programme in Biology - specialisations Cell and Molecular Biology; Immunology and Microbiology
University of Gothenburg	MSc in Molecular Biology
	MSc in Genomics and Systems Biology
The Norwegian University of Science and technology	MSc in Biology - specialisation in Cell- and Molecular Biology
	MSc in Biotechnology
	MSc in Biotechnology (5-year Integrated MSc programme)
	MSc in Molecular Medicine
	Teacher Education MSc - specialisation in Chemistry and Biology (5-year integrated MSc programme)
UiT The Arctic University of Norway	Marine Biotechnology

Throughout the project, the participating programmes have been represented by one MSc student and two faculty members who among them have experience from teaching, research and programme design/leadership. Thus the programmes' input is the combined experience and views from these stakeholders.

1.2.2 Expert teams

In addition to the programmes, two expert teams, representing academic peers and students in Economics and Molecular Biology respectively, had crucial roles in the project. The expert teams have facilitated the discussions between programmes by challenging them to reflect on critical quality factors, their own practice and assessing what constitutes good practice and relevant indicators related to these factors. The expert teams have performed comparative analyses at various stages during the project, highlighting differences and similarities between countries and programmes as a baseline for identifying the most important quality factors, common strengths and challenges, and addressing important areas for further development of high quality (see below). In Chapter 4 of this report, the Molecular Biology expert team summarises its analysis of major differences and similarities between countries and programmes, critical quality factors, assessments of good practice and provide comments and suggestions for further development.

The Molecular Biology expert team:

- Professor Jan Kok, University of Groningen, the Netherlands.
- Professor Ann-Kristin Östlund Farrants, Stockholm University, Sweden.
- Professor Dag Inge Våge, Norwegian University of Life Sciences (NMBU), Norway.
- Associate Professor Melisa J. Wallace, Swansea University, UK.
- MSc Taja Železnik Ramuta, European Students' Union (ESU).

1.2.3 Quality assurance agencies

Representatives from the national quality assurance agencies for the Netherlands and Flanders (NVAO), Sweden (UKÄ) and Norway (NOKUT) developed the plan and methodology for the project, recruited programmes and expert teams, organised meetings and seminars, and acted as secretaries. NOKUT administered the project.

From NOKUT – Stein Erik Lid (overall project manager), Helèn Sophie Haugen, Stephan Hamberg, Dagfinn Rødningen and Maja Søgård.
From NVAO – Lineke van Bruggen, Lisette Winsemius and Axel Aerden.
From UKÄ – Charlotte Elam and Carl Sundström.

1.3 Brief overview of major outcomes from the project

The major outcomes from the project fall in three categories:

- The first outcome is the development and testing of the methodology. The details are described in this report with the purpose of making it possible for any programme to use the methodology for quality development.
- The second outcome is the analysis of critical quality factors for master degree education in Molecular Biology given in this report. This also includes analyses of major differences between countries and programmes, discussions of strengths and challenges/weaknesses of different strategies, scopes and practices related to the critical quality factors, as well as examples of good practices, relevant indicators and perspectives on future development of master degree education in Molecular Biology. This gives all stakeholders, including universities and programmes that did not participate, as well as quality assurance agencies and governing authorities, insights into how the programmes work to achieve high quality, and inspiration for quality development and improvement.

- The third outcome lies in the self-reflection, discussions and sharing of experiences, practices and ideas among the participants, which provide points of reference for quality enhancement and further development at the participating programmes.

2 Methodology and process

The methodology for this project was developed with the purpose of identifying and comparing characteristics, strengths and challenges, sharing experiences in general and good practices in particular, and promoting quality enhancement. It has not been an aim to assess or rank the programmes individually on specific aspects or as whole entities.

The key elements of the methodology are that the participating programmes first contributed to identifying critical factors for achieving high quality subject-specific master's education, and subsequently reflected on their own goals and practices related to these quality factors together with peers from other programmes and external experts. The methodology included meetings and discussions between programmes, which served to highlight common critical quality factors, as well as facilitated comparisons of practices and sharing of knowledge and experience between programmes.

2.1 Key steps

The project had three main phases:

- In phase one descriptive information was collected such as the programmes' goals, structure, scope and intended learning outcomes, information about what the programmes' considered to be the most important factors for achieving high quality education, and the programmes' own assessment of quality in prioritised areas. Each programme provided this information in short self-presentations[3]. The programmes then shared and discussed the information at subject-specific national seminars, with programme representatives from each programme, within each country, and the expert team (the Dutch and Flemish programmes participated in the same national seminar)[4]. Following the national seminars, the secretariat and the experts wrote preliminary reports for each subject field, where the expert teams compared national characteristics, similarities and differences between programmes, and developed a list of across-country (international) subject specific critical quality factors to be explored further in the next phase of the project[5].
- In phase two, the programmes performed a self-reflection analysis on strengths, weaknesses and examples of good practice related to the international subject specific critical quality factors established during phase 1[6]. All of the programmes then shared and discussed the information further at one subject specific international seminar, with programme representatives from every participating programme, within each subject field and the expert team[7].
- In phase three, the expert teams and the Quality assurance agencies analysed the output from the previous phases of the project, the results of which are summarised in this report.

Table 2 gives a schematic overview of the methodology for the project, including the main phases, key steps and timeline. The full project plan can be found in Appendix 1.

[3] The detailed template for the programmes' self-presentation reports can be found in Appendix 3.
[4] The detailed programs for the national seminars can be found in Appendix 4.
[5] The preliminary reports will not be published.
[6] The detailed template for the programmes' self-reflection analysis can be found in Appendix 5.
[7] The detailed programs for the international seminars can be found in Appendix 6.

Table2. Schematic overview of the methodology for the project.

Step	Task/event	Timeline	Involved	Comment
PHASE 1 (Establishing critical quality factors)				
1	The programmes submit self-presentations	June-August 2016	-Programmes	The self-presentation contains three parts, where the programmes are asked to: • Highlight elements and practices they consider vital for high quality of master education within their subject field. • Describe areas of quality and/or practices where they consider they do especially well. • Key facts that describe their programme such as number of students, learning outcome descriptors, programme structure and assessment of master thesis/project/dissertation. Where possible, factual information were filled in by the national agencies. The primary purpose of the self-presentations is to share information between programmes and experts as part of the preparation for the national seminars (step 3). Documentation will not be required. The self-presentations should be kept short and sharp (maximum 5 pages).
2	National subject specific seminars/ workshop (one day in each country)	September-October 2016	-Programmes (1 seminar each) -Expert panels (3 seminars each) -National QA agencies acts as secretaries	The programmes within the same subject field and country together with the expert team meet and through discursive processes arrive at 'national' critical factors for achieving high quality master's programmes in a given subject. The expert teams attend the seminar in every country. Their role is to facilitate the discussions and challenge the programmes to pinpoint which factors are critical for high quality.
3	Preliminary quality profile reports	November 2016-January 2017	-Expert panels (one report each) -NOKUT (secretarial assistance)	Two reports (one for each discipline) where the experts compare and comment on differences and similarities between programmes and countries. Based on the self-presentations and the discussions at the national seminars, the experts also develop a list of across-country subject specific critical quality factors that the programmes will compare themselves against in phase 2.
PHASE 2 (Strength/weakness analyses)				
4	Programmes' self-reflection	January-February 2017	-Programmes -National agencies	Self-reflection in the form of a strength/weakness analysis and examples of good practice against subject critical quality factors from phase 1. Self-reflections are kept short and to the point, and supported by documentation only as necessary. Documentation that already is available through national register databases or recent quality assurance processes will be compiled by the QA agencies to lessen the administrative burden for the programmes.
5	Analyses of self-reflection	February 2017	-Expert panels	Expert teams' introductory analysis of submitted self-reflections, with the purpose of preparing questions for the seminars in step 6.
6	International seminars (One day gathering all programmes in each subject field)	March 2017	-Programmes (1 seminar each) -Expert panels (1 seminar each) -National agencies acts as secretaries	Expert teams will facilitate discussions between programmes on their strengths and weaknesses related to the international subject specific critical quality factors, as well as sharing good practices. The discussions will be organised as workshops and presentations. They will have the character of a peer conversation and seeks to clarify and highlight how strategies and practices reflect subject specific critical quality factors.

PHASE 3 (Analyses and discussion of output from the project)				
8	Final report	Fall 2017	-Expert panels -NOKUT , UKÄ, NVAO (secretarial assistance) -Programmes	Experts' final analysis of the output of the project in the form of a published report, presented in terms of discussions of characteristics between programmes and countries, strengths and weaknesses, areas for improvement, and good practice, in relation to critical quality factors. The emphasis will be comparisons and discussions of strategies and practices rather than individual programmes. The programmes comment on factual errors before publication.

3 Brief description of participating programmes

Eight Universities and 13 master programmes participated in the project. All programmes are full-time and government-funded. Table 3 indicates some characteristics of each programme related to structure, number of students and teaching language.

Table 3. Characteristics of the participating Molecular Biology programmes.

University	Programme	Duration	Master research project	Number of students enrolled in 2015	Teaching language
Uppsala University	MSc in Biology	2 years 120 EC	30 EC, 45 EC or 30+30 EC	18[8]	English
Lund University	MSc in Molecular Biology	2 years 120 EC	30, 45 or 60 EC	70	English
University of Gothenburg	MSc in Molecular Biology	2 years 120 EC	30, 45 or 60 EC	16	English
	MSc in Genomics and Systems Biology	2 years 120 EC	60 EC	9	English
VU Amsterdam	Biomolecular Sciences	2 years 120 EC	24-30 EC + 30-36 EC	Approx. 40	English
Wageningen University	Molecular Life Sciences	2 years 120 EC	24 EC + 36 EC	107	English
VU Brussels, KU Leuven, University of Antwerp	MSc in Molecular Biology (Interuniversity Programme Molecular Biology)	2 years 120 EC	30 EC	24	English
The Norwegian University of Science and technology	MSc in Biology - specialization in Cell- and Molecular Biology	2 years 120 EC	60 EC	10	English
	MSc in Biotechnology	2 years 120 EC	60 EC	27	English
	MSc in Biotechnology	5 years 300 EC	60 EC	45	Norwegian
	MSc in Molecular Medicine	2 years 120 EC	60 EC	Unknown	English
	Teacher Education MSc - specialisation in Chemistry and Biology	5 years (300 EC) with 1 year Master (60 EC)	30 EC	Unknown	Norwegian
UiT - The Arctic University of Norway	Marine Biotechnology	2 years 120 EC	60 EC	7	Norwegian

[8] A total of 87 students were enrolled in the MSc Biology programme, of which 18 chose one of the Molecular Biology specializations Cell and Molecular Biology (12 students) or Immunology and Microbiology (6 students).

3.1 Uppsala University

The first year is divided in four parts, each corresponding to 15 EC courses. The first part consists of an introductory course. In parts 2-4, students take 15 EC courses according to their specialisation in either Cell and Molecular Biology or Immunology and Microbiology. In the second year, students can choose either an individual research project course or other thematic courses, followed by their master research project work of 30 or 45 EC.

Distinguishing features

- Students are systematically trained in oral and written presentations as well as in their capabilities to work in groups through a University programme termed Dialog in the Natural Sciences (DiaNa). This includes communication training in the Molecular Biology courses, as well as common online resources provided by the University. Each student has an electronic portfolio, where after every piece of student work they can self-evaluate their performance and learning results.
- The students can take a 15-EC research-training course that can also be combined with a master research project in the same research group. It is possible to take multiple research training courses in different research groups, e.g. during the summer, to get experience from different research groups (but the students only get the credits for one).

3.2 Lund University

Students at the Molecular Biology programme can either design their own plan of study with the courses and specializations they prefer (termed the general programme), or choose one of three specializations: Medical biology, Microbiology, or Molecular Genetics and Biotechnology. The programme consists of 60 EC of advanced courses in Molecular Biology (students in the general program choose freely, whereas certain courses are mandatory for the specialisations), 30, 45 or 60 EC master research project (thesis) and electives, with the number of ECs depending on the size of the thesis.

Distinguishing features

- In the general programme, the students have a very high degree of flexibility in choosing courses and designing their own specialisation.
- The programmes have a very high share of international students (more than 50 %).

3.3 University of Gothenburg

In the Molecular Biology programme, a personal study plan allows students to specialise in their area of interest, including Molecular Biology, Genetics, Microbiology, Plant Molecular Biology and Immunology. 60 EC must be at the advanced level in the major subject, which includes a master research project of minimum 30 EC. 30 EC must be at the advanced level in any subject, and 30 EC may be at any level and in any subject. The Genomics and Systems Biology programme builds on an interdisciplinary approach and the first year the students take four 15 EC courses: Advanced Functional Genomics, Advanced Bioinformatics, Experimental Systems Biology, and Evolutionary Genomics. In the second year, they work on their master research project (60 EC).

Distinguishing features

- In the Molecular Biology programme, the students have a very high degree of flexibility to choose courses and design their own specialisation.
- The Genomics and Systems Biology programme is the only programme participating from Sweden in which all the coursework in the study plan is mandatory and the size of the master research project is set to 60 EC.

3.4 VU Amsterdam

The programme emphasises multidisciplinary knowledge of various approaches and techniques to solve biological questions. The programme consists of general compulsory courses (6 EC), 30 EC of restricted optional courses depending on specialisation, a total of 15 EC where the students can choose any Biomolecular courses they like, a literature-based thesis (9 EC) and two master research projects termed research internships where the students work independently under supervision. The first research internship is 24-30 EC, the second 30-36 EC. In total, the two internships should equal 60 EC. The programme has two specialisations: Molecular Cell Biology and Biological Chemistry. To qualify for a specialisation, it is mandatory to include a minimum of 12 EC of coursework and carry out the first research internship within the scope of the specialisation.

Distinguishing features

- The programme primarily aims to prepare students for a scientific career, and the students are expected to be able to successfully commence a PhD trajectory. About 85 % of the graduates continue with a PhD.
- The programme strongly emphasises that students need to discover their own interests and talents. A strong ownership of the independent research projects (internships) is crucial for talent development and developing the right attitude and ability to “survive” in an international scientific environment. For the second internship, the students have the option to carry out their project in any lab in the world (given the host is accepted by the programme director), and they are expected to take a leading role in identifying relevant labs and projects.

3.5 Wageningen University

The first year consists of a compulsory 3-EC introductory course, a career preparation cluster (12 EC), as well as restricted optional courses (total 12 EC) and a research methods course (3-12 EC). The restricted optional courses and the research methods course depends on the chosen specialisation, which can be Biomedical Research, Biological Chemistry, Physical Biology or Physical Chemistry. The students can choose between four career preparation clusters: Research proposal writing, preparing for an academic career; Academic consultancy, preparing for work as a consultant in governmental- and non-governmental organisations or industry; Entrepreneurship, preparing students as self-employed or private sector enterprise entrepreneurs; Education, preparing for work as a scientifically-trained teacher at Dutch high schools. In the second year, the students carry out two research projects under supervision. The first is referred to as a research internship (24 EC), and the second constitutes the master research project (30 EC).

Distinguishing features

- The program aims to combine Biology, Chemistry and Physics, and bridge the gaps between these disciplines. The rationale is that interdisciplinary research enhances scientific insights, but that the potential for interactions between fields is often not realised in a more "typical" Molecular Biology programme. The students are expected to have a strong background in all three disciplines, and be able to communicate at a scientific level with specialists from Physics, Chemistry, Biology or Biomedical Sciences.
- The programme at Wageningen is the only programme participating in this project that contains designated elements preparing the students for different types of careers with career preparation clusters.

3.6 VU Brussels, KU Leuven, University of Antwerp

This programme is an interuniversity programme in Molecular Biology carried out in collaboration between three Flemish institutions. The first year consists of a common core of 42 EC (including courses in Molecular Biology, Biochemistry, Microbiology, Immunology and Mathematics/Statistics), two courses in practical lab training totalling 15 EC and an option to choose courses in Plant or Animal Physiology (3 EC). The second year consists of a common core of 18 EC (including courses in advanced Molecular Biology, Microbiology, Physical/Structural Chemistry and Social and Economic aspects of Biotechnology), an option to choose courses that allows one of three specialisations (Human health, Plant production or Animal production), and a master research project of 30 EC.

Distinguishing features

- This is the only joint programme participating in the project. The programme is supported as an international programme by the Flemish Interuniversity Council. The majority of student activities takes place at VU Brussels, but the teaching staff and supervisors are mobile and come from all three universities.
- The programme's main characteristic is a strong (though not exclusive) focus on students from developing countries in the south as a target group. The programme gives prospective students a chance to compete for scholarships covering all expenses of the training, irrespective of country of origin. Very few European university programmes offer scholarships for non-EU students. The student population is very international; the majority of students come from the south, and in particular from African countries.
- The programme has developed a very strong alumni network that is actively used for quality assurance of prospective students as well as programme development.

3.7 The Norwegian University of Science and technology (NTNU)

NTNU has five master programmes, which include specialisations in Molecular Biology (see Table 3). The MSc in Biology, MSc Molecular Medicine and one of the MSc's in Biotechnology comprise 2 years of study (120 EC). There are also two 5-year integrated master programmes, namely the MSc in Biotechnology as well as the Teacher Education programme with specialisation in Biology and Chemistry. The 2-year programmes at NTNU consist of theoretical and methodological courses, in addition to the master research project[9]. The first 9 months are essentially occupied by mandatory theoretical courses, followed by lab courses. All programmes, except the Teacher Education programme, contain one research project of 60 EC, where students work independently under supervision, referred to as the master thesis project. The Teacher Education programme contains a 30 EC master thesis project.

Distinguishing features

- The master education in Molecular Biology at NTNU is not organised in one or more designated programmes, but as specialisations within several programmes spanning three departments. The rationale is that it creates a broad academic and student environment in the subject field, increases the number of involved teachers, supervisors and technical facilities across departmental borders, and promotes inter-/multidisciplinarity in the programmes.
- "Experts in teamwork" is a mandatory course for all master students at NTNU (7,5 EC), where students across all types of disciplines work on solving problems in teams. The main goal is for the students to experience cooperation and teamwork in an interdisciplinary framework.
- The 5-year integrated master programme in Biotechnology, as well as the 5-year integrated Teacher Education programme, are the only programmes participating in this project that are not organised as a 120 EC master programmes building on a 180 EC bachelor degree. The programmes comprise 300 EC and do normally not lead to separate bachelor degrees. Both programmes are taught in Norwegian.

3.8 UiT - The Arctic University of Norway

The Marine Biotechnology programme at UiT focuses on the marine environment and utilisation of marine natural resources and possibilities within the marine segment. In addition to Biotechnology, the programme has courses in bioprospecting and innovation. The first semester of the programme consists of elective courses in Biotechnology, innovation and safety (lab and field work). In the second semester, students choose elective courses. In their last year, the students work on a master research project (60 EC).

Distinguishing features

- The Marine Biotechnology programme at UiT is relatively new, with its first students graduating in 2011. So far, the programme has had very few students. The university expects increasing student numbers, as the programme represents a field of strategic importance for the university, the northern region of Norway and the country.

[9] The structure of the 5-year integrated programmes and the Teacher Education programme at NTNU will not be described here.

- The Marine Biotechnology programme was initially established as a direct response to demand for competence in this field by companies and research institute clusters in the northern region of Norway. These institutions have been highly involved in evaluating and developing the programme, as well as contributing to teaching, supervision and internships in order to deliver students that meet the companies need for competencies.
- So far, the programme has been taught in Norwegian, but there are plans to change the teaching language to English to attract international students in the future.

4 Discussions on critical quality factors

As described in the introduction, the term "critical quality factor" used in this report is the answer provided by the programmes on the following question: *"What elements (practices, resources, etc.) do you consider particularly important for achieving high quality in master programmes in your subject?"*. Based on the programmes' self-presentations, self-reflection analyses and discussions at the seminars, the participating programmes and expert group identified a range of factors that were considered critical for achieving a high quality in MSc education in Molecular Biology across the participating programmes. The quality factors can be grouped in different areas, as shown in Table 4.

Table 4. Areas of critical quality factors.

Programme design	Programme structure and organisation
	Flexibility
Scope and content	Multi-/interdisciplinarity
	Internationalisation and mobility of students
	Integration of new scientific or technological knowledge and trends
	Employability and transferrable skills
Input factors	Recruitment of motivated and talented students
	Teachers as quality factors
	Quality assurance systems
Learning processes and assessment	The master research project(s)
	Assessment of master research projects
	Innovative teaching and learning formats
	Feedback to and from students

In addition to identifying critical quality factors, the programmes were challenged to reflect on their own practices, as well as sharing and discussing examples of good practice and what they consider relevant indicators for monitoring quality, all related to the identified quality factors. The critical quality factors are discussed in detail below. The discussion highlights major similarities and differences between countries and programmes, compares different practices, reflects on strengths and weaknesses, and gives examples of good practice in terms of quality in education related to the critical quality factors. In addition, the experts provide general comments to the discussion and suggestions that the programmes may consider for further development.

The discussion also includes examples of relevant indicators, where identified. The list of indicators does not establish benchmarks for what constitutes a high quality level, but point to relevant information the programmes may use to monitor quality in their programmes. When using these indicators, the programmes have to identify their own thresholds. Some quality factors may be analysed and monitored by quantifiable data. For other factors, quantitative data may not be available or relevant. In this case, qualitative indicators may be used, and the report suggests types of relevant assessments or surveys. In addition to the indicators, the report suggests control questions relevant for quality assurance of quality factors not easily expressed as indicators.

Some readers of this report may find it puzzling that research-based- or research-led education is not highlighted as a separate quality area of critical importance in Table 4 (above) and the discussion below. There was general agreement among the participating programmes that the most critical factor for achieving high quality in MSc programmes in Molecular Biology is that the programmes should be *research-led*. Throughout the project, questions pertaining to research-led education was typically discussed with reference to three other areas: integration of new scientific or technological knowledge and trends, teachers (competence) as quality factors, and master research projects. The discussion on research-led education is therefore embedded in the discussion under these three headings below.

4.1 Programme design

4.1.1 Structure and organisation

Molecular Biology concerns the molecular basis of biological activity between biomolecules in the various systems of a cell, including the interactions between DNA, RNA, and proteins and their biosynthesis, as well as the regulation of these interactions. Biochemistry and Genetics are closely related disciplines without sharp delimiting lines. In the participating countries, the Molecular Biology master programmes are organised differently. Lund University, the University of Gothenburg, VU-Amsterdam, Wageningen University and the collaboration between VU Brussels, KU Leuven and University of Antwerp organise their MSc education in Molecular Biology as designated programmes with further specialisations. Uppsala University and NTNU have Molecular Biology as a specialisation under a broader Biology programme or several programmes in Biology and Biotechnology, respectively. UiT has a programme that specialises in Marine Biotechnology.

The majority of participating programmes have an overall structure where the MSc is organised as a 2-year, 120 EC, programme, building on a relevant 180 EC bachelor degree. Two of the programmes at NTNU are organised as 5-year integrated MSc programmes; the integrated programme in Biotechnology, and the integrated programme in Teacher Education with a specialisation in Chemistry and Biology. Further details on the structure of the programmes is given in Chapter 3.

The overall goal of the programme design is to achieve close connection with research and to prepare the students for their future career. Ordinances, laws and traditions also influence the actual design of the programmes. The participating programmes are designed differently, but generally more similar within countries than between. In Sweden, all programmes have individual modules taken one after another, with a certain flexibility in each period. The Norwegian participants also have flexible modules, but the modules are more interwoven. In the Netherlands and Flanders, a less flexible structure prevails where students take several modules at the time. The majority of programmes have a starting module, which is meant as an introduction and to get the students to the same level early on in the programme. All programmes contain strong associations to research and the modules reflect the research that is being conducted at the departments or faculties. External scientists and to some extent industry representatives are also involved.

Expert comments

The organisation itself is probably not the determining factor for the student’s ability to choose among different courses/subjects, but rather the size and diversity of the Molecular Biology research groups (and those from related disciplines) and of the courses at the individual universities. Normally, larger universities, faculties or departments can offer more specialisations than smaller ones, but e.g. NTNU has established collaborations over departmental borders to increase the possibilities for students to follow their interest. The Interuniversity programme takes advantage of research and teaching environments at the three collaborating universities.

NTNU also gives five-year integrated master programmes, combining the bachelor and master[10]. Discussions during the seminars indicated that both advantages and disadvantages exist with this structure that the experts would like to point out. NTNU finds that the 5-year integrated programmes recruit better Norwegian students than the 2-year programmes. The 5-year programmes also gives the students more time to learn how to perform experimental work than the 3-year (bachelor) + 2-year (master) option at NTNU. One disadvantage is that students risk ending up with no degree (bachelor) if they do not complete the full 5-year programme. Another disadvantage is that 5-year programmes could hinder internationalisation and student mobility. These students may not have the option to do their bachelor at NTNU and their master at another university. Moreover, the fact that students have to commit to a 5-year programme from the start, and that the programmes are given in Norwegian, makes those programmes unattractive for most international students.

4.1.2 Flexibility

Flexibility for students to choose tracks, modules or courses in order to specialise according to their interests was generally viewed as a critical quality factor, but the degree of flexibility varies between programmes and countries.

In several of the Swedish programmes, the students have the freedom to make individual plans of study by selecting a range of courses or specialisations, given that the plan is approved by a programme board or similar authority at the programme level. At Uppsala University, flexibility is linked to specialisation modules, while for the general Molecular Biology programmes at Lund University and the University of Gothenburg, the students can freely design their individual plans. The exception is the Systems Biology programme at the University of Gothenburg, which has very little flexibility.

Both Dutch programmes have a small share of compulsory courses in the beginning of the first year, while the majority of the ensuing courses are restricted optional courses that depend on the chosen specialisation.

The Flemish programme has relatively little flexibility. The majority of courses are defined in packages termed common cores. The programme’s flexibility is linked to choosing between set specialisation modules.

For the Norwegian programmes, the largest part of the time for coursework consists of mandatory courses, but the programmes also contain slots for electives.

An interesting distinction between countries and programmes is the difference in the freedom for students to choose courses and specialisations to be included in their master. There is an element of flexibility in most programmes, but the possibility for students to choose is clearly greatest in the Molecular Biology programmes at Lund University and the University of Gothenburg.

While there was universal agreement that some degree of flexibility is an important quality factor, the discussions showed that flexibility also poses some challenges with respect to quality. For programmes with compulsory modules following a set curriculum, content, learning outcomes and

[10] Several universities, specialized universities and university colleges in Norway offer 5-year integrated master programmes in different types of education. These programmes, most often connected to professional education (e.g. civil engineering, economics, law), have traditionally had a good reputation, and are often more popular than similar 3+2 programmes among Norwegian students and employers.

progress are more easily monitored than in highly flexible programmes. Although a high degree of flexibility to choose courses gives the students a good opportunity to follow their interests, there is a risk of designing a suboptimal programme simply because the students still have a limited overview of the field at the time they have to make their choices. This could result in a plan that is too narrow (little or no multidisciplinarity), too broad with poor preparation for the master research project(s), or consists of a package of courses that does not follow a logical order, which could hamper progression. Highly flexible programmes are also more challenging with respect to securing that students obtain the proper theoretical- and practical skills sets to prepare them for different careers (broad employability, see also discussion of this topic below).

Expert comments
It is important that the programme boards find the right balance between compulsory and elective courses so that the programme offers a profile that ensures quality by linking to strong research areas, is attractive to the students and connects to the labour market. For the most flexible systems, it is very important that the students have sufficient access to highly competent supervisors when they design their master programme, and that the individual study plans go through an approval process by the programme board (or a similar authority). The seminar discussions indicated that a particular challenge in highly flexible programmes is the monitoring of training and learning outcomes related to transferrable skills (see also the chapter on Employability and Transferrable Skills below). To secure these learning outcomes, it is necessary to coordinate relevant training between teachers responsible for the different courses.

4.2 Scope and content

4.2.1 Multi-/interdisciplinarity

To clarify these terms: multidisciplinarity involves knowledge from different disciplines, but the disciplines stay within their boundaries (additive). Interdisciplinarity analyses, synthesises and harmonises disciplines into a coherent whole (interactive). There was general agreement between the participating programmes that a critical quality factor is that Molecular Biology students should be exposed to multi-/interdisciplinary work, since both reflect how frontline research is carried out, and are also important for the labour market outside academia. The programmes at Wageningen University and VU Amsterdam explicitly aim at educating students with interdisciplinary and multidisciplinary research skills; these skills are part of the learning outcomes of these programmes. For the other programmes, inter- and multidisciplinarity is mainly achieved by providing opportunities for choosing elective courses or master research project supervisors from different departments.

Together, the participating programmes display a range of good examples of how experience with inter- and multidisciplinary approaches can be achieved. For example, Wageningen University combines Biology, Chemistry and Physics in their curriculum to realise the potential of multi-/interdisciplinary work, and the students are expected to have a strong background in all disciplines. The interdisciplinary focus in the programme is emphasised from the start with the introductory course “Frontiers in Molecular Life Sciences”, where the learning outcomes are centred on understanding and analysing opportunities for interdisciplinary research. VU Amsterdam emphasises multidisciplinary knowledge as important for solving biological questions, and integrates training in different approaches and techniques into the courses and projects. This is to some extent also taken care of by the system, in which students have to complete two internships outside their own laboratory, and thereby can choose groups/supervisors with skills or disciplines different from those available in their home institution. The programme at Uppsala University allows their students to take multiple research training courses[11] in different research groups, thereby providing the possibility to obtain experience from diverse research environments and approaches. Molecular Biology education at NTNU achieves inter- and multidisciplinarity by being offered as specialisations within several programmes spanning three departments with different scopes, while supervisors for master research projects with different backgrounds often collaborate on student supervision. Also, NTNU students take a mandatory 7,5 EC course for master students called “Experts in teamwork”, in which students across disciplines cooperate to solve problems and, thus, get interdisciplinary training.

Expert comments

Some degree of multi- and interdisciplinarity is clearly a critical quality factor. However, there is some discussion as to how multidisciplinary the master programme can or should be. A 2-year master is a short period and introducing several disciplines might come at the cost of sufficient depth. As described above, examples of good practice include appointing more than one supervisor with different relevant expertises for master research projects, and enabling students to carry out projects in different research groups or with peers with different backgrounds and approaches. A minimum requirement must be that the students are able to understand and effectively communicate with researchers from related disciplines.

4.2.2 Internationalisation and mobility of students

A critical quality factor and a goal for the majority of the participating programmes, is to be international in the sense that they are able to both recruit international students and provide an international student atmosphere in their programmes. The programmes from Sweden and the Netherlands/Flanders generally have a high percentage of international students. In this respect, the Interuniversity programme is exceptional, with its focus on recruiting international students from developing countries in the South.

Internationalisation and mobility are prioritised by the participating programmes, partly because international students are crucial for recruiting enough students to offer master programmes in Molecular Biology. From a quality perspective, international students are also considered important since most students are expected to work in an international environment throughout their later careers. Students trained in an international environment learn to appreciate differences in cultures and approaches to solving problems. Whereas the programmes from Sweden and the Netherlands and Flanders have a high percentage of international students, the share of such students in Norway is lower, and NTNU and UiT struggle to recruit well-qualified international students to the extent they would like. With the exception of the Marine Biotechnology programme at UiT and the 5-year integrated programmes at NTNU, all programmes are taught in English and therefore accessible for international students. The programme at UiT plans to change the teaching language to English in the near future in order to recruit international students.

Several programmes find it challenging to identify the most talented students from abroad. Different grading systems and variable trust in recommendation letters and other means for assessing the

[11] One research training course is mandatory as a preparation for the master research project.

applicants’ competence, complicate the selection process (discussed in more detail below). The programmes at the University of Gothenburg and the Interuniversity programme from Flanders make extensive use of their own international students to recruit new students (alumni network). A reputation of a good programme is easily spread among students and improves the recruitment of new students.

Internationalisation and mobility of students is not only about recruiting international students but should also provide opportunities for students to get international experience abroad through student exchange or other means. In general, it seems that this is prioritised to a larger extent among the Norwegian programmes that have a lower share of international students than the programmes from Sweden and the Netherlands and Flanders. A good example of how this can be achieved is the programme from UiT, in which the slots for elective courses are concentrated in the second semester, thereby essentially freeing up this semester for exchange. One exception is the programme at VU Amsterdam, in which students are encouraged and enabled to carry out one of their internships (master research projects) in labs anywhere in the world.

Expert comments
For programmes with a goal of being attractive for international students, it is necessary to give the programme in English.

The Swedish programmes raised a particular concern regarding international students from outside the EU, which in Sweden have to pay relatively high tuition fees in contrast to EU-students. As the system requires that they register for courses and pay up front, the non-EU students are not allowed the flexibility to change courses or take more than 30 EC per semester. The programmes and experts feel that these limitations represents real quality liabilities for these students, which should be addressed at the national level. Also in the Netherlands, non-EU students pay higher tuition fees, but in contrast to the situation in Sweden, students in the Netherlands pay for a year and are free to take as many courses they would like in that year. This may be one solution to the problem experienced in Sweden. In Norway, the tuition fees are very low (practically zero) for everyone regardless of country of origin. As tuition fees are becoming higher in many countries that are popular among international students, this may represent an advantage for Norwegian programmes in the competition for international students.

Indicators
Quantitative indicators

- The number and share of international students successfully completing the master and the time to completion. These numbers should be compared to similar data on non-international students. To evaluate the success of recruitment of international students, the criteria should not be the number of recruited students.

Control question
Does the programme structure make it easy, or even possible, for students to take a semester of courses or a research internship abroad?

4.2.3 Integration of new scientific or technological knowledge and trends

Keeping up to date with the relevant research front and technologies is a critical quality factor for all the participating programmes, and the discussions did not indicate any major differences on this aspect. Giving updated courses and training in latest technologies seems mainly to be assured by using research-active teachers, which is also considered a critical quality factor for all the participating programmes (see more on this under "Teachers as quality factors" and "Master research projects" below).

The seminar discussions indicated that it is a challenge to fit newer topics or techniques, such as high-throughput technology and analysis of Big Data, into the programmes. Introducing new topics is handled in different ways, depending on the main structure and the aim of the programme. These issues are handled by a programme board, steering group, a group of teachers, or coordinators. More flexible programmes have the advantage that it is relatively straightforward to develop new elective modules or courses without having to redesign parts of the programme. In less flexible programmes, new developments will have to be integrated in existing courses or by development of new study tracks.

Hiring of staff with expertise in new fields or technologies is also one important means for modernising the content of the programmes. The discussions indicated that the participating programmes tend to integrate new developments in established courses, rather than making new courses, in line with the expertise of new staff. Another important aspect is to allow students to integrate in the research groups, ensuring communication with, and "informal learning" from, the group members.

Expert comments

Using research-active teachers is the most effective way of keeping up to date and introducing the students to new scientific and technological knowledge. However, one should keep in mind that researchers are most updated in their own research field, which normally is far narrower than the scope of a master programme. The overall programme design should therefore be such that it combines teachers with different backgrounds and research focuses.

Indicators

Quantitative indicator

- Share of research active teachers in the programme.

Control question

Is state of the art experimental equipment used for research made available to the students?

4.2.4 Employability and transferrable skills

To educate employable candidates is an obvious goal and quality indicator for all participating programmes. There appears, however, that there is more variation between the programmes from the Netherlands and Flanders in terms of goals and means for achieving this, than between programmes in Norway and Sweden. With the exception of the Teacher Education programme at NTNU, the Norwegian and Swedish programmes all state that their goal is to educate candidates for PhD positions and academic research, as well as research, consultancy and management work in industry and the public sector outside academia. This is mainly achieved by integrating relevant elements of both research training and transferrable skills into the Molecular Biology courses and student projects. The participating programmes from the Netherlands/Flanders appear to more specifically aim at educating their candidates for different careers. The programme at VU-Amsterdam, and to some extent also the Interuniversity programme, primarily focus on educating candidates for PhD and research positions, whereas the programme at Wageningen University provides different career preparation clusters from which students can choose.

The discussions showed that broad employability can be interpreted in different ways. For example, VU Amsterdam provided the clearest case of a purely academic programme design, but also made the interesting argument that employers outside academia are increasingly seeking new employees with PhDs. A primary scope of preparing master candidates for PhD positions can therefore be a legitimate strategy to achieving broad employability, and does not have to be in conflict with educating candidates for academic research versus the other types of careers. However, one should keep in mind that this strategy could in turn lead to an increased pressure on PhD programmes to include a larger emphasis on broad employability and training in transferrable skills, which is a tendency that is currently observed in many countries.

There was general agreement among the participating programmes that Molecular Biology graduates should have training in transferrable skills, such as scientific writing and presentation, data handling, statistics, ethics, teamwork, project management and so forth. However, there was some debate as to when this training should be given. VU Amsterdam felt that competence in transferrable skills should primarily be acquired during the bachelor, and not so much time should be spent on this during the master, which should instead be focused on scientific depth. The majority of programmes felt that including transferrable skills training in the master was a critical quality factor.

An interesting example of good practice in the education of candidates for different careers is the programme at Wageningen University, which has integrated specific career tracks. Students can obtain training towards different careers by choosing one of four tracks: Research proposal writing, preparing for an academic career; Academic consultancy, preparing for work as a consultant in governmental- and non-governmental organisations or industry; Entrepreneurship, preparing students as self-employed or private sector enterprise entrepreneurs; Education, preparing for work as a scientifically-trained teacher at Dutch high schools. The core focus is always on Molecular Biology but with slightly varied labour market oriented angles. Uppsala University has an institution-wide system for integrating training in oral and written presentations as well as working in groups in the natural sciences programmes, called Dialog in the Natural Sciences (DiaNa). The Molecular Biology students have an electronic portfolio, in which, after every piece of work, they can self-evaluate their performance and learning results related to these transferrable skills. Another good example, although not a part of the programme design per se, is the course given at NTNU called “Experts in teamwork”. This is a 7,5 EC course that is mandatory for all master students at the university, in which students across all types of disciplines work in teams on solving problems. The main goal is for the students to experience cooperation and teamwork in an interdisciplinary framework. The Molecular Biology students at NTNU felt that this course was highly valuable.

Different means of exposing students to potential future employers through student projects is also a good way of increasing employability. Both NTNU and UiT emphasised that their programmes have strong research collaborations with industry. Students are often included in these collaborative projects during their thesis work, and typically also stay for a period with the industrial partner. Also, the system of internships in the Dutch programmes at VU-Amsterdam and Wageningen University allows students to stay for some months in institutions outside their universities, which increases the students' network and the chance of future employment. Both of these approaches are example of good practice in extending the students' network during the master, and thereby increasing the chance of future employment.

Good links with central university career services are also an indicator of quality in career planning. Several programmes reported that these departments were ill-informed about job prospects for Molecular Biology graduates. Good practice would be for programmes to reach out to and work with these services to coordinate the transfer of up-to-date career information to students. Programme alumni, professional organisations, learned- (e.g. national academies) and student societies are excellent resources. An additional benefit may be that academics are better informed about what employers want - the jobs that their graduates actually get. If a skills gap becomes apparent through graduates not finding employment or feedback from relevant stakeholders, there is potential for change in the curriculum to fill the gap. More accurate career information may also improve student recruitment by revealing a diversity of career options, which can serve as a marketing tool to attract ambitious, motivated students.

Expert comments

All programmes aim at finding a mix of modules that cover fundamental knowledge about the topics of study and relevant methods, but also knowhow that will make the students employable outside of academia. Through the seminar discussions, however, it became clear that most programmes tend to view students as future PhDs. This is a curious assumption because it is at odds with what most programmes reported – namely that a large number of their students do not aim for a PhD. It is easier to design a programme for PhD students than to provide elements that would make students employable outside the research arena. Programmes with a goal of educating candidates for different types of careers should therefore carefully consider the educational and employment outcomes of their students, as many of them will not follow a career path similar to that of their research supervisors. Not all will go on to do a PhD, and not all will stay strictly within Molecular Biology.

In order to prepare students for all types of relevant careers, training of transferrable skills should be embedded in the programmes. The experts feel that this is a critical quality factor, which should be prioritised in curricula. A conscious effort should be made to ensure that these skills are not treated as tacit outcomes of attending lectures and working in a laboratory. Ideally, in order to add relevance to these skills, they should be framed within the scientific content of the course, rather than set apart from it. For example, the inability of new graduates to work effectively in a team is frequently cited by industry as a critical skills gap. It is a transferable skill that makes graduates more employable, but is complicated by the fact that students beyond undergraduate level are often taught to work independently.

Furthermore, science is international; it brings together diverse groups of people. Implicit or even explicit bias can create a culture-clash that disrupts group projects and thus hampers innovation. Pedagogical research on transferable skills in the sciences suggests that students engage more with this training if it is integrated in the subject.[12,13] For example, a Molecular Biology topic could be assigned for a group assessment but with training offered alongside it on e.g. implicit bias, project management, communicating to a lay audience, thus providing a learning resource for both the subject knowledge and the transferable skill.

The experts also believe that whenever possible, transferable skills should be directly assessed and expressed in the overall mark. They realise that integration of transferable skills with subject knowledge may not always be possible, and non-integrated, central resources may need to be used.

Indicators

Quantitative indicators

- Monitoring of candidate's careers.
  - Average time from graduation to first relevant job.
  - Share of candidates employed in different sectors (PhD students, industry, governmental organisation, teachers, etc.).
- Feedback (surveys) from alumni, relevant employers and other external stakeholders.

Control questions

- Are alumni, relevant employers and other external stakeholders involved in programme design and development?
- To which extent does the programme involve lecturers from sectors outside the university sector?
- Does the programme offer internship options in academia and/or other sectors?
- Can students who prefer carry out master research projects in collaboration with external institutions and/or industry?

4.3 Input factors

4.3.1 Recruitment of motivated and talented students

All of the participating programmes agreed that recruiting motivated and talented students is a critical quality factor. The programmes vary considerably in size in terms of student numbers, from seven students enrolled at the UiT programme in 2015, to 107 in the same year at the Wageningen University programme. In general, the Dutch programmes as well as the programmes at Uppsala University and Lund University enrol the highest numbers of students.

Recruitment of a critical mass of motivated and talented students obviously has to do with several factors, some of which the programme can directly improve in the short term. These are typically factors that will increase the quality and the attractiveness of the individual programmes (which is the primary topic for this project and discussed throughout this report), as well as measures to amend knowledge gaps, admission requirements and quality assurance of prospective students, which will be discussed in this section of the report. Others have to do with factors that the programmes themselves

[12] Atlay M. and Harris R. (2000). An institutional approach to developing students' transferable skills. Innovations in Education and Training International, 37 (1), 76–81.
[Taylor & Francis Online]

[13] Cottrell S. (2001) Teaching study skills and supporting learning. London: Palgrave Study Guides.
[Google Scholar]

cannot easily change. These include the general popularity of Molecular Biology among young people and their knowledge about the subject, the labour market situation for Molecular Biologists, the general reputation and attractiveness of both countries and institutions among prospective students and national systems for student financing. The Dutch and the Flemish programmes reported that they have experienced a steady increase of applicants for MSc education in Molecular Biology over several years. At Wageningen University, this has resulted in a steady increase in student numbers, whereas the programme at VU Amsterdam and the Interuniversity programme have chosen not to enrol more students. The Norwegian and the Swedish programmes have not experienced a similar increase in popularity in Molecular Biology, with student numbers having been relatively stable over the last years.

The seminar discussions revealed that all participating programmes agreed that the teaching of Molecular Biology in secondary education (high school level) is generally poor, in terms of both quantity and quality. The programmes felt that this influences the attractiveness of higher education in Molecular Biology among prospective students, which limits their potential to recruit motivated and talented students, especially from their own countries. The Teacher Education programme at NTNU and the track at the Wageningen University programme preparing for work as a scientifically-trained teacher at Dutch high schools, therefore represent examples of good practice for addressing this challenge.

Some of the programmes have enough applicants to be highly selective. In particular, the Interuniversity programme adopts this strategy of selectiveness, and admits only about 30 new students each year (of which the 13 best receive full scholarships covering all expenses) out of about 350 applicants. Other programmes essentially have to admit every qualified applicant in order to ensure a critical mass of students. It should be noted that national regulations could set limits to what strategies the programmes may employ when it comes to whom they admit. In the Netherlands, the universities have to admit qualified applicants from their own bachelor programmes. Wageningen University offers a bachelor programme in Molecular Biology, whereas VU Amsterdam does not and experiences a higher degree of freedom. Systems for public funding of higher education, in which universities and programmes are payed per student credits or graduates they produce, may also restrict the possibility to adopt a selective strategy if the numbers of qualified applicants do not exceed the available capacity. This seems to be the case for the majority of the Norwegian and Swedish programmes.

One of the challenges the programmes report is the heterogeneity of the student population. Since tertiary education is currently more accessible than ever, the pool of candidates is very diverse. Over the last decades, the expansion in tertiary education has been significant, and across OECD countries on average 35% of 25-64 year-olds have tertiary education. In 2016, 43% of 25-34 year-olds had tertiary education in Belgium, 45% in Netherlands, 46% in Sweden and 48% in Norway[14]. Moreover, a key feature of the global tertiary education has been the growth of internationally mobile students. The number of those students has increased from 800.000 in the mid-1970s to over 3,5 million in 2009[15]. Therefore, the universities also face an inflow of candidates who differ in their cultural background and knowledge. The programmes have (mostly) good experiences with international students and agree that they bring added value to the programme, but the heterogeneity of the student

[14] OECD. 2016. Education at a Glance 2016: OECD Indicators. OECD Publishing, Paris.

[15] British Council and Oxford Economics. 2012. The shape of things to come: Higher education global trends and emerging opportunities to 2020. London, UK.

population also brings challenges. The participating programmes felt that these challenges are related to international students coming from educational cultures where individual responsibility for learning and innovation is less valued and to students who are used to a more school-like learning experience. The programmes also reported that international students sometimes have less practical lab training (but often stronger theoretical knowledge) than what they are used to of students from their own countries. Therefore, international students may need some time to adjust to different ways of teaching and learning and developing practical skills, on top of the general challenge of adapting to new environments in a foreign country.

Regardless of the reason for heterogeneous student populations, the programmes agree that getting all students to the same expected level early on is a critical quality factor. As described in the section above on programme structure, most of the participating programmes have some form of introductory course, and for some of them the primary goal of this course is addressing this challenge. At NTNU, the students take an introductory course called "How to do science?", with the goal of making the students realise the expected academic standard at the master's level. The programmes at Uppsala University, Lund University and the Interuniversity programme give courses covering scientific methods and lab skills at the start of the first semester to ensure that their students acquire the basic knowledge and skills from the start. The programme at Lund University also runs a two-week non-compulsory introductory course for international students prior to the start of the first semester, focusing on lab skills, scientific writing and ethics of science. All of these are good practice examples for addressing the challenge of heterogeneous student populations.

Other important factors for enrolling motivated and talented students are related to admission requirements and other mechanisms to further ensure the quality of applicants. There are some differences between the programmes with respect to admission requirements. All programmes require a bachelor's degree (except the 5-year integrated programmes at NTNU) in Biology with Chemistry, with variations in the extent of required specialisation in different sub-fields. For instance, the Biotechnology programmes at NTNU and UiT require a background in Biotechnology. The programme at Lund University requires a minimum number of ECTS' in several sub-fields including Cell- and Molecular Biology, Genetics, Microbiology, Physiology, Biochemistry and Chemistry. The admission requirements for the programmes at Uppsala University, the University of Gothenburg and the Interuniversity programme are less subject-specific. That is also the case for the Biology and Chemistry requirements for the Wageningen programme, but it has certain requirements for competence in Mathematics, Statistics and Computer skills.

In addition to subject specific admission requirements, other important tools for ensuring recruitment of motivated and talented students include requiring certain grades from the bachelor degree, proof of English skills, motivation letters and letters of recommendation. For instance, the programme at Wageningen University requires a Grade Point Average of at least 70% of the maximum grade for the BSc in questions. The Interuniversity programme requires that applicants should at least have obtained a distinction for the bachelor degree. All programmes given in English require proof of English skills, typically documented by standardised international tests such as IELTS and TOEFL.

When assessing potential candidates for admission, however, the programmes feel that they cannot rely on the transcript of records or English tests alone, because the grading systems and the level to reach learning outcomes vary too much between countries, institutions and programmes, and it is often difficult to verify the authenticity of test results or motivation letters. In general, the programmes choose a conservative approach when they feel they cannot ascertain the level of proficiency of international applicants, as exemplified by a quote from NTNU: “I am sure we sometimes miss out on some very clever students, but we cannot afford to take the chance if we are not certain”. The Interuniversity programme gave an example of how this challenge can be addressed. They ask applicants from countries or educational systems they are not familiar with to also send in two recommendation letters from either alumni or previous professors/academic supervisors they can trust.

Expert comments
Heterogeneous student populations are a challenge that the programmes increasingly face, and it is critical that the programmes find adequate ways of handling it. The seminar discussions indicated that the mechanisms for dealing with this issue is primarily related to admission criteria and other means of assuring proper quality of their applicants, as well as offering introductory courses to bring all new students to the expected level. Together, the programmes display a range of examples of good practices. The expert team would like to also bring to the attention a third element that was not particularly emphasised by the programmes in the discussions, namely the importance of securing good support systems, especially for their international students. This may include active engagement of competent study advisors, tutors, alumni and student bodies to help and motivate students both academically and socially.

Indicators
Quantitative and qualitative indicators

- Number of qualified applicants/year in relation to the numbers of students admitted and enrolled.
- Applicants’ grades from their bachelor degree.
- Share of enrolled students who graduate (completion rate), time to graduation and drop-out rate, as well as trends over time.
- Careers of alumni (PhDs obtained by alumni, senior positions in universities, research centres, government and private sector).

Control questions

- Does the admission requirements correspond to the programme’s overall goals and scope?
- Are the students attractive, and is it easy for them to be accepted for internships or as PhD students in good research labs, outside their own institution?

4.3.2 Teachers as quality factors

All the participating programmes agree that teacher competence is a critical quality factor. The teacher competence means the ability to facilitate learning experiences of high quality and that the teachers should be active researchers. Enthusiastic and pedagogically trained teachers facilitate high quality learning processes by choosing effective learning formats and providing feedback, motivating their students and enabling them to reach the intended learning outcomes.

The seminar discussions indicated that all programmes emphasise the importance of formal pedagogical training and systems for pedagogical development. There was also agreement that this is not enough, it is equally or even more important that the teachers are enthusiastic about teaching and are able to motivate students to work hard.

Even though both the quality of teaching and research are viewed as critical quality factors, which to a large extent depend on each other, one of the most difficult challenges the programmes report is maintaining a good balance between the teaching and research efforts of the teacher/researcher. The majority of programmes experience that incentives for individual development of academics, such as hiring processes, tenures and promotions tend to be skewed towards research. Moreover, the researchers compete for large research grants that are critical sources of external funding for their research groups and institutions, whereas the resources that may be acquired for development of teaching is usually very small in comparison. Consequently, all programmes felt that the time available for designing and planning teaching is a limiting factor. The Norwegian programmes experienced that researchers sometimes applied for funds as part of prestigious research grants to hire someone else to do their teaching. There was general consensus among the programmes that it is more difficult than it ought to be to motivate researchers, and to some extent also the institutional leadership, to invest time and resources for pedagogical development and designing the best possible learning formats. Furthermore, while the will to engage with pedagogy and teaching development may be there for some, other teachers may have difficulty in engaging with the literature or may simply not see the value of doing so. Educational research can be quite different from basic science and it may be difficult for scientists to 'switch gears' and engage with what is frequently a less quantitative research method.

Despite these challenges, all the participating programmes emphasise the importance of pedagogical competence and appear to work hard using available resources and means to facilitate pedagogical development for their research active teaching staff. Several examples of good practice were identified and discussed during the project. Most programmes require that new staff have some form of formal pedagogical training, often given at the university, in order to get tenure or positions as associate professors. Several programmes felt that this should be required also for established professors who do not have this formal training. The academic environments surrounding the programmes at NTNU, the University of Gothenburg and Uppsala University provide regular seminars where teachers update each other on different topics, such as how to develop student active learning forms, different types of assessment, how to use data from student evaluations and so on. NTNU and the University of Gothenburg also organise a system of teacher supervision, where teachers sit in on each other's lectures and seminars and provides peer-feedback. These initiatives provide good informal arenas, not only for motivating individual teachers to develop their pedagogical competencies and teaching formats, but also for establishing common goals and strategies related to quality of teaching in the larger academic environments to which they belong.

The Swedish universities have implemented an incentive system where teachers may be evaluated on their teaching merits and pedagogical competence, to be awarded the status of Excellent teachers and a pay rise. The Excellent teachers should be a resource by sharing their knowledge with their colleagues. The Swedish programmes reported that very few of their colleagues in Molecular Biology choose to follow this path because they feel it is too much work to be compatible with a successful research career, and the programmes feel that their teaching has not benefited from this incentive system so far. In Norway, a white paper on quality in higher education from February 2017[16], states that all Norwegian universities and university colleges should develop systems for meriting individual

[16] Meld. St. 16 (2016–2017). Quality Culture in Higher Education. https://www.regjeringen.no/contentassets/aee30e4b7d3241d5bd89db69fe38f7ba/en-gb/pdfs/stm201620170016000engpdfs.pdf

teachers based upon teaching qualities and pedagogical competence within the next two years. The Norwegian programmes reported that this is currently being developed by their universities.

PhD students, post docs and to some extent senior MSc students are also involved in teaching at the programmes. They are a natural and quite necessary resource for day-to-day supervision and guiding in the laboratories when the students carry out experiments for their master research projects. They may also give seminars and lead other types of training associated with courses. This is typically seen as a quality factor and is highly appreciated by the students. In Sweden all PhD students are obliged to teach 20 % of their time, and in the Netherlands most teach 10 %. This is more variable in Norway, where some PhD students have three years without teaching, while others have four years with teaching obligations (25 %). The programme at UiT reported that they are not able to involve PhD students in teaching to the extent they would like to, because they have very few PhD students with four-year funding.

The programmes also involve external lecturers from industry, government and research institutes in teaching. This is universally seen as a quality factor that adds value to the programmes. Through external lecturers, the students (and teachers) get insights into what kind of skills and knowledge different types of employers look for, find mentors for master research projects or internships, and get to know their potential employers. It also provides an important channel for receiving feedback from external stakeholders on the quality of the programmes and employability of their graduates. One challenge is that, since external lecturers are usually not familiar with the detailed structure and scope of the programme or courses, it can be difficult to ensure that their teaching is always relevant for the programme's intended learning outcomes. Lack of pedagogical competence may also pose a risk. Good communication between the teachers and external lecturers, as well as close monitoring of the quality of teaching, are very important for quality assurance of external contributions to teaching and learning.

Expert comments
Enthusiastic and competent teachers are absolutely essential for developing effective learning methods and providing good teaching and learning experiences, but it is important that the responsibility is not left to the individual teacher. Systematic fostering of quality teaching is a multi-level endeavour and the support for quality teaching takes place at: i) the institution-wide level (policy design, support from the leadership to the faculties, departments and programmes and internal quality assurance systems), ii) the programme level (actions to measure and enhance the design, content and delivery of the programmes) and iii) the individual level (initiatives to help teachers achieve their mission, encouraging them to innovate and to adopt a learner-oriented focus)[17]. In order to succeed, high quality teaching and learning needs to be prioritised at all levels.

Programmes and institutions should make resources available for pedagogic development projects and establish arenas where their teachers can share and discuss practices, experiences and pedagogical research, and work in teams to assess and develop their quality of teaching. They should also implement clear requirements for emphasising pedagogical training, teaching experience and outcomes in hiring and promotion processes. Systems such as the "Excellent teacher" scheme in Sweden can clearly be an important mechanism for giving teaching a higher status and promote pedagogical and didactical research relevant for master education in Molecular Biology. However, if

[17] Henard F. and Roseveare D. 2012. Fostering quality teaching in higher education: Policies and practices: an IMHE guide for higher education institutions. OECD Publishing, Paris.

these mechanisms are designed for the excellent few, it is very important that they are supplemented by less formal and demanding systems for pedagogical development and peer-review in order to be accessible for all teachers.

Buying out researchers from their teaching responsibilities seems to be a very short-sighted strategy. Teaching by top researchers is attractive for talented students, and good research groups renew themselves by attracting these students. If the top researchers do not teach, both the quality of teaching and research is likely to suffer in the long run.

The expert team believes that all PhD education should involve some teaching obligation, both because it is a quality factor for the master programmes, but also because it is important that the academics of tomorrow learn to appreciate both the joy and the importance of teaching from the very start of their academic careers. Ideally, PhD students should also have access to relevant support, such as pedagogics seminars or mentoring from experienced teachers.

Indicators
Quantitative and qualitative indicators

- Share of research active teachers.
- Share of teachers with formal pedagogical training.
- The quality of courses and teaching staff, based on student and alumni feedback in surveys.

Control questions

- Are systems available (time, money, structure) for both individual teachers and teachers working in teams to develop teaching skills and learning forms?
- Does the programme/relevant academic community at the university arrange seminars, workshops or courses where teachers discuss pedagogical developments, share teaching experiences and give each other feedback on teaching and learning activities?
- To which degree is teaching competence and experience a part of the assessment criteria that underlie hiring, promotions and career development for academics?

4.3.3 Quality assurance systems

There was general agreement that quality assurance and good systems for implementing it, are critical factors for achieving high quality in master programmes. The project did not identify major differences between countries or programmes on this aspect, but the self-presentations and discussions at the seminars indicated that the Swedish programmes tend to put more emphasis on the importance of their formal quality assurance systems than the programmes from Norway and the Netherlands and Flanders.

The discussions and input with specific reference to quality assurance systems were related to collecting and acting on data from student evaluations and feedback from alumni and potential employers. Quality assurance of other important aspects, such as programme design, applicants, individual plans of study, teacher competence, supervision and assessment, was mostly discussed without reference to the quality assurance systems per se, and is therefore also described and discussed elsewhere in this report.

The programmes regularly collect feedback from students through questionnaires and other evaluations. Most of the programmes face the same challenge – low numbers of students actively participating in quality assurance, and especially low turn-outs on student evaluations. Promotion of the importance of student engagement in quality assurance through student representatives and systematic feedback to students could tackle this issue. One example of good practice was presented by the Uppsala University programme, where teachers at the beginning of each term have to tell students what has changed as a consequence of previous student feedback. Wageningen University has a programme committee involved in quality assurance of all aspects of the programme, including programme design, consisting of five student representatives and five faculty staff. The programme director and study advisers advice this committee. The students are highly involved and committed, and this system appears to represent a good example for promoting student engagement in quality assurance.

All of the participating programmes see contact with and feedback from alumni and potential employers for their students as extremely important for monitoring programme design, academic level and the degree of employability for different types of careers. Most programmes, however, felt that this was an area with a clear potential for improvement. Several programmes reported that they invested too little resources in building strong alumni networks, and that the feedback they received from potential employers was too fragmented. One exception and an example of good practice was reported by the Flemish Interuniversity programme, which has systematically built a very strong alumni network that is actively used for a range of quality assurance purposes. The Interuniversity programme states that the feedback they receive from their alumni is of high quality and very important for the development of their programme. Also, the UiT programme, originally established as a response to the demand from regional businesses and research institutes for building competence in Marine Biotechnology in the northern part of Norway, has maintained very close connections to these potential employers and actively involves them in quality assurance. Another example was given by VU Amsterdam, which is in the process of establishing a programme specific advisory board of relevant external stakeholders. This seems to be a very good idea for systematic strengthening of this type of feedback.

Expert comments

Lack of motivation for active participation in quality assurance procedures among students is a common issue that is often a consequence of a lack of communication between the students and the university/faculty/programme leaders. Students are often discouraged from answering evaluations if they do not receive good information on what has changed as a result of their feedback. The examples of good practice given in the discussions above indicate ways to address this point.

Lack of motivation among teachers to act on results from student evaluations can sometimes be a challenge when they perceive this feedback as vague or based on ‘what students like’ rather than ‘what students need.’ Moreover, research on feedback from students has shown that it can also be biased against women and minority teachers[18,19]. Such problems can be especially demotivating for teachers if they experience that promotions are based on potentially vague or biased feedback. The experts encourage the programmes to be aware of these challenges when designing student evaluations and other systematic systems for collecting student feedback.

[18] Stark P.B. and Freishtath R. ‘An Evaluation of Course Evaluations’ http://www.specs-csn.qc.ca/site-com/qlp/2015-2016/2016-03-30/articles.pdf accessed September, 24 2014

[19] Boring A., Ottoboni K., and Stark P.B. ‘Student evaluations of teaching (mostly) do not measure teaching effectiveness’ Science Open Research https://www.scienceopen.com/document?vid=818d8ec0-5908-47d8-86b4-5dc38f04b23e accessed June 6, 2017

Alumni and external stakeholders such as potential employers may provide very important feedback for monitoring several aspects of quality, and they are crucial for receiving feedback on the employability of graduates. Most of the programmes could clearly benefit from building stronger contacts with their alumni and relevant external stakeholders.

Indicators

Quantitative and qualitative indicators

- Student participation in surveys.
- Students' opportunities to influence (representation in boards and working groups etc.).

Control questions

- Does the programme systematically collect and act on feedback from all relevant stakeholders (students, alumni, relevant employers and external academic institutions)?
- Are the students informed about changes made, based on their feedback?
- Does the programme maintain an alumni network of high quality?

4.4 Learning processes and assessment

4.4.1 The master research project(s)

In this context, a master research project refers to a major project in which the student carries out individual research and writes it up in a report under supervision. There was general agreement among all participants that the master research project(s) represents one of the most, if not the most, important learning process within the master programmes in Molecular Biology. The programmes exhibit variation with respect to the number and duration of master research projects. For the majority of programmes, these are referred to as thesis projects, but VU-Amsterdam and Wageningen University also use the term research internship for such projects.

In Norway, all programmes except the Teacher Education programme at NTNU has one large master research project of 60 EC, as has traditionally been the norm in Norway for MSc education in experimental sciences at the universities.

The Swedish programmes give the students several options. The programme at Uppsala University gives the option to do one project of 30 or 45 EC, or two projects of 30 EC each, depending on personal interest and plan of study. In the Molecular Biology programmes at both Lund University and University of Gothenburg, the students carry out one project, with the option to choose 30, 45 or 60 EC. The Genomics and Systems Biology programme at University of Gothenburg has one large project of 60 EC.

The programmes from the Netherlands both contain two projects. At Wageningen, the first project is referred to as a research internship of 24 EC, and the second is called the thesis project (36 EC). At VU-Amsterdam, both projects are referred to as research internships. The first internship carries 24-30 EC, the second 30-36 EC.

At the Flemish Interuniversity programme, the students carry out one master research (thesis) project of 30 EC.

For the sake of simplicity all of these different projects are further referred to as master research projects.

There was general agreement among the participating programmes that the goal of the master research project(s) is to introduce the students to real research questions and methods, and enable them to carry out independent research under supervision. These goals are considered critical quality factors. It should be noted that “independent” does not mean that the students should work on isolated projects. The norm among the participating programmes is that students carry out research connected to bigger projects in the research groups. Although the master students are very often real contributors to bringing science in their field forward through their projects, which is also important and attractive for supervisors and the research groups, the programmes clearly expressed that although ideal, producing publishable results should not be considered a critical quality factor for master education. It is, however, critical that the students are given the possibility and incentives to have real ownership of their project, by writing their project proposal, taking some degree of responsibility for project planning and management, experimental design and ensuring data quality. It was felt by the participating programmes that a minimum of approximately 30 EC was required in order to achieve these learning outcomes.

Apart from that, there was no clear consensus opinion among the programmes as to the number and duration of master research project(s). The majority of programmes agreed that the longer the students spend time in the lab, embedded in research groups, the better, and that the sum of the master research project(s) should equal at least 60 EC. Some programmes argued that the students’ understanding of the research process and ownership of a research project is best achieved with one longer project. Another argument from a more practical angle is that many supervisors often prefer to have students in their research groups for a longer time because they felt that this increases the students’ chances of producing publishable results, thereby “giving something back” to the supervisors and research groups. This was particularly emphasised by the Swedish and Norwegian programmes. On the other hand, some programmes, especially the programmes from the Netherlands and Flanders, were of the opinion that shorter projects of approximately 30 EC allow the students several possibilities that may not be realised by larger projects. The students at the Dutch programmes become exposed to more (and possibly quite different) research questions, methods and research groups by carrying out two projects. They argued that as long as the primary goal of the project is not to produce but to learn science, the experiences from carrying out two shorter projects are more important to prepare the students for their future careers. At VU-Amsterdam the students are also given the option to extend their final project from 30-36 EC if they want to in order to obtain publishable results, and this flexibility appears to be an elegant solution for shorter projects. The Interuniversity programme on the other hand, felt that it was important for their students to be able to take more courses, rather than two master research projects.

Expert comments

All participants in this project strongly felt that one of the most critical quality factors for achieving high quality in MSc programmes in Molecular Biology is experiencing and acquiring the diverse sets of learning outcomes ideally associated with the master research projects. This point therefore deserves a further explanation of what this actually means. The students should know what it is like to work as a scientist in an active research environment. As such, they should be exposed to all the successes, failures and interpersonal complications that this inevitably involves. They should participate in journal clubs, give lab-meeting presentations and, when possible, be involved in manuscript preparation, even if this is to simply proofread. In short, a master student should *be* a scientist for the duration of his or her master research project. The experts would like to emphasise that these experiences are equally important in giving the students a range of transferrable skills relevant not only for students preparing for a PhD trajectory but for all types of careers.

The expert team agrees that the primary goal of the master research project should be to learn and not produce science. However, the project should be scientifically sound and should seek to ask an important question whose answer has significance. Moreover, the students should take some part in project design and management, to the extent that at the end they are able to answer important questions (and perhaps also disagree with their supervisor) such as: has the data been appropriately analysed; are the conclusions logical and based on the data?; what was the rationale for the choice of experimental methods used?; why didn't you get "usable data"?; how do your findings fit (or not) into the broader context of the field?; what could/should be the follow up experiments?.

The discussions indicate that there are advantages and disadvantages with both longer and shorter master research projects, and that it is not meaningful to conclude that one particular way of organising the master research project(s) results in the highest level of quality. It seems that a system with some degree of flexibility may be preferable, as this gives the students the possibility to choose between obtaining experience from more than one research project and research group/supervisor, or focus on one project.

Indicators

Quantitative and qualitative indicators

- Completion times and drop-out rates for students who have started their master research project(s).
- Feedback by external examiners (both in terms of grades and qualitative feedback).

Control questions

- Are all supervisors also active researchers?
- Is the quality of thesis reports systematically monitored and evaluated by periodical reassessment carried out by external experts?
- Are students involved in publications and product development?
- Are the students fully integrated in the research labs, both academically and socially?

4.4.2 Assessment of master research projects

At all the participating programmes, the students have to present and defend their master research project(s) as part of the assessment. This is viewed as a critical quality factor, but it varies considerably as to how the assessment is organised and carried out, and what grading system is being used.

Students at Uppsala University defend their project in front of two student opponents and one senior opponent (most often a PhD student), whereas the examiner is a professor/lecturer from the university. At Lund University the assessment is carried out as an open seminar, followed by defence in front of an external opponent, and finally a discussion with the audience and the examination committee, the latter including an examiner. At Gothenburg University, the students defend their project in front of the appointed examiner and supervisor. The examiner, following consultation with the supervisor, gives the grade. In Sweden, the participating programmes use the grading system suggested in the

Swedish Higher Education Ordinance[20] for assessing the master research projects: *Fail* and *Pass,* with the option to also give *Pass with distinction* (also referred to as *High Pass*) for the best students. The programme at Uppsala University uses *Fail* and *Pass*, whereas the programmes at the University of Gothenburg and Lund University also use *Pass with distinction*.

At VU-Amsterdam and Wageningen University, the assessment is carried out by the supervisor who assesses and grades the entire set of activities including the student's oral presentation, report, attitude and performance during labwork, and a second internal examiner not involved in the project who assesses and grades the written report. The two marks are averaged. For the Interuniversity programme, the defence takes place in front of a promoter, copromoter, supervisor and two external members (readers). One mark is given by the promoter, after consultation with copromoter(s) and supervisor(s), and one is given by each of the external members. The final mark is the average of the three. The assessment is based on evaluation of practical skills, report writing, oral presentation, the students' attitude and how he or she function as a team member. The programmes from the Netherlands use the Dutch grading system with grades from 1-10 including half grades, where below 5,5 is fail. The Interuniversity programme from Belgium use the Flemish system from 1-20, where 10 and below is fail. For both systems, the particular failing grade indicates how much the student has to improve in order to pass on a second attempt.

At the Norwegian programmes, the students present and defend their project in front of the supervisor(s) and an external examiner. The external examiner is responsible for assessing the thesis. National legislation requires that the external examiner cannot be affiliated with the university, and he or she usually comes from another university, university college or research institute in Norway. The Norwegian programmes grade the master research project using the EC system from A-F, where A-E are passing grades and F is fail.

The seminar discussions indicated that the programmes find assessment of master research projects quite challenging and despite efforts to design grading grids and specific criteria for grading, several programmes felt that it often came down to an "overall gut-feeling". In general, the critical factors and the goals for all participants is to organise the assessment in a way that both secures transparency and fairness, and at the same time makes it possible to take the students' performance in the lab, work ethics and attitude into account, in addition to the written report. The first is typically secured by involving one or more external examiners who have not been directly involved in the supervision of the student. The second is made possible by allowing the supervisor(s) some degree of influence in the assessment. These two goals can to some degree be considered contradictory, and are handled quite differently. For example, the Dutch programmes allow the supervisor and external examiner to formally grade on equal footing. The strength of this approach may be that it is easy to take attitude and performance in the lab into account, as the supervisor(s) are in a good position to do this. The Norwegian programmes on the other hand, use a system where the supervisor does not formally participate in the grading. Moreover, the external examiner cannot be affiliated with the university in Norway, which is not the case in the other countries. The strength of this approach is securing transparency. This system is also designed to harmonise grading practices between institutions, and the Norwegian programmes felt that this is very important. The practice at e.g. the University of

[20] The grading is not nationally regulated, and the Swedish Higher Education Ordinance gives the institutions freedom to use other grading scales.

Gothenburg where the external examiner gives the grade after consultation with the supervisor(s) lies somewhere between the Dutch and Norwegian practices.

Providing feedback to the students on their performance during their project, in order for them to be able to improve, is important for all the participating programmes. The principal mechanism is regular feedback by the supervisor(s). The Dutch programmes also use midterm evaluations involving staff not directly involved in supervision, to ensure that the project does not go completely wrong. There was general agreement among all the participating programmes that this system was an example of good practice, which could be implemented by more programmes.

Expert comments
As discussed above, each of the different ways of organising the assessment of master research projects has its strengths and weaknesses. It is important that the programmes design systems that ensures transparency and fairness. The experts also believe that performance and attitude in the lab, as well as a range of transferrable skills not readily observed by assessing the written report, such as team working skills, independence, ability to come up with new ideas, ownership, responsibility and ethical awareness are very important learning outcomes from the master research projects. The systems for assessment should therefore be designed to effectively take these into account.

The expert committee finds it rather curious that the programmes from the participating countries use completely different grading systems. This seems to go against the Bologna process and the general aim of harmonising educational systems between European countries in order to facilitate mobility of students and employees across countries. Although diploma supplements go some way to address this problem, the discussion at the seminars indicated that it does pose a real challenge. For instance, the Dutch programmes clearly stated that they would have difficulties accepting applicants from the Swedish programmes (where only fail and pass/pass with distinction is given) to their PhD programmes. The discussions also indicated that many students at the Swedish programmes want grades that discriminate performance to a larger degree. In addition, many employers want some sort of grading to distinguish the proficiency of candidates.

4.4.3 Innovative teaching and learning formats

The use of innovative teaching and learning formats was seen as a critical quality factor by all participating programmes. While traditional teaching formats such as lectures still dominate, the programmes reported that alternative and more student-active learning activities are increasingly being used. These include problem-based learning approaches, journal clubs, the ‘flipped’ classrooms, the use of ‘clickers’ to poll students in the lectures in order to focus on areas they apparently find challenging, and team-projects. Several programmes also include available online lectures or demonstrations in the curriculum, thereby freeing up time in lectures and seminars for discussion. Moreover, lab training, which is a major part of most Molecular Biology programmes, is inherently student active, although the degree of demonstration versus individual or team practice may vary.

The discussions at the seminars clearly showed that the above concepts are all limited by the fact that the development or implementation of alternative teaching and learning activities are time and resource limited. The programmes report that the main challenge of developing and implementing new teaching formats and learning activities is that they simply do not have time to fit this effort into their teaching practice to the extent they would like to.

Expert comments
The increased use of both novel and more student-active learning methods represents a development that is seen as positive by all programmes, their students and the expert team. However, teachers should be cautious in adopting a novel approach and critically assess whether it actually improves student learning or is implemented just for novelty's sake. Sometimes a traditional lecture can be just as useful and engaging as newer methods. The choice of teaching and learning formats should primarily be adopted to reach the intended learning outcomes. The programmes and courses have a range of different intended learning outcomes. In order to reach them the programmes need to use a range of different teaching and learning formats. Often the pedagogical literature can provide suggestions and answers, and teachers are encouraged to engage with resources within their institution. Put simply, the key question should always be - does a particular innovation in a learning activity actually improve the students' learning? Does it foster an attitude of lifelong learning? Are students feeling motivated and actively engaged? Are they being encouraged to think creatively?

4.4.4 Feedback to and from students

All participants agreed that proper feedback to the students is a critical quality factor that is essential for their opportunities to develop and improve. Without proper feedback, students are not able to fully engage with the learning experience and assessment of their performance. In order to successfully reach the intended learning outcomes, students need feedback on how they perform – what they did well and how they can improve. Moreover, giving and receiving feedback is an important transferable skill that is essential for employability. For instance, scientists are constantly being evaluated - through grant applications, manuscript submissions, and conference presentations and so on. This skill is equally important for all types of careers and it is how scientists estimate how well they are doing in their field of research, but this skill is equally important for all types of careers.

It was also agreed that a simple mark is not enough to provide quality feedback to students. However, most if not all programmes, felt constrained by time in their ability to give formative feedback, especially to individual students. The programmes mentioned that there is no easy solution to this challenge, while the discussions indicated that there is a need for thinking creatively about solutions. For example, feedback to the whole class on common challenges could be given alongside more limited, individual feedback. Additionally, electronic marking systems such as Grademark enable the formulation of common, repeated stock feedback phrases that can save time when similar issues consistently reappear in student work[21]. Peer-marking between students can also provide valuable feedback, especially in formative or less-high stake assessments.

Expert comments
The flip-side to feedback *to* students is feedback *from* students. This is not only important as part of systematic student evaluations and quality assurance (discussed above), but also for being able to adapt teaching and learning activities to address areas that the students need to develop or improve on a day to day basis. While the discussions did not offer any easy solutions to the challenges of giving and receiving high quality feedback, training and dialogue around feedback provision, both to and from students, should go some way to raise the awareness of and communication between students and teachers. Even more simply, teachers can ask for feedback after a lecture or practical. This can be as

[21] https://guides.turnitin.com/01_Manuals_and_Guides/Instructor_Guides/Turnitin_Classic_(Deprecated)/25_GradeMark/QuickMark

informal as asking students to write their feedback on a particular learning activity on a post-it note. However simple, this method could be a valuable reflective tool.

The experts would also like to raise a debate around the following questions: Is it possible that students are too excessively assessed? Is it possible to provide fewer, more ‘real-world’ assessments and still accurately test student learning? Is part of the solution to strike a better balance between formative and summative assessment so that students are given a chance to act on feedback before the mark ‘counts’? Allowing students the choice to engage with formative opportunities should encourage them to take ownership of their own learning.

5 Future developments of master education in Molecular Biology

During the second seminar, the programmes and the expert team reflected upon critical quality factors or issues for future development of master education in Molecular Biology in the broader sense, without reference to specific programmes. This chapter briefly highlights the topics that were discussed, and which the programmes and experts feel are relevant for all master programmes in Molecular Biology.

5.1 Big Data and Bioinformatics

In order for Molecular Biology training to keep pace with demands in the field, Big Data and Bioinformatics are going to be ever more important. The challenge for the master programmes in Molecular Biology will be to incorporate enough of that in their programmes without becoming a "Bioinformatics Master" or sacrificing sufficient depth in the programmes. In that respect, it is essential to train the students in the interdisciplinary field that modern Molecular Biology is, with sufficient emphasis on the rapidly growing amount of biological data that needs to be handled.

5.2 Novel teaching and learning resources

Internet, IT and the modern social media offer interesting possibilities with respect to teaching. Also, "teaching at a distance" and in a truly international environment are real options nowadays. One challenge will be to integrate these novel possibilities, such as Flipped Classrooms, Massive Open Online Courses (MOOCs), Gamification and so on, in a meaningful way in the programmes' teaching arsenal. Many MOOCs and other online courses, lectures and demonstrations of high quality, given by international top experts, are available via the internet. "Micro-Masters" and online (part-time) Masters have already been set up in fields neighbouring Molecular Biology[22]. Another challenge will be to create a good student environment as well as a scientific community surrounding such provisions. Of course, Molecular Biology is about teaching the methodology of science, with a major emphasis on teaching practical/laboratory skills. Therefore, online theoretical teaching should, at some stage, be complemented with practical training in the research groups at the Universities. This organisation of the training could be positive with respect to student mobility.

It will be a challenge to implement exciting new programmes in Molecular Biology as a lot is out there already and the competition is fierce. Also, it is time consuming and, thus, costly to set up and maintain online courses/programmes, although they may ultimately save time and take off teaching load. Decisions to do this should probably be made at the strategic levels of the universities. Possibly, the new teaching methods could be used for integration of programmes between institutions, even in different (European) countries, as they could share courses and offer more modern, different or diverse programmes.

[22] Eg, http://www.wur.nl/en/Education-Programmes/Online-Education/MOOC/MicroMasters.htm
http://www.wur.nl/en/Education-Programmes/master/MSc-programmes/MSc-Food- Technology-online-master-specialisation.htm

5.3 Molecular Biology and the society

Molecular Biology has the potential to contribute to solving major challenges for society and individuals, but in order to succeed and secure future funding for research, counteracting scepticisms towards science and “alternative” facts, it is essential that this knowledge is shared and communicated widely. In this respect, it is important that academics are involved in popularising science, but this is not nearly enough. It is also very important that Molecular Biology students learn to explain to various audiences and stakeholders what they do and why it is important. We of course need to train enough people with the skills to become excellent scientists, but Molecular Biologists are required in many niches in society. The quality of Molecular Biology taught in high school is often poor because specialists do not teach it. This has consequences both for the general awareness of Molecular Biology in society, and for the attractiveness of the field among young people and future students. In this respect, the Teacher Education programme specialising in Biology and Chemistry at NTNU, and the Teacher Education career track at Wageningen University are very interesting and important endeavours. Moreover, there is a need to train and encourage Molecular Biologists to become journalists in order to communicate science to the public, or to take on jobs in industry as well as in governmental bodies and environmental agencies or start their own companies.