Evaluation of the 2-year Master's programme in Biotechnology (MSBIOTECH) and 5-year Master's programme in Biotechnology (MBIOT5) at NTNU Trondheim

Summary

- The MBIOT5 programme attracts a high calibre of student and is valuable as part of NTNUs strategy of making Biotechnology a core enabling technology. However, it has high transfer-out and drop-out rates which need to be addressed
- The MSBIOTECH programme is a logical adjunct to the MBIOT5 programme but is not meeting its recruitment targets. Some action has already been taken to rectify this but further improvements are suggested.
- The conveners for both programmes need to define the learning objectives more clearly, so that "Biotechnology" gains a distinct identity. This should help with recruitment and retention, assist with evaluating the content of the non-core elements of the programme (eg projects) and help with regular programme evaluation. We also advise following the recommendations of the NOKUT report "Kartlegging av læreingsutbyttebeskrivelser" (2015).
- To decrease the dropout rate, the MBIOT5 programme needs to engage students with Biotechnology at an earlier stage in the programme. Various methods are suggested, ranging from formal teaching to keynote lectures and student-led activities. Because it starts with a curriculum which is common with other biosciences, Biotechnology only emerges in year 3.
- The MSBIOTECH programme needs to be reviewed to assess whether the background of students and the courses on offer provide access to all the opportunities supposedly available. As a 2-year post-graduate course it potentially offers different trajectories to different students and these need to be identified and catered for. This might result in restriction of the acceptable qualifications for intake and/or provision of greater mentoring and guidance.
- Perhaps not specific to these programmes, constructive feedback on coursework and greater support through academic counselling are areas that score consistently poorly in student satisfaction surveys; the underlying problems need to be addressed
- The design and execution of the programmes needs greater input from the Biotechnology industry. Apparently, plans are in place for two industry representatives to be on the programme board. While this is a move in the right direction, a separate external advisory board made up of a cross section of society able to provide a view from the user community would also be beneficial.

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Key information about the study programmes

The 5-year Masters programme (MBIOT5) was established in 2003 and leads to the degree: Master i bioteknologi / Master of Science in Biotechnology. It is an integrated Masters programme (Second Cycle/Level 7, Norwegian Qualifications Framework for Lifelong Learning) combining core undergraduate level training in Biosciences with advanced training and research in Biotechnology. It is managed by the Faculty of Natural Sciences and Technology and the course covers 10 semesters. Instruction is in Norwegian and English. The programme comprises 2-years of core bioscience modules, 1 year of core biotechnology and optional modules followed by 2-years of Master's research project and thesis together with complementary specialist courses.

Level of study: ECTS: 300 credits, of which Master's thesis comprises 60 credits.

Max number of students admitted (2016): 40 (35 NTNU + 5 Faculty)

The 2-year Masters programme (MSBIOTECH) was established in 2012 and leads to the degree: Master i bioteknologi / Master of Science in Biotechnology (Second Cycle/Level 7, Norwegian Qualifications Framework for Lifelong Learning). The programme is a continuation from (1) MBIOT – 2-year national Master's programme in Biotechnology and (2) MCBIO 2-year national Master's programme in Cell biology. Both of these programmes are now discontinued. It is managed by the Faculty of Natural Sciences and Technology and the course covers 4 semesters. Instruction is in English. The programme comprises 2-years of specialist courses and a Master's research project.

ECTS: 120 credits, of which Master's thesis comprises 60 credits.

Max number of students admitted (2016): 25 (15 NTNU + 10 Faculty)

Selected quality areas

None selected

Evaluation committee composition

Head of committee:	Professor David Leak, University of Bath
Committee members:	Assistant professor Kristofer Modig, Lund University
	Professor Berit L. Strand, NTNU
	Associate Professor Thorsten Hamann, NTNU
	Student Goro Malene Brennmoen Strypet, NTNU
Committee secretary:	Jo Esten Hafsmo

The composition of the evaluation committee is based on initial suggestions of committee composition given in a letter to relevant departments and study program leaders by NTNU Faculty of Natural Sciences and Technology 27.01.2016. Appointment of the committee members for evaluation of the degree programs in biotechnology 2016 was made 11.02.2016 (NTD resolution 2016/49) based on recommendations from Department of Biology and Department of Biotechnology. The composition of the evaluation committee follows the recommendations given in «Guidelines for periodic evaluation of programmes

of study» from June 2016, with the exception of the presence of 1-2 representatives from the working community that are lacking from the current committee.

Choice of methods for the evaluation

The review adopted the 3 step method employing a single review by both internal and external panel members, producing a single final report. However, the review panel which met on 2nd September 2016 did not contain an industry/community representative. Views from the user community were not available during the compilation of the report. However, industry representatives have been invited on to the programme board for 2017 onwards and recommendations are made for a separate advisory panel to provide input from the user community.

Background information for the evaliation

The assessment and recommendations made by the evaluation committee were based on the following information provided by the Faculty:

- Mandate of the committee (Appendix 1)
- NTNU and Faculty strategies
- Academic regulations, NTNU
- Annual evaluation reports
- National guidelines, Norwegian Qualifications Framework for Lifelong Learning
- Study Requirements, NTNU
- Study plans for the programmes, course descriptions and course reports
- Overview over research activities at departments involved.
- Details per programme:
    - Student satisfactory surveys
    - Master's theses submitted – overview of topics
    - Surveys and reports on relevance to society/work life, internationalisation, recruitment, through-put/drop-out and learning environment.
- 1-day visit to NTNU 2 September 2016
    - The evaluation process – background and committee member roles
    - Discussion based on SWOT analysis / comparison / benchmarking
    - Site visit:
        - NMR laboratory
        - Biopolymer laboratory
        - Food Chemistry / fermenter / cell lab
        - Natural Science Library, computer rooms
        - Cell, optics, teaching laboratory
        - Reading room, individual works space master's students
        - Metabolomics laboratory
    - Planning of evaluation process

Confer https://innsida.ntnu.no/wiki/-/wiki/Norsk/Biotechnology+Evaluation+2016 for a compilation of all background material made available for the committee.

Review of the findings in previous programme evaluations

The evaluation committee has been given access to three faculty evaluations reports[1] as well as the NOKUT evaluation report on study plans[2]. The major conclusions of these are the following:

MSBIOTECH: The need for more stringent admission requirements was identified. This has partly been fulfilled by more stringent English and lab skill admission requirement. The employment rate is high. There is a low number of applicants, although an increase can be seen the last years. One plausible cause was identified: the intake process finishes late, which gives an unnecessarily large losses of applicants to other universities. Fairly low drop-out rates, with the exception of the last year.

MBIOT5: A large number of applicants with good grades. There are, however, large drop-out and transfer rates. The need to introduce the programme specific subjects early was identified in all three faculty evaluation reports.

The faculty evaluations notice that more knowledge about the work community is needed. A skill competence survey was completed and found satisfactory (in line with the current findings). The evaluations also address the need for better data compilation (from faculty) for analysis.

In the NOKUT report, the study plans and specified learning outcomes of 30 biology programmes were investigated and compared to the guidelines in Nasjonalt kvalifikasjonsrammeverk (NKR). The report found no study plans that followed the guidelines properly. In particular, the study plans lack subject profile, level descriptions and progression descriptions. This holds also for the learning outcomes of MBIOT5. For example, the following problems were identified:

- Some learning outcomes are placed in the wrong category.
- Well-defined NKR level descriptors are missing.
- Important NKR goals are missing, including important goals such as “applying knowledge to new areas”, “use relevant methods in an independent manner”, “perform independent research tasks” and communication skills to different targets groups.

It is the current committee’s belief that the conclusions drawn in the three faculty reports are still valid. The problems we have identified when it comes to the programme syllabus are in line with the NOKUT report findings.

Comparison to master's programmes in Lund and Bath

Lund University

At Lund University (LU), there are primarily four master's programmes that may be compared with the master's programmes at NTNU, as listed in Table 1. Of these, LUMBIO, LUGENBTECH and LUBIOINF are given at the Science faculty, whereas LTHBTECH is given at the faculty of engineering (LTH). There are some major differences in how the Master's programmes are organized at NTNU and LU. (1) There are no five year Master's programmes at LU (with the exception of some the programmes training for specific professions, as physician or engineer (“Civilingenjör” in Swedish). (2) In Lund, the Master's thesis is done at the end of the programme, typically as the last course occupying

the last semester. Thus, the Master is not defined by the Master's thesis as is apparently the case at NTNU. (3) There are a considerable number of mandatory courses on all four programs, in addition to a lower limit on courses on the advanced level (see Table 1). This is perhaps the biggest difference to the NTNU programmes.

LU has been fairly successful in recruiting foreign students. Since 2011, Sweden students coming from outside the EU are required to pay a study fee. For LU, the fee is SEK 290 000. In addition, the applicant has to pay an application fee of SEK 900. When the fees were introduced, the number of applicants dropped drastically (for example from 790 applicants to LTHBTECH 2010 to 132 applicants 2011) but the numbers have then increased and are now on the same level as 2011. Table 1 lists the total number of applicants 2017 for each of the four programs, together with the number of students that had the program as primary choice and the number of students that will have to pay fee if admitted. The table does not contain statistics on the finally admitted students, but overall, in 2016, about 36% of the students enrolled to all LU's Master's program were paying. LTH has a higher rate of fee paying students than the rest of LU, because the Master's programmes at LTH has international recruitment as main focus and are always directed towards (industrial) application. Judging from the number of primary applicants, MBIOTECH has about the same level of popularity as the Master's programmes in Lund.

When it comes to the content of the Master's programmes, the three LU are quite “basic science” oriented, focusing on strong methodological knowledge and skill in microbiology and bioinformatics. Notably, the programmes LUMBIO and LUGENBTECH have no special prerequisites in math or statistics, probably reflecting the fact that the corresponding bachelor programmes at LU do not contain any compulsory math courses. On the other hand, LTHBTECH has a significant amount of calculus as a prerequisite.

Table 1. Relevant Master's Programmes at Lund University. In Sweden, every study year consists of 60 hp.

Programme Abbreviation	**Web page**	**Compulsory courses**	**Advanced credits needed to graduate**[a]	**Number of applicants** - in total - prio 1 - fee required
Microbiology LUMBIO	http://www.biology.lu.se/education/undergraduate-graduate-studies/masters-programmes/molecular-biology/microbiology	22,5 hp	60 hp	291 90 256
Molecular genetics and biotechnology LUGENBTECH	http://www.biology.lu.se/education/undergraduate-graduate-studies/masters-programmes/molecular-biology/molecular-genetics-and-biotechnology	22,5 hp	60 hp	572 233 514
Bioinformatics LUBIOINF	http://www.biology.lu.se/education/undergraduate-graduate-studies/masters-programmes/masters-programme-in-bioinformatics	45 hp	60 hp	261 102 216
Biotechnology LTHBTECH	http://www.lunduniversity.lu.se/lubas/i-uoh-lu-TABIT	37,5 hp[b]	60 hp	411 159 349

[a] These numbers are excluding the Master's thesis.
[b] This number includes a mandatory project work in either Life Science or Process and Plant Design, 15 hp.

It might also be noted that LU has a three-term preparation programme available for talented foreign students that are not used to the European way of doing academic study and have a need to improve their English (http://www.lunduniversity.lu.se/international-admissions/bachelors-masters-studies/pre-masters-preparation-programme). This

programme contains English language studies (including academic writing and reading, presentation and discussing etc), research methods, data analysis, project planning and an introduction to how studies in Sweden work. A “lighter” version of this course is also offered as a summer course to all foreign Master's students.

Bath University

The Department of Biology & Biochemistry at University of Bath have historically offered two types of Master’s course: the Master of Research (MRes) and Master of Science (MSc), in a variety of disciplines, not yet including Biotechnology (although there are some Biotechnology options within the units). There are specific courses in Developmental Biology, Evolutionary and Population Biology, Evolutionary Biology, Medical Biosciences, Molecular Microbiology, Molecular Plant Sciences, Protein Structure and Function and Regenerative Medicine plus a general Bioscience option. While this seems like a lot of courses they are, in reality, variations on the same theme but with different sets of course options and research project themes. They are all 12 month courses and the department does not offer a 4 or 5-year Integrated Master’s. A number of UK universities used to offer an 4 year undergraduate Master in Science (MSci) degree, which involved an extended research project, but these have gone out of fashion after signing up to the Bologna Accord.

The MRes and MSc courses overlap substantially, but the former is designed to provide extended laboratory and research skills to students hoping to progress to a PhD. In some departments in Bath and other UK Universities the MRes is a formal requirement for progression to a PhD. This is normally where the department has a significant number of fully-funded 4 year PhD positions to offer and students are typically recruited to the MRes component of this Integrated PhD and only decide on their PhD programme during the first, MRes year. This system operates in the Life Sciences department at Imperial College London. Regardless of whether they are integrated or stand-alone, the MRes component is a recognised level 2 qualification enabling transfer directly onto PhD courses in any European country which has signed the Bologna Accord.

MRes courses incorporate 2 x 16 week research projects (27 credits each) and theses with different research supervisors and project areas together with 4 courses (x6 credits) from the relevant final year* undergraduate stream and a 12 credit Critical Research Analysis Master’s level course which involves a literature review, critical analysis of research papers, oral presentation of research and associated critical analysis and writing a research proposal. The MSc courses contain a larger taught component with 7 final year courses taken across the 2 semesters and the Critical Research Analysis is replaced by a literature review (6 credits) and a practical course in Research Training and Support Skills (12 credit). At the end of the course there is then a 20 week, 30 credit research project.

The MRes in Biosciences, while nominally following the same structure as other MRes courses, has a specific requirement to follow two Master’s level courses some of which incorporate a greater mathematical content e.g. Mathematical Biology 1 & 2 and Evolutionary quantitative genetics. These courses are options in other streams.

Both streams are popular, with a similar number of Home/EU students taking MSc and MRes course, while the MSc course is more popular with overseas students. In 2016/7 the MSc intake almost doubled, possibly due to improved marketing, so the current cohort is

in excess of 50 students, mainly from Home/EU with 10-15 overseas students (across both courses) being typical. Home/EU students currently pay £6,500 fees, while overseas students pay £19,800.

*2 may be from the second year

Analyses of the quality of the study programmes

The study programmes

Objective. Out of all the stages in higher education, the purpose of a Master's degree programme (NQF 2nd Cycle) is the most difficult to define, partly because it could serve a multitude of purposes and in many cases, serves more than one. Therefore, in any assessment of learning outcomes, it is critical to have some appreciation of the outcome objectives/mission statement for the programme. A clear sense of purpose provides both a guide to potential applicants and a framework in which to measure success. Clarity of purpose and learning outcomes should also help to reduce drop-out rates, by eliminating those students who discover that the course is not what they imagined.

The study plan for the five year integrated master's program MBIOT5 presents a slightly confusing contrast between research and industrial processes, firmly placing itself in the research camp but not making it clear that the ultimate purpose is to develop the technology which might one day become an industrial process. The 2-year master's programme MSBIOTECH is more direct in this respect, but neither present the logical progression that, in order to "do biotechnology" you need to understand the basics of cell and molecular biology, biochemistry and microbiology. With a better structure it should then be possible to define "doing biotechnology" as the learning outcome, which is essentially a creative activity, where biology tends to be more analytical.

The five year programme has the advantage that it incorporates the core bioscience learning and the opportunity to undertake extended research training, so it should be clear to applicants that this is why it is a longer course. However, the purpose of the 2-year master's course is less transparent. Applicants could have one of a number of degree level entry points ranging from food science to biotechnology. A food scientist may see this as a mechanism to move into a different discipline, but will require more training in fundamental biosciences. Someone with a biochemistry/biotechnology background may see this as a route to a PhD. Are they equally catered for; are the programmes and guidance in place to achieve these different applications? Is this being monitored?

As highlighted above, both programmes would benefit from a clear statement of objectives and how they will be achieved, which would make curriculum design easier as well as monitoring of outcomes. This is clearly in line with the NOKUT report 2015, which points out that the study plan of the MBIOT5 lack subject profile as well as level and progression descriptions. In addition, it would make sense to highlight the fact that Biotechnology is identified as a core enabling technology in the NTNU 2011-2020 strategy document.

Relevance. "Biotechnology" is an internationally recognised term which people have difficulty defining. Unlike "Biology" and "Biochemistry" where the content of an undergraduate curriculum is very similar across the world, a training in "Biotechnology" has a multitude of meanings. Indeed, it is predominantly taught at a master's level or as a

specialisation in a bachelor's degree because it relies on having a basic bioscience training. In reality, that is what the 5-year master's course provides in the first 2.5-years. This lack of a strict curriculum makes it important to define how the courses at NTNU address the underlying principles of "Biotechnology" training, and this point is raised later in the context of research projects. In other institutions (Imperial College London, University of Bath, University of Kent, University of Edinburgh) it is normal practice to focus on the particular specialisms of the department, but then ensure that the research projects involve skills which are relevant to biotechnology.

The strengths of the study programme – what is working well?
The 5-year programme is well established and exceeds its targets for applicants/place and exam grades of applicants. Thus the course is seen as attractive, providing training in an area that is relevant to society. It is noted that this trend appears to be stable, despite the problems highlighted below.

The challenges or problems of the study programme – what can be better?
Recruitment to the 2-year programme is below expectations and, while quite variable, shows no sign of increasing ie it is currently not attractive to International students. Both the 5- and 2-year courses show an alarming drop-out rate and exam failure rate, which are probably connected. It is difficult to rationalise this from the raw data, but is clearly an area than should be improved.

Organisation and leadership
The programme councils of MBIOT5 and MSBIOTECH consist of four faculty representatives, two students, two external representatives and one from administration as secretary, and by this follows the mandate. The faculty members are two from Department of Biotechnology (IBT), including the programme leader, and two from Department of Biology (IBI). The external representatives have been one from NTNU, Medical Faculty, and one from SINTEF (research institute). New representatives from 2017 will be from industry (Tine and Vectron). The study board meet once per semester to discuss strategic issues. A study program committee consisting of the program leader, a faculty representative from the department that the leader is not representing and a secretary, deals with the day-to-day businesses. This seems to work well on paper, both based on the composition of the board and the use of a working group except that the working group lacks a student representative. However, the meetings of the board has been far less than once per semester, which may be linked to the allocated time for the leader being insufficient (100 hrs per annum). This has changed from November 2016 so that a 20% position is allocated to the head of the study program. Also, from 2016 NTNU is offering courses in leadership for the heads of the study programs. The lack of meetings may have limited the strategic work of the board and also the influence of externals as well as student representatives to the program. The study program leader position is not organised in the line organisation at NTNU. The MBIOT5 and MSBIOTECH study programs are a collaboration between two departments (IBT and IBI). The collaboration with the head of the departments and dean works well. However, some problems with communication and leading the course coordinators and course contents are recognized which is reflected in the problems described from the student perspective in the following.

Students can influence the individual courses in reference groups. Some lectures take the students point of view into consideration and some do not, but the students write an evaluation report by the end of the semester which is saved in NTNU's Quality Assurance Database. This way, if a problem continues for years, these reports can be used as documentation.

Another way students can have influence is through the ITV (department student representative), who participates in meetings with the head of the department. The experience of the previous ITV is that this position is a useful link between students and the department, but that the influence the ITV can have on the programme itself is limited.

The students mainly use the reference groups and not the ITV to bring up problems that occur. This can be a problem when the courses belong to different departments, and the problem is lack of collaboration between departments. An example is the 5th semester of the molecular direction, where the students have had three almost similar courses for many years (BI2014, BI2015, TBT4145). There has also been an overlap between labs, and a lot of work close to the exams. The problem had been brought up in all the different reference groups (BI2015 does not have one), but the problem continues. From the year 2017/18, TBT4145 will no longer be part of the study program, thus this particular problem will be eliminated. However, it illustrates a problem with the organisation and leadership that could be connected to lack of collaboration between IBI and IBT, low activity of the program board and the lack of student influence on the program via their channels.

Professional community and relation to research

Both the MBIOT5 and MSBIOTECH programmes incorporate a significant laboratory based research project, linked to specific training modules selected in consultation with the project supervisor. This should provide the students with technical and problem solving expertise within an advanced intellectual framework. Disappointingly, under the "learning outcome" responses, students seem less happy about their research skills, research experience and opportunity for critical thinking than might be expected from this structure. So an analysis of how this situation might be improved (including critical thinking and experimental design in the first 3 years – see below) would be valuable. Supervisors are trained to PhD level with the majority also having post-doctoral research experience and, thus, are highly experienced researchers in their own fields. Faculty representatives are obliged to fulfil an obligatory course in pedagogics (100 hrs) the first years of employment at NTNU. More limited pedagogic courses are offered to all researchers. Also, supervision by colleagues is a voluntary program at NTNU. There are no provisions linked to the supervisor regarding the numbers of students he/she is supervising, however supervisors get funding (typically 20 kNOK in IBT and 10 kNOK in IBI) to cover consumables and other running costs for the student project.

The students are rarely exposed to industry. The existing exposure happens via presentations organized by the student organisation for chemistry, biology and biotechnology (Volvox og Alkymisten). The frequency of these presentations varies, and few are directed towards biotechnology specifically. There is room for far more exposure to industry, in smaller forums, and a general move of focus from plain research to also include industry, innovation and entrepreneurship. It is believed that this would be

beneficial to better prepare students for work life. Also, showing the students possible jobs in other fields than research can motivate them to stay in the program.

Programme design

The 5-year programme provides a very strong scientific foundation in the range of compulsory core bioscience courses for the first 2.5-years. There is a strong emphasis on experimental skills which is based on the impressive resources available to the students (see Learning environment). However, there are little, if any, training in independent experimental problem-solving during the first 3 years. Given the resources available, we feel that this is a missed opportunity.

The programme has a some-what traditional structure, in that it first gives a large number of basic core courses, of which some, albeit very important, might seem quite boring for a student eager to engage directly with Biotechnology. During the first year of the programme, the students do not meet bio-related topics until the second semester. This might be a reason for early drop-outs from the 5-year programme. TBT4170 Biotechnology, that is an introductory course in biotechnology obligatory for Nanotechnology students as well as students in Industrial Chemistry and Biotechnology, or similar course, could be of relevance to the MBIOT5 and MSBIOTECH programmes.

Ethical issues of Biotechnology are adequately covered in both programmes, while Health, Safety and Environment (HSE) issues on both programmes are treated through mandatory lecture days (one during the first week of MBIOT5 and one in the fourth/first year of MBIOT5/MSBIOTECH) that cover general laboratory safety rules. These lectures are then followed up with lectures during lab courses and lectures on Department-specific rules. However, there is no obvious forum for discussion of sustainability issues in the broader sense, i.e. how the use of biotechnology may impact society. It would be useful if that could be introduced into the programme.

The programme is potentially unique for a Biotechnology programme in a Natural Science Faculty, in having several mandatory courses in maths and statistics. Some of these are offered at an advanced level but students have options between 2 levels of difficulty in each mathematics module. This is admirable if the maths being taught finds application during the project or other aspects of the programme, as in many undergraduate bioscience programmes students have poor mathematical skills. A greater level of mathematical proficiency might be required for the Systems Biology options. However, this is currently not a popular theme. Including bioinformatics in the course portfolio could be discussed on a general basis and as a way to strengthen the program towards Systems Biology.

One strength (if used appropriately) of the programme is the design of the specializations built around the choice of research project. On the 5-year programme, the students choose research projects before entering the 4th year and then select courses to match the project theme, together with the supervisor. On every specialization, there is a palette of courses to choose between and very few courses (in total 15 credits) are mandatory. Of these courses one is the interdisciplinary course Experts in Teamwork. This way, the project work can be seen as defining the specialization. In theory, this design is very appealing, since it has the potential to build expertise in the specialization from the viewpoint of an application. However the choice of research projects on offer seems to include many topics for which these specialized modules would be irrelevant and which should not be described

as “biotechnology”. It may be that, given the background of the students, these projects are not chosen. Nevertheless, to ensure greater rigour in this respect, and consistent with the suggestion that the core skills of Biotechnology should be better characterised, we suggest that all offered projects should identify which core Biotechnology skills they cover, and if this is not possible then these projects should not be offered.

On a programme level perspective there are some issues that need to be addressed:

- Since there are few mandatory courses, the learning outcomes are dictated by the chosen project work, of which a wide range are available. Apparently they are not all “certified” to meet the learning outcomes of the Biotechnology programmes. Thus: can the programme guarantee that every student reaches the required learning outcomes? Do the supervisors need advice on how to design the project work and the related courses to ensure good progression.
- As recorded above, many courses are available but it is unclear how they relate to each other. Can it be guaranteed that every student takes courses that lead to the required depth of understanding within the field? There is an apparent risk that a supervisor may help the student to find courses that are only relevant to their project work and possibly not the ones that are the most important ones for the student’s subsequent career.

The three specializations of MBIOT5

The MBIOT5 programme offers three distinct specialisations: biochemistry and biopolymer chemistry, systems biology and molecular biology. The systems biology component has a requirement to study 6 specialist courses in statistics, calculus and systems biology plus the more general course in molecular cell biology. From an outside perspective this seems very rigorous but offers less choice than the other specialisations. However, it seems that few students take this option. By contrast the biochemistry and biopolymer chemistry option only has 3 mandatory courses, in thermodynamics (with lab), statistical modelling and biopolymers, while the molecular biology option also has 3 mandatory courses in cell biology, molecular cell biology and statistical modelling. However, it also has an additional requirement to take the molecular biology lab at the end of the first semester of year 3. Both of the latter two options seem equally popular (for N=82 since 2012: Molec Biol = 49, Systems Biol = 3, Biochem & Pol = 30). It should be noted that, given the requirements of the other courses the manadatory course for MSBIOTECH only allow access to the molecular biology specialisation.

This pattern of specialisation is clearly unbalanced and needs to be investigated from the students’ perspective. On the one hand it may be that the high mathematical/statistical content of the system biology specialisation may be off-putting, although equally it could be argued that this is a unique feature of the programme at NTNU and more students should be encouraged to take it. It seems slightly surprising that the systems biology courses are not available as options to the molecular biology students until after the research project starts. Introducing some systems biology as a pre-requisite of the molecular biology specialisation and reducing the number of mandatory courses (if this feasible) for the systems biology specialisation would seem to be a logical approach. If there were specialisations in bioinformatics available a NTNU this programme could link with both molecular biology and systems biology programmes.

Relevance to society and the work community

Biotechnology, in its broadest sense, is highly relevant in modern society and a strong graduate and post-graduate recruiter. Graduates of the NTNU Biotechnology programmes have a high employment rate in comparison to other NTNU programmes. It also potentially contentious, with topics such as genetic engineering, first generation biofuels and gene therapy being subjects of lively scientific and media debate. Although "Ethics" is provided as an optional module in year 4, we believe the elements of ethics and sustainability should be covered by all students, possibly not in a formal taught module but in a form that encourages debate.

It is not clear to what extent the design of the programmes have included demands from industry and other future employers. The program board should consider doing a survey among relevant employers on how they view the competence and relevance of candidates from MBIOT5/MSBIOTECH. Having industry partners as externals in the program board (as of 2017) and establishing an advisory board may also be ways of increasing the relevance to industry and work community.

Internationalisation

In accordance with NTNU goals for internationalisation, the 2-year MSBIOTECH has an allocation of places specifically for recruitment of EU students from outside Norway and international students from outside the EU. After a promising start, intake of non-EU international students dropped from 11 in 2012 to 3 in 2015. A renewed focus on international recruitment has doubled this to 6 for 2016. Recruitment of non-Nordic EU students has always been low, but increased significantly in 2016.

Of the 96 students who completed and graduated from the MBIOT5 programme, 36% spent at least 1 semester abroad. Some of these were at NTNU partner institutions but the majority seem to have been arranged independently. This is close to the recommended target of 40% for NTNU degree students.

Recruitment

Recruitment to the 5-year MBIOT5 programme has been healthy over a number of years, with the programme being over-subscribed (>3 primary applicants per place) compared to target figures (2 per place) and the admission points of those recruited in 2016 all exceeding the minimum target. Recruitment shows a strong gender bias (approx. 4:1) towards female students, which would be interesting to compare with other competitor programmes.

Recruitment to the 2-year MSBIOTECH has fallen below the target of 20 students. The decline since 2013 is in all categories (although very few non-Nordic EU recruits have been taken on until 2016). The increase in 2016, primarily in non-Nordic students may be attributed to the transfer of responsibility for recruitment from the central NTNU office to the Faculty, and a renewed focus on marketing. The gender balance for this programme shows a slight female bias, but this is exaggerated by the size of the cohort. As pointed out in all three previous faculty evaluation reports of the programmes, it is imperative that the admission procedure to the MSBIOTECH programme is not completed too late, since this will inevitably lead to foreign students selecting other, competing programmes.

Throughput

For a programme that is over-subscribed and recruits a high calibre of student, the MBIOT5 programme has a very high percentage (approx. 48% based on students starting from 2007 onwards) of dropouts. 15% transferred to other related programmes (eg BSc Biology, MSc Technology/Engineering, MSc Molecular Medicine) at NTNU. While this may be acceptable given the flexibility to switch between programmes it is not matched by students switching from other programmes to the 5-year MSc in Biotechnology. Of more concern is that more than 30% of the students starting the programme drop-out without transferring and are effectively untraceable. Nearly half of these drop out in year 1 which, as highlighted above, is part of the core skills element. As the recruitment to the programme is healthy, which ensures a high standard of entry, this suggests that students are not engaged by the programme in the early stages.

In the MSBIOTECH programme there is also an alarming "drop-out" rate, but we are assured that the majority of these are students who had accepted a place on the programme but did not enrol from the outset. While this makes the "dropout" rate less alarming it is nonetheless a cause for concern and suggests there is a requirement for greater rigour during the recruitment process (in 2014 although 16 students accepted the offer only 10 students actually started the programme). Approximately 12% of the students drop-out having started the programme and few students transfer to other programmes.

Of the students who complete the programme, over 70% of the MBIOT5 students gain a grade A or B; with the MSBIOTECH students, performance is slightly weaker, with approximately 55% gaining an A or B grade. Over 30% of the MSBIOTECH students gained a C grade with a small, but significant tail into the D and E grades (total approximately 10%, equating to 5 students over the Spring 2012-Spring 2016 period sampled.

Learning environment

Undoubtedly, there are excellent resources available at NTNU to give Biotechnology programmes of high quality. The committee was shown different state-of-the-art experimental equipment available to the students in nearly all relevant areas. For example, in the NMR-laboratory, one modern spectrometer is used primarily for courses at the undergraduate levels. In addition, the students on both programmes are assigned designated working places for both laboratory and study work. The laboratory working places are normally situated within an active research environment.

Based on the student satisfaction survey results, students are generally happy with the provision, although they are less happy with the standard of administrative information flow. This may partly explain the relatively low score attributed to the question "I show up well prepared for organised learning activities". They see the courses as relevant training for a future career and this is confirmed by the surveys of recent graduates, and students find them academically challenging and well integrated. However, two areas of feedback that have consistently scored lower than the Biology average are "Teaching" and "Participation". Interestingly, both of these areas scored badly in all Biology courses in 2013 and have shown significant improvement in 2014 and 2015, but the scores for the Biotechnology courses remain behind those of the Biology course average. A low score in

"Teaching" is surprising given the previous comments, but deeper analysis of the responses shows that the problems are primarily around academic counselling and feedback on assessed work. A related trend is also seen in "Participation", where students feel that their viewpoints are not being taken into account and they have little opportunity to influence the course content and design, as previously described in this report. Again, and particularly in the Biotechnology courses, this has shown a dramatic improvement since 2013, so some action may already have been taken to address this.

Recommendations on how the quality of the study programme(s) can be strengthened

Short term actions for improvement

- Update the learning outcomes of both programmes to clearly include ethics and sustainability. Interpret what this means for Biotechnology and implement in relevant courses. Also clarify the relevant skills and learning outcomes that define a Master of Biotechnology and ensure that these are met by the programme.
- Update the learning outcomes according to the suggestion on the NOKUT (2015) report. In particular, make use of the proper level and progression descriptors and make sure the learning outcomes contains goals regarding independent research work, application of knowledge to new areas, problem analysis and communication skills. Again, the courses contributing to these goals need to be identified. In turn, this might increase the students rating of their acquired research skills and experience.
- Implement a certification routine for the research project and associated courses. Every project should be attached to the relevant specialisations and identify how it contributes to the specified learning outcomes defined for the master's programme. Educate supervisors on how to arrange a course progression to ensure students meet the programme goals.
- Perhaps not specific to these programmes, constructive feedback on coursework and greater support through academic counselling are areas that score consistently poorly in student satisfaction surveys; the underlying problems need to be addressed

Long term actions for improvement

- Evaluate the need for clearer prerequisites for admission to the 2-year programme and the support provided during the MSBIOTECH to ensure that students' objectives are met. This might lower the drop-out rate, since possibly more students will feel they have found the right education for them. In addition, this will help to certify that the 2-year and 5-year programme students fulfil the same objectives.
- The MBIOT5 programme needs to engage students with Biotechnology at an earlier stage in the programme. Because it starts with a curriculum which is common with other biosciences, Biotechnology only emerges in year 3. Various methods are suggested: 1) Postpone the general science course in the first semester of the five year program and make room for a course where the students meet real Biotechnology problems (it is not needed that the students are able to solve them), maybe in cooperation with external partners. 2) Introduce keynote lectures with a Biotechnology

focus in years 1-3. 3) Encourage student led activities that might co-ordinate outside speakers, visits to relevant facilities and get involved with outreach.

- In addition to the proposed industry members of the programme board proposed for 2017, consider creating an advisory board for the programmes, which includes members from the Biotechnology industry.

Conclusion whether the study programmes should be continued as-is

Biotechnology is a currently recognised core enabling technology at NTNU and it is important to provide relevant training in this area to meet the strategy objectives. The MBIOT5 programme provides an effective platform for this, recruits a highly calibre of student and is strongly oversubscribed. However, the programme has some structural weaknesses, which we highlight in this document. Addressing these issues should reduce the alarming drop-out rate, increase student satisfaction and ensure the continued success of the programme. The 2-year MSBIOTECH is a logical adjunct to the 5-year programme, but needs greater clarity in its objectives and appropriate provision to meet them. The desire to recruit more international students to this programme is consistent with NTNU strategic plans but has not been as successful as envisaged. We propose some approaches that may help to improve this situation.

- The MBIOT5 programme starts with core skills teaching in the Biosciences. While we recognise this as being fundamental it means that students get little exposure to "Biotechnology" until later in the programme. This can lead to disengagement and loss of original motivation. We suggest that Biotechnology elements are introduced during year 1 and 2 to address this. A number of approaches may be envisaged, some or all of which may be adopted: formal lecture content; "keynote" speakers from Industry/academia; a student led "Biotechnology Society/Club" which could host Biotechnology relevant visiting speakers and arrange eg company visits. The Society/Club concept could be extended to include aspects of outreach, where students become Biotechnology "ambassadors" to local schools or community projects.
- It would be valuable to define the learning outcomes for both programmes more clearly, in terms of key skills and knowledge. This will make it easier to define whether certain elements (eg lab projects) have sufficient Biotechnology content and also assist students, staff and assessors to determine whether these outcomes have been achieved (and through what measures)
- The intake requirements, consequent programme requirements and overall direction of individual students on the MSBIOTECH programme need to be better defined, possibly by providing more mentoring during the 2-years and/or limiting the range of backgrounds that are suitable for joining the programme. We are not convinced that students from a diverse range of backgrounds are able to benefit from all aspects of the programme. This is not necessarily a problem so long as students are aware of possibilities and restrictions before starting the programme and can still benefit fully from some aspect of the programme.

Appendix 1

NTD 2016/277 - Mandate for evaluation of biotechnology study programs at NTNU

The Faculty of Natural Sciences and Technology (NT) have two independent lines to a master in biotechnology. One is a specialization within the 5-year engineering programme Industrial Chemistry and Biotechnology (MTKJ), and the other is the integrated 5-year master programme in Biotechnology (MBIOT5). In addition there is at 2-year international master programme in biotechnology (MSBIOTECH). The study programmes are hosted by Department of Biotechnology (Institutt for bioteknologi, IBT) and the Department of Biology (Institutt for biologi, IBI) at NT faculty. In addition, IBT and IBI are involved in the interdisciplinary International Master's degree programmes in Environmental Toxicology and Chemistry (MSENVITOX), marine coastal development (MSMACODEV) and Natural Resource Management (MSNARM), and the engineering program MTKJ. This evaluation comprises the two programmes MBIOT5 and MSBIOTECH.

The MBIOT5 and MSBIOTECH programmes admit about 45 and 12 students per year, respectively. For MBIOT5, the students have a core curriculum during the first three semesters and then choose one of three specializations: Molecular Biology, Systems Biology or Biochemistry and Biopolymer Chemistry. The MBIOT5 programme has among the highest admission standards among biology programmes in Norway, whereas the recruitment to MSBIOTECH is not as good.

The NT Faculty requires an external evaluation of study programs every five years. To this end, the faculty has commissioned a committee that includes two external members supported by department staff. We specifically ask the committee to evaluate the following aspects of the study programs:

- General assessment of program structure (including specialist/generalist issues) and progression, teaching methods, coordination of teaching activities between participating departments, and evaluation methods
- Quality of hands-on training and development of career-relevant skills
- Evaluation of the 3 study directions in the MBIOT5/ MSBIOTECH curriculum
- Measures to reduce student drop-out rate
- Future viability and career relevance of the Master's programs
- International level: compare the programs in scope and level with equivalent study programs at University of Bath and Lund.

Expected Outcome
Report with recommendations.

Committee members and responsibility:

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Information provided to the committee by involved departments and program leadership:

- Detailed description of the study programs, courses and study structure. Expected learning outcomes.
- NOKUT Evaluation report on description of learning goals
- Memo on overlap in curriculum for the three courses TBT4145, BI2015 and BI2014
- List of Master's degree theses completed by students in all programs in the last five years
- List of people and research groups involved in the programs (both research and teaching)
- Course evaluation surveys and reports
- 2014 survey of skills development in the MBIOT5/MBIOT curricula
- 2013 employment survey of graduates from NT Faculty study programs

Economics, timeline and other practical issues

- The evaluation will start in March/April 2016 with a report due on October 1st 2016.
- The committee leader shall establish a more detailed progress plan in collaboration with the program leaders, including deadlines for the deliverables from NTNU to the committee and their own deliverables.
- Economy: See attached document from the NT faculty.
- Report: The Committee leader is responsible for finalizing the evaluation report and all committee members should contribute to the writing process. NTNU will provide administrative support.