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MSc Bioinformatics and Systems Biology
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Project code P2114

Contents

Summary

The MSc BiSB is a 120 EC research-oriented programme that aims to educate its students in performing research in bioinformatics, systems biology or both fields. It is offered as a joint degree by the Vrije Universiteit Amsterdam and the University of Amsterdam.

The profile and aims of the master's programme Bioinformatics and Systems Biology are fitting for an academic programme within the field. The programme has a strong interdisciplinary character and meets the demand from academia and industry for students that can combine biology with computer science and/or mathematics. Combining bioinformatics and systems biology in a single programme is a strong asset of the programme and is of added value for students in both domains. The panel concludes that the intended learning outcomes (ILOs) provide a well-structured overview of the knowledge, skills and attitudes that students should attain throughout the programme and in both tracks. They clearly reflect the goals of the programme, and are aligned with the Dublin descriptors for master's programmes as well as the domain-specific framework. The panel appreciates the role of the Professional Advisory Board in keeping the programme's ILOs attuned to the demands of the professional field. The panel recommends better emphasizing in the ILOs that students are taught to acquire new methods and techniques in a rapidly changing field, rather than study a fixed body of technical skills and knowledge.

The MSc BiSB has translated its intended learning outcomes into a well-structured and balanced curriculum for both tracks. It has many options for customization by students, such as the option to combine both tracks and the choice between one or two research projects of variable size. The teaching methods emphasize interdisciplinary collaboration and the development of professional and academic skills. The choice to offer the programme in English is well-supported and fits the international character of the related fields. To further improve the design of the curriculum, the programme could consider making curriculum design choices (such as the choice to use single cell modelling to teach students about the concepts of modelling in the Systems Biology track) more insightful to students and formulating learning trajectories throughout the courses. A particular learning trajectory recommended by the panel is one highlighting ethics and integrity, expanding these beyond FAIR data principles to include bioethics, privacy and data protection. Furthermore, the programme should investigate whether the Bioinformatics track contains sufficient statistics.

The panel is very positive on the attention to feasibility and student support in the programme. The intake procedures as well as the options for bridging knowledge gaps add to the feasibility of the curriculum for the heterogeneous student population the programme serves. Students are well-supported through a solid mentor system consisting of a peer mentor as well as an academic advisor that helps shape the individual curricula. The programme is flexible and accommodates the goals of individual students. The joint character is felt by students: they experience the BiSB as a coherent, single programme offered by two universities. Issues arising from two different administrative systems are noted and remedied wherever possible by the programme, which the panel encourages. According to the panel, both universities should support the programme to overcome administrative hurdles when students want to join courses from both universities. Online education and student support during the COVID-19 pandemic were well-organized and have led to several structural new teaching methods in the programme.

The programme is taught by a passionate, knowledgeable and motivated teaching staff. The participating departments from UvA and VU form a team that collaborates well and pays sufficient attention to professionalization. The panel supports initiatives to tackle the workload associated with growing student

numbers, such as the introduction of teaching assistants, reducing the workload for the UTQ portfolio, and plans to expand the teaching staff with a junior staff member for the Systems Biology track.

The programme has a valid, transparent and reliable system of assessment in place. Assessment is aligned with the policies of the VU, and the assessment methods are designed to fit the goals of the programme. Assessment in the programme is supported by solid quality assurance procedures, monitored by a professional Examination Board that has its checks and balances in place. The change to online examination was generally successful, although the panel recommends returning to on-site exams as soon as possible to prevent further technical issues with online proctoring. Group projects are accompanied by individual components to prevent free-riding in courses. The panel recommends improving the assessment of group work by formulating an overall vision on this and using this vision in designing a learning trajectory on communication and collaboration skills. Assessment of the final research projects is well-designed, with sufficient attention paid to the possibilities and limitations of using external supervisors as assessors. The panel recommends choosing a term other than 'mentor' to describe the role of the second assessor to avoid future confusion and ensuring that this advisory role does not interfere with the independence of the research project assessment. The panel appreciates the attention to the assessment of code quality, as well as the consideration of project size in assessment. The assessment form used in grading the research projects is transparent and is used in an insightful way. Based on its assessment of the projects itself, the panel recommends making better use of the full range of grades, particularly regarding the grades below 8,0.

The panel concludes that BiSB graduates achieve the intended learning outcomes. The final research projects are generally of very high quality, for which the panel praises the programme. Alumni find relevant positions after graduation and are in high demand.

Score table

The panel assesses the programme as follows:

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

Prof. dr. Yves Moreau
Date: 10-03-2022

Peter Hildering MSc

Introduction

Procedure

Assessment

On 16 and 17 December 2021, the joint degree programme Bioinformatics and Systems Biology of the Vrije Universiteit Amsterdam (VU) and University of Amsterdam (UvA) was assessed by an independent peer review panel as part of the cluster assessment Bioinformatics & Systems Biology. The assessment cluster consisted of 2 programmes, offered by Maastricht University and VU Amsterdam/University of Amsterdam (joint degree). The assessment followed the procedure and standards of the NVAO Assessment Framework for the Higher Education Accreditation System of the Netherlands (September 2018).

Quality assurance agency Academion coordinated the assessment upon request of the cluster. Peter Hildering MSc acted as coordinator and secretary in the cluster assessment. He has been certified and registered by the NVAO.

Preparation

Academion composed the peer review panel in cooperation with the institutions and taking into account the expertise and independence of the members as well as consistency within the cluster. On 13 October 2021, the NVAO approved the composition of the panel. The coordinator instructed the panel chair on his role in the site visit according to the Panel chair profile (NVAO 2016).

The programme, represented by the VU as coordinating institution, composed a site visit schedule in consultation with the coordinator (see Appendix 3). The programme selected representative partners for the various interviews. It also determined that the development dialogue would take place after the site visit. A separate development report was made based on this dialogue.

The programme provided the coordinator/secretary with a list of graduates over the period 2020-2021. In consultation with the secretary, the panel chair selected 15 final research projects, taking diversity of tracks, final grades and examiners into account. This selection consisted of 10 projects of the Bioinformatics track, 3 of the Systems Biology track, and 2 double projects of students that followed both tracks. Prior to the site visit, the programme provided the panel with the projects and the accompanying assessment forms. It also provided the panel with the self evaluation report and additional materials (see Appendix 4).

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

Site visit

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

Report

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

Panel

The following panel members were involved in the cluster assessment:

- Prof. dr. Yves Moreau (KU Leuven) - chair
- Prof. dr. Barbara Bakker (UMC Groningen)
- Dr. Jildau Bouwman (TNO)
- Dr. Sonja Isken (Wageningen University & Research)
- Dr. Peter Reinink (Gadeta BV)
- Claudia de Buck, BSc (Wageningen University & Research) - student member

The panel assessing the MSc Bioinformatics and Systems Biology at VU and UvA consisted of the following members:

- Prof. dr. Yves Moreau (KU Leuven) - chair
- Prof. dr. Barbara Bakker (UMC Groningen)
- Dr. Sonja Isken (Wageningen University & Research)
- Dr. Peter Reinink (Gadeta BV)
- Claudia de Buck, BSc (Wageningen University & Research) - student member

Peter Hildering MSc acted as panel secretary on behalf of quality assurance agency Academion.

Information on the programme

Name of the institution:	Vrije Universiteit Amsterdam
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive
Name of the institution:	University of Amsterdam
Status of the institution:	Publicly funded institution
Result institutional quality assurance assessment:	Positive
Programme name:	Bioinformatics and Systems Biology
CROHO number:	65020
Level:	Master
Orientation:	Academic
Number of credits:	120 EC
Specialisations or tracks:	Bioinformatics Systems Biology
Location:	Amsterdam
Mode(s) of study:	Fulltime
Language of instruction:	English

Joint programme:	
Partner institutions involved:	Vrije Universiteit Amsterdam University of Amsterdam
Type of degree awarded:	joint degree
Submission date NVAO:	01-05-2022

Description of the assessment

Standard 1. Intended learning outcomes

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

Findings

Aims and profile

The MSc BiSB is a research-oriented programme that aims to educate its students in performing research in bioinformatics, systems biology or both fields. The didactic concept of the programme consists of training in *focus*, *balance* and *translation*. Students learn to *focus* on in-depth scientific problems in research-based projects, to *balance* skills through courses that combine programming, mathematics, and molecular biology, and to *translate* life sciences and biomedical questions into technical solutions by working on assignments that draw from various domains and application areas. The programme embraces heterogeneity: it encourages students from various backgrounds to learn from each other and offers opportunities for students to differentiate across the full spectrum of bioinformatics and systems biology.

Students choose between two specialization tracks. The Bioinformatics track focuses on analysis of biological and biomedical data, with programming, algorithms, and machine learning as important elements. Systems Biology allows students to specialize in modelling of biological networks, with mathematical modelling, experimenting and statistical analysis as main skills. Using elective space, students can combine both tracks in their individual curriculum. Both tracks share a common core: the programme believes that bioinformatics and systems biology share a set of background skills and knowledge, and that students in both fields should be able to understand mathematical equations as well as programming scripts.

The panel studied the aims and profile of the programme and concludes that it has a clear and relevant profile. According to the panel, BiSB meets a clear demand from academia and industry. Bioinformatics and systems biology are rapidly developing fields, with a strong demand for graduates that can use an interdisciplinary approach by combining computer science and/or mathematics in a biological and biomedical context. The panel appreciates that the programme offers both bioinformatics and systems biology. The programme has a clear vision regarding the overlap between the two fields, causing BiSB to be more than the sum of the two tracks. With an intake of approximately 70-100 students per year, BiSB has developed into a viable programme that has an important role of educating specialists in both fields within the Netherlands.

Intended learning outcomes

The programme has summarized its aims in a set of 13 general intended learning outcomes (ILOs) as well as one specific ILO for each of the tracks (see Appendix 1). The ILOs are structured along the five Dublin descriptors for master's programmes and are also explicitly related to the didactic concepts of focus, balance and translation. The programme uses a domain-specific framework of reference for Bioinformatics & Systems Biology to relate the competencies of graduates to the expectations of the academic fields. To keep the programme aligned with the demands of the professional field, the programme is advised by a Professional Advisory Board (PAB), consisting of professional field representatives in various companies

relevant to bioinformatics and systems biology. The PAB discusses the relevance of the ILOs for the professional field, the final level achieved by graduates and the structure and content of the curriculum.

The panel studied the ILOs and concludes that they provide a well-structured overview of the knowledge, skills and attitudes that students should attain throughout the programme and in both tracks. As demonstrated in an overview provided by the programme, the ILOs align with the domain-specific framework of reference, thus demonstrating the competences required of a graduate in the fields of bioinformatics and systems biology. The panel appreciates that the programme uses input from the professional field through the PAB in order to keep the programme's ILOs attuned to external demands for graduates. The use of the Dublin descriptors in designing the ILOs guarantee that they meet the requirements for an academic master's programme with regard to level and orientation. During the site visit, the panel discussed with the programme whether the ILOs could be made more specific with regard to the skills required from students. The panel understood that the programme does not aim for its students to master specific methods and techniques. The field is currently developing too fast to capture this in a well-defined body of methods and techniques. The programme therefore wants its students to grasp the concepts of the field and use this to acquire new technical skills and expertise they need for specific challenges. The panel appreciates this and recommends emphasizing this more in the ILOs.

Joint degree
The MSc Bioinformatics and Systems Biology (BiSB) is a 120 EC master's programme offered jointly by the Faculties of Science of the Vrije Universiteit Amsterdam (VU) and the University of Amsterdam (UvA). The programme has been offered as a joint degree since 2018, with the VU taking charge of the administrative aspects as lead institution.

BiSB's teaching staff belong to the VU Bioinformatics and Systems Biology research groups, and the UvA Swammerdam Institute for Life Science. BiSB has a Programme Committee (PC), which has both VU and UvA representatives and which follow the rules and regulations of the VU. The programme falls under the faculty-wide VU Examination Board for the Physics, Chemistry, Mathematics and Information Science programmes (EB NSM-IS), where it is part of the subcommittee Information Sciences. This subcommittee has one member representing the UvA. The directors of Education from VU and UvA meet once per year to discuss the BiSB programme in detail.

BiSB emerged from the MSc Bioinformatics (VU) and the MSc Life Science (UvA) in 2018. As the joint degree was already envisioned at the time of the previous accreditation, both programmes were accredited in a joint process in 2016. The panel therefore considers the recommendations of the previous panel to be transferable to BiSB.

The panel concludes from the organizational structure as well as from the interviews during the site visit that the joint degree is well-established and forms a convincing and coherent whole. VU and UvA have complementary expertise in systems biology and bioinformatics and combine this in a coherent curriculum. Both institutions contribute proportionally to the courses as well as the organizational bodies of the programme. Students register at the VU, but follow projects and courses at both institutions, depending on the affiliation of the associated teaching staff and the project topics. As is often the case with joint programmes, students sometimes still experience small procedural frictions when dealing with two universities (see Standard 2), but overall, the cooperation on the level of teaching staff and management is smooth and fruitful. The panel praises the development the programme has undergone since the previous accreditation.

Considerations

The profile and aims of the master's programme Bioinformatics and Systems Biology are fitting for an academic programme within the field. The programme has a strong interdisciplinary character and meets the demand from academia and industry for students that can combine biology with computer science and/or mathematics. Combining bioinformatics and systems biology in a single programme is a strong asset of the programme and is of added value for students in both domains. The panel concludes that the ILOs provide a well-structured overview of the knowledge, skills and attitudes that students should attain throughout the programme and in both tracks. They clearly reflect the goals of the programme, and are aligned with the Dublin descriptors for master's programmes as well as the domain-specific framework. The panel appreciates the role of the Professional Advisory Board in keeping the programme's ILOs attuned to the demands of the professional field. The panel recommends better emphasizing in the ILOs that students are taught to acquire new methods and techniques in a rapidly changing field, rather than study a fixed body of technical skills and knowledge.

Conclusion

The panel concludes that the programme meets Standard 1.

Standard 2. Teaching-learning environment

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

Findings

Curriculum

The curriculum of the MSc BiSB consists of a shared core for both tracks (18 EC), specialization courses within the tracks Bioinformatics or Systems Biology (18 EC), constrained choice electives (6 EC) and free electives (18-36 EC). The final part of the curriculum consists of one or two research projects (42-60 EC). Students have the flexibility to use up to 18 EC for either extra electives or larger research projects and can choose between one large or two smaller research projects in their second year. The major research project serves as the final project of the programme. Students can combine the two tracks by choosing the specialization courses of one track as electives in the other track, and choose either one research project in each field, or a single research topic that integrates both fields. BiSB is offered in English, following the international character of the research field as well as the prospective academic or professional environment in which graduates can be expected to work. Internationalization is further promoted through an international classroom: approximately 30% of the students have a non-Dutch background.

The compulsory courses are designed to bring students with a diversity of backgrounds to a similar level of competence in molecular biology, programming in Python, calculus and linear algebra. In addition, students are taught the basics of both bioinformatics and systems biology, and the relation between those two fields. In the specialization courses, students obtain in-depth knowledge in the research area of one of the two tracks. For the constrained choice elective, students choose one out of two courses in quantitative data analysis on cellular systems. The free electives allow students to further shape the curriculum according to their own preferences. Students usually select courses from the other track, or courses offered by the master's programmes in AI, Molecular Cell Biology or Computational Science. Students complete the curriculum with an optional minor research project (18-30 EC) and a compulsory major research project (30-60 EC). The minor research project is aimed at broadening the research experience of students, for instance

by providing an option for a research project in industry. The major research project aims to deepen the research skills on a particular topic in bioinformatics or systems biology. The major research projects is often executed in one of the research institutes related to the programme at VU or UvA, but students can also do a project at another university or in industry upon request.

Group projects play an important role in the didactic vision of BiSB. Students acquire new knowledge and skills by working on open-ended research questions. Solving problems together in interdisciplinary groups allows students to develop their communication and cooperation skills. The core and specialization courses contain several of such group projects. The programme takes care to form heterogeneous project groups where students can learn from each other.

The panel studied the curriculum of the programme, as well as the content of a number of courses, and discussed them with the programme management, students and teaching staff. It concludes that the programme's ILOs are well-incorporated into the curriculum. The curriculum is well-structured and has a good balance between core courses, electives, and projects in both tracks. It offers students many options for customization. The panel particularly valued the option for students to combine both tracks using the elective space, the flexibility to choose between doing one or two research projects, and to determine the size of their research projects. The group projects fit the interdisciplinary character of BiSB and allow students to develop and practice their professional and academic skills. The alumni that the panel interviewed mentioned these projects as an important element in their education, where they developed a wide range of skills and learnt to connect research to technical solutions. The panel praises the attention the programme pays to an equal distribution of group projects throughout both tracks, and to the interdisciplinary composition of the project groups. The panel considers the choice for English as language of instruction natural for an academic master's programme with regard to the international character of the academic and professional fields. The international classroom stimulates an intercultural awareness in students that can be very helpful for their future career in an international environment.

The panel learnt from the student chapter and the interviews that students are not always fully aware of the design of programme. Some students did not recognize the aim to show the relation between bioinformatics and systems biology. Furthermore, students in the Systems Biology track mentioned that it has a narrow focus on single cell modelling, whereas the programme mainly uses this approach as an example to teach the concepts of modelling. The panel recommends making these curriculum choices more insightful to students. More generally, the panel thinks that BiSB could benefit from an explication of the overarching structure. One way to do this is by formulating learning trajectories related to the various skills that students develop throughout the programme, such as academic and professional skills, programming and modelling, and showing students how the various courses contribute to the attainment of these skills. In addition, learning trajectories provide a useful tool to monitor and adapt the curriculum with regard to skills education. One particular point of attention with regard to the Bioinformatics track is the amount of statistics provided in the courses. The panel noted that statistics is mainly covered in the electives rather than the specialization courses. Since some alumni mentioned that they would have appreciated more statistics in the curriculum, the panel recommends investigating this and adapting the programme if this is deemed necessary.

The panel noticed with appreciation that the programme pays attention to ethics and integrity, in particular to FAIR data principles and the systematic storage of project data and code. The panel advises the programme to consider broadening the attention paid to ethics in the curriculum, particularly regarding handling medical data. According to the panel, the curriculum should at least cover basic ethical principles relating to bioethics and privacy and data protection (GDPR), and the Systems Biology track should also

include the ethical procedures relating to experimentation. Ethics and integrity could be developed into one of the learning trajectories mentioned above.

Feasibility and student support
The programme aims to create a feasible programme for a heterogeneous student population. Students can be admitted to the programme if they have a BSc degree in any discipline that contains sufficient mathematics, molecular biology and/or computer science. Before starting the programme, students get individual advice from the programme on potential knowledge gaps and the options available to remedy these. The first two courses of the curriculum (*Fundamentals of Bioinformatics* and *Introduction to Systems Biology*) contain bridging modules, aimed to bring students at a similar level for the remainder of the curriculum. Students with larger knowledge gaps can complete a dedicated minor or pre-master programme before entering the programme. Typically, 10-15% of students drop out in the first two months, as they discover that the programme is not a good fit. The remaining students usually complete the programme, the majority within three years.

Students are supported throughout the programme by a peer mentor and an academic mentor. Peer mentors are second-year students who help first-year students get acquainted with the programme, and help them with practicalities, social life at the university and advice on electives. The academic mentor is an academic staff member and examiner who helps students make a personal education plan. In this plan, students lay out their study path, including track, electives and research projects. The academic mentors help with choices, the coherence of the curriculum and with determining whether a research project is realistic in the allocated ECs. The academic mentor often becomes the examiner on the student's research projects.

The panel is very positive on the attention to feasibility and student support in the programme. The admission procedures and the bridging options in the first two months help students get a realistic impression of the programme, and remedy knowledge gaps. According to the panel, the low drop-out rates after the first two months show that the programme succeeds in keeping the curriculum feasible for students with various disciplinary backgrounds. Students are well-supported throughout the programme. The panel is particularly enthusiastic about the peer mentor system. This provides students with a very approachable point of contact in the first year of their studies, without adding to the workload of the teaching staff. Furthermore, the academic mentor helps students compose a coherent curriculum, allowing them to work towards their research projects through electives early in their curriculum.

The students that the panel interviewed were satisfied with the support they receive during the programme. They particularly emphasized the student-centred character of the programme: the individual goals of students are central to the programme, and the programme is very flexible to accommodate these. With regard to the joint character of BiSB, students mention that they experience the curriculum as a coherent unit, with no noticeable differences between components offered at VU or UvA. The only issues are of an administrative nature: students sometimes have trouble navigating between two different course registration systems and procedures. The panel understood that the programme coordinators try to remedy this as much as possible, and it encourages the programme to continue these efforts.

Education during the COVID-19 pandemic
During the lockdowns in the COVID-19 pandemic in 2020 and 2021, most of the programme was fully taught online. Whenever possible, the VU and UvA allowed students on campus for lab work and group projects. Based on the interviews, the panel concludes that online education was organized to the satisfaction of most students and staff members, although there were several setbacks, in particular related to online exams (see

Standard 3). Hybrid education has slowly become the standard in most courses, with an online environment on a Discord server and/or Slack to allow distant participation. To improve social cohesion, the peer mentor system was introduced, which was such a success that it became a permanent part of student support. The panel praises the programme for its efforts and noticed that students, even though they very much welcomed a return to on-campus education, felt sufficiently supported during the pandemic. Moreover, the panel was glad to see that the COVID-19 pandemic also led to improvements in the programmes, such as the introduction of new online learning platforms and the peer mentor system.

Teaching staff

The MSc BiSB is associated with three departments, that provide the majority of the teaching staff: the Bioinformatics group at the Computer Science department of the VU, several groups in the Swammerdam Institute for Life Sciences at UvA, and the Systems Biology Lab in the department of Molecular Biology at VU. Most staff members are actively involved in research closely related to the course they teach. In addition, the programme uses a number of junior teachers and teaching assistants (second-year students assisting with tutorials and group projects) in some of the first-year courses. All teaching staff members are expected to acquire a university teaching qualification (UTQ), including an English-language teaching certificate if they are not native speakers. 75% of staff members have completed a UTQ or are in the process of completing it. The entire teaching staff of BiSB meets two or three times a year to discuss potential changes in the curriculum and large changes within courses. In addition, both tracks organize teacher meetings several times per year.

The self-evaluation documents and interviews during the site visit have given the panel a very positive view of the programme's teaching staff. The three participating departments provide a broad range of expertise relevant to bioinformatics and systems biology. Attention towards teacher professionalization adds to the quality of the teaching staff, and the regular teacher meetings in the programme keeps the teaching staff involved in coherence of the education on a curriculum level. The interviews during the site visit supported this view. The teaching staff as well as the programme management report a fruitful and inspiring collaboration, between individual teachers as well as between the different groups at both VU and UvA. Students reported that their teachers are passionate, very knowledgeable on the subject matter and very approachable. The panel praises the programme for this.

During the site visit, the teaching staff reported a heavy workload related to the growing student numbers. The programme management has alleviated some of this by introducing teaching assistants for first-year courses. The teaching assistants are a valuable addition to the teaching staff according to both students, who appreciate the opportunity to participate in teaching, and teaching staff, who appreciate the reduction in workload for first-year courses. The panel suggests investigating whether the role of teaching assistants can be expanded to further decrease workload for the teaching staff. Furthermore, the panel understood that the programme has plans to recruit an additional staff member in Systems Biology to meet the need for additional teaching capacity. The panel fully supports this.

The panel noticed that a relatively large part of the teaching staff is in the process of obtaining an UTQ, but has not yet obtained the qualification. Teaching staff members explained that this is mostly an administrative issue: the portfolio associated with the UTQ has rather strict criteria, leading to the situation where several teachers have completed all courses and assignments, but did not yet manage to complete the portfolio. The panel recommends investigating whether completing the portfolio can be made less time-consuming, also in the light of the abovementioned workload.

Programme-specific facilities

The programme uses the lab facilities of the three participating departments at VU and UvA for the experimental work and research projects. Due to the online nature of the site visit, the panel could not visit the facilities, but it concludes based on the documentation and the students' appreciation that the facilities are up to standard.

Considerations

The MSc BiSB has translated its intended learning outcomes into a well-structured and balanced curriculum for both tracks. It has many options for customization by students, such as the option to combine both tracks and the choice between one or two research projects of variable size. The teaching methods emphasize interdisciplinary collaboration and the development of professional and academic skills. The choice to offer the programme in English is well-supported and fits the international character of the related fields. To further improve the design of the curriculum, the programme could consider making curriculum design choices (such as the choice to use single cell modelling to teach students about the concepts of modelling in the Systems Biology track) more insightful to students and formulating learning trajectories throughout the courses. A particular learning trajectory recommended by the panel is one highlighting ethics and integrity, expanding these beyond FAIR data principles to include bioethics, privacy and data protection. Furthermore, the programme should investigate whether the Bioinformatics track contains sufficient statistics.

The panel is very positive on the attention to feasibility and student support in the programme. The intake procedures as well as the options for bridging knowledge gaps add to the feasibility of the curriculum for the heterogeneous student population the programme serves. Students are well-supported through a solid mentor system consisting of a peer mentor as well as an academic advisor that helps shape the individual curricula. The programme is flexible and accommodates the goals of individual students. The joint character is felt by students: they experience the BiSB as a coherent, single programme offered by two universities. Issues arising from two different administrative systems are noted and remedied wherever possible by the programme, which the panel encourages. According to the panel, both universities should support the programme to overcome administrative hurdles when students want to join courses from both universities. Online education and student support during the COVID-19 pandemic were well-organized and have led to several structural new teaching methods in the programme.

The programme is taught by a passionate, knowledgeable and motivated teaching staff. The participating departments from UvA and VU form a team that collaborates well and pays sufficient attention to professionalization. The panel supports initiatives to tackle the workload associated with growing student numbers, such as the introduction of teaching assistants, reducing the workload for the UTQ portfolio, and plans to expand the teaching staff with a junior staff member for the Systems Biology track.

Conclusion

The panel concludes that that the programme meets Standard 2.

Standard 3. Student assessment

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

Findings

Assessment system

Assessment within BiSB is organized using the assessment policies of the Faculty of Science of the VU. This includes alignment of assessment methods with the learning objectives of the course as well as the ILOs of the programme, and peer review of tests before use. The main assessment methods of BiSB are written exams, individual assignments and group projects. The programme takes care that all courses have individual components related to the main learning objectives, so that students can never complete a course through free-riding in group projects. During the COVID-19 pandemic, exams were mostly organized online, using systems for online proctoring to prevent fraud.

The faculty-wide Examination Board NSM-IS has mandated most of the responsibilities for quality assurance of assessment in BiSB to the subcommittee Information Sciences. This four-member subcommittee (which also includes an UvA representative) meets on a monthly basis to discuss student requests, approval of individual curricula, issues regarding assessment and allegations of fraud. A separate faculty-wide assessment committee, consisting of one member of all sub-committees of the EB, investigates the quality of assessment of courses and final research projects on an annual basis through sampling. Results of these investigations are reported to the programme directors.

The panel is positive on the system of assessment in the programme. The assessment methods, in particular the frequent use of assignments and group projects, fit the aims and ILOs of the programme. Students were generally satisfied with assessment within the programme. The use of online proctoring during the COVID-19 pandemic resulted in some technical issues that led to invalid exams. The panel learnt that the Board allowed for extra resits whenever possible. It agrees with the programme's choice to return to on-site exams as soon as possible. Based on the documentation and the interview during the site visit, the panel concludes that the Examination Board, including the subcommittee responsible for the programme, functions well. The Board has a proactive role in safeguarding the quality of assessment and has solid procedures in place for the approval of individual curricula, suspicions of fraud and quality checks of course assessment and final research projects. It learnt that the work of the Board is sometimes complicated by the manual work related to the collection and storage of assessment materials. This was echoed by the teaching staff, that felt that too much manual administrative work is involved, particularly when dealing with research project assessment. The panel supports the request by the Board and teaching staff for a system that structurally facilitates and stores assessment procedures.

During the site visit, the panel discussed the assessment of group projects with programme representatives. It noticed with appreciation that group projects within courses are always accompanied by individual components to guarantee that students realize the course goals individually. However, it points that the programme does not yet have an overall vision on how to assess group projects. The learning objectives directly related to group work, such as communication and collaboration skills, are assessed differently throughout the courses. Students are either graded individually, or through peer assessment or collectively. Even though these are all valid assessment methods, the panel encourages the programme to form an overarching vision on the assessment of group work. This could be incorporated in a learning trajectory on communication and collaboration skills (see Standard 2). Such a learning line should also include incentives for students to fulfil different roles in project group, allowing them to develop a broad range of skills.

Assessment of the final research project

Students complete the programme with the major research project, an individual project conducted under supervision of one of the staff members of BiSB. The project is assessed through a uniform procedure following the assessment policy at the VU, regardless of whether the project is executed at UvA or VU. The assessment consists of four parts: research competence, professional development, research thesis and final presentation plus defence. The student's supervisor serves as the first assessor, the second assessor and also examiner is always a staff member from within BiSB. Both assessors independently form an opinion on each part of the project (with the exception of professional development, that is assessed by the supervisor only), and separately complete an assessment form detailing the grades. In the case of a research project executed outside VU or UvA, the supervisor can serve as assessor if he or she holds a PhD and is approved beforehand by the responsible examiner. As an extra quality assurance measure, the assessment of the external supervisor is only used if it does not deviate more than one grade point from the assessment of the second assessor. In the case of a larger deviation, a third assessor is appointed during the process to mediate and set the final grade. The student is provided with the assessment forms of the examiners, which contain grades and feedback on the different subcriteria for the thesis, presentation and defence.

The panel considers assessment of the final research projects in BiSB to be well-designed. The use of two assessors that independently grade the projects add to the reliability and transparency of the assessment. Allowing external supervisors as assessor guarantees that the daily performance of the students is adequately covered in the project. Unwanted effects of potential difference in grading culture are sufficiently safeguarded by the option to use a third examiner if the deviations in assessments are too large. The panel was initially reserved about the role of the second assessor, which is often fulfilled by the academic mentor of the student. It felt that a mentor might be too involved with the student to serve as independent examiner. However, it understood from the discussions during the site visit that the academic mentor does not discuss personal issues or individual performance with students, but is rather an academic advisor that helps students compose their individual curriculum on more formal grounds. The panel was reassured by this. It recommends choosing a term other than 'mentor' to describe this role to avoid future confusion and ensuring that this advisory role does not interfere with the independence of the assessment of the final project.

As part of its preparation of the site visit, the panel studied 15 research projects with the accompanying assessment forms, representing both tracks of the programme. It concludes that the assessment forms have useful subcriteria and rubrics, providing an insightful and transparent substantiation of the grades given, as well as useful feedback to the student. The panel noticed with appreciation that the programme separately assesses the quality of the code and scripts used in the project. It considers this to be a best practice in the light of the growing realization of the importance of code quality and maintainability. Furthermore, the panel understood from the interviews that the size in EC of the project is considered in grading. The panel praises the programme for this, as this adds to a fair assessment of projects of different sizes, preventing students from choosing larger projects in the hope of receiving a higher grade.

The panel noticed that the research project grades given in the programme are high, with the majority of students graduating with a grade between 8.0 and 9.0. The panel agreed that the projects are generally very good (see Standard 4), but would have given somewhat lower grades in several cases (0.5 or incidentally 1.0 points). This was mainly the case with projects in the range between 7.0 and 8.0. The panel recommends making better use of the full range of grades and, if necessary, discussing and adapting the rubrics and/or the interpretation with the examiners within BiSB to accommodate this.

Considerations

The programme has a valid, transparent and reliable system of assessment in place. Assessment is aligned with the policies of the VU, and the assessment methods are designed to fit the goals of the programme. Assessment in the programme is supported by solid quality assurance procedures, monitored by a professional Examination Board that has its checks and balances in place. The change to online examination was generally successful, although the panel recommends returning to on-site exams as soon as possible to prevent further technical issues with online proctoring. Group projects are accompanied by individual components to prevent free-riding in courses. The panel recommends improving the assessment of group work by formulating an overall vision on this and using this vision in designing a learning trajectory on communication and collaboration skills. Assessment of the final research project is well-designed, with sufficient attention paid to the possibilities and limitations of using external supervisors as assessors. The panel recommends choosing a term other than 'mentor' to describe the role of the second assessor to avoid future confusion and ensuring that this advisory role does not interfere with the independence of the assessment of the final projects. The panel appreciates the attention to the assessment of code quality, as well as the consideration of project size in assessment. The assessment form used in grading the projects is transparent and is used in an insightful way. Based on its assessment of the projects itself, the panel recommends making better use of the full range of grades, particularly regarding the grades below 8,0.

Conclusion

The panel concludes that that the programme meets Standard 3.

Standard 4. Achieved learning outcomes

The programme demonstrates that the intended learning outcomes are achieved.

Findings

Quality of the final research projects

Prior to the site visit, the panel studied 15 final research projects of the programme. The panel concludes that the projects are generally of high quality in both tracks. They are well-structured and show that students all learn to investigate relevant research topics in-depth with attention to the interdisciplinary context. In some cases, the panel felt that the projects could relate more to biological aspects, but generally they covered interesting and relevant topics in bioinformatics and systems biology. According to the panel, the projects demonstrate that all students convincingly achieve the intended learning outcomes.

Even though the panel felt that grades were slightly inflated on the low end of the spectrum (see Standard 3), it concludes that the programme delivers very good graduates. The panel thinks this is partly caused by the inherent attractiveness of the fields of systems biology and bioinformatics to very good and highly motivated students, and partly by the high-quality education that students receive in the programme. It praises BiSB for this achievement.

Alumni

A recent alumni survey on LinkedIn showed that approximately one-third of the programme's graduates have obtained, or are in the process of obtaining, a PhD degree. Another third works as experts in industry directly related to systems biology or bioinformatics, and the final third work in other positions, often as data scientist or software developer. The panel learnt from the programme management and alumni that graduates of the programme are in high demand in industry and academia, and usually quickly find a job after graduation. The alumni and representatives of the professional field that the panel interviewed were

very satisfied with the quality of the education provided by the programme. The panel concludes that graduates perform well in positions relevant to the goals and aims of BiSB.

Considerations

The panel concludes that BiSB graduates achieve the intended learning outcomes. The final research projects are generally of very high quality, for which the panel praises the programme. Alumni find relevant positions after graduation and are in high demand.

Conclusion

The panel concludes that that the programme meets Standard 4.

General conclusion

The panel's assessment of the MSc Bioinformatics and Systems Biology is positive.

Development points

1. Emphasize in the ILOs that students are taught to acquire new methods and techniques in a rapidly changing field, rather than study a fixed body of methods and techniques.

2. Make curriculum design choices more insightful to students, such as the choice to use single cell modelling to teach students about the concepts of modelling in the Systems Biology track.

3. Formulate learning trajectories related to the various skills that students develop throughout the programme, such as communication and collaboration. Demonstrate how the various courses and assessments contribute to the attainment of these skills.

4. Expand attention to ethics and integrity in the curriculum, moving beyond FAIR data principles to include bioethics, privacy and data protection.

5. Keep working to solve the administrative issues that students can encounter when joining courses from both universities.

6. Keep working on reducing the workload associated with growing student numbers, such as through the introduction of teaching assistants, reducing the workload for the UTQ portfolio and plans to expand the teaching staff with a junior staff member for the Systems Biology track.

7. Make better use of the full range of grades in the assessment of the final projects and, if necessary, discuss the rubrics and/or their interpretation with the examiners and assessors.

8. Choose a term other than 'mentor' to describe the role of the second assessor to avoid future confusion and ensure that this advisory role does not interfere with the independence of the research project assessment.

Appendix 1. Intended learning outcomes

At all events, a graduate of the master programme will have:

Knowledge and understanding

1. both a solid academic basic as well as specialist knowledge and understanding in the field of bioinformatics and systems biology and in one or more sub-areas of bioinformatics and systems biology, and related fields such as biophysics, biochemistry, mathematical modelling and cell biology [focus and balance];
2. the ability to access and use international professional literature and master current scientific research developments and has knowledge of current scientific developments within relevant subdomains of bioinformatics and systems biology [focus and translation];
3. knowledge and understanding of the (iterative) research process in Bioinformatics and/or Systems Biology: i.e. the relation between model, experiment, data analysis and the biological system [focus]

Applying knowledge and understanding

4. the skills to analyse and interpret biological patterns and processes in both a qualitative and quantitative sense and make inferences based on these scientific results [balance and focus];
5. acquired profound knowledge, insight and practical experience in at least one specialist area of bioinformatics or systems biology [focus];
6. insight of the applications of bioinformatics and systems biology in general and specific specialisations in particular and is able to apply this knowledge in new and continuously changing practical situations, also in broader, multidisciplinary contexts [translation];
7. the ability to independently set up and implement experiments contributing to a line of research [focus, balance and translate]

Making judgements

8. the ability to get acquainted with a field of study and acquire specialist knowledge, understanding and skills in a short period of time [focus and translation];
9. the ability to continue his/her career either as a researcher able to pursue a PhD degree at the best universities, as a scientist in research institutes worldwide, or as a research-skilled professional in organisations of government, civil society or business and industry [balance and translation];
10. an attitude that enables critical reflection and discussion [translation]

Communication skills

11. the skills to present research projects and results both orally and written in English, at various scales and levels of abstraction, and communicate these to specialist and non-specialist audiences [focus and translation]

Learning skills

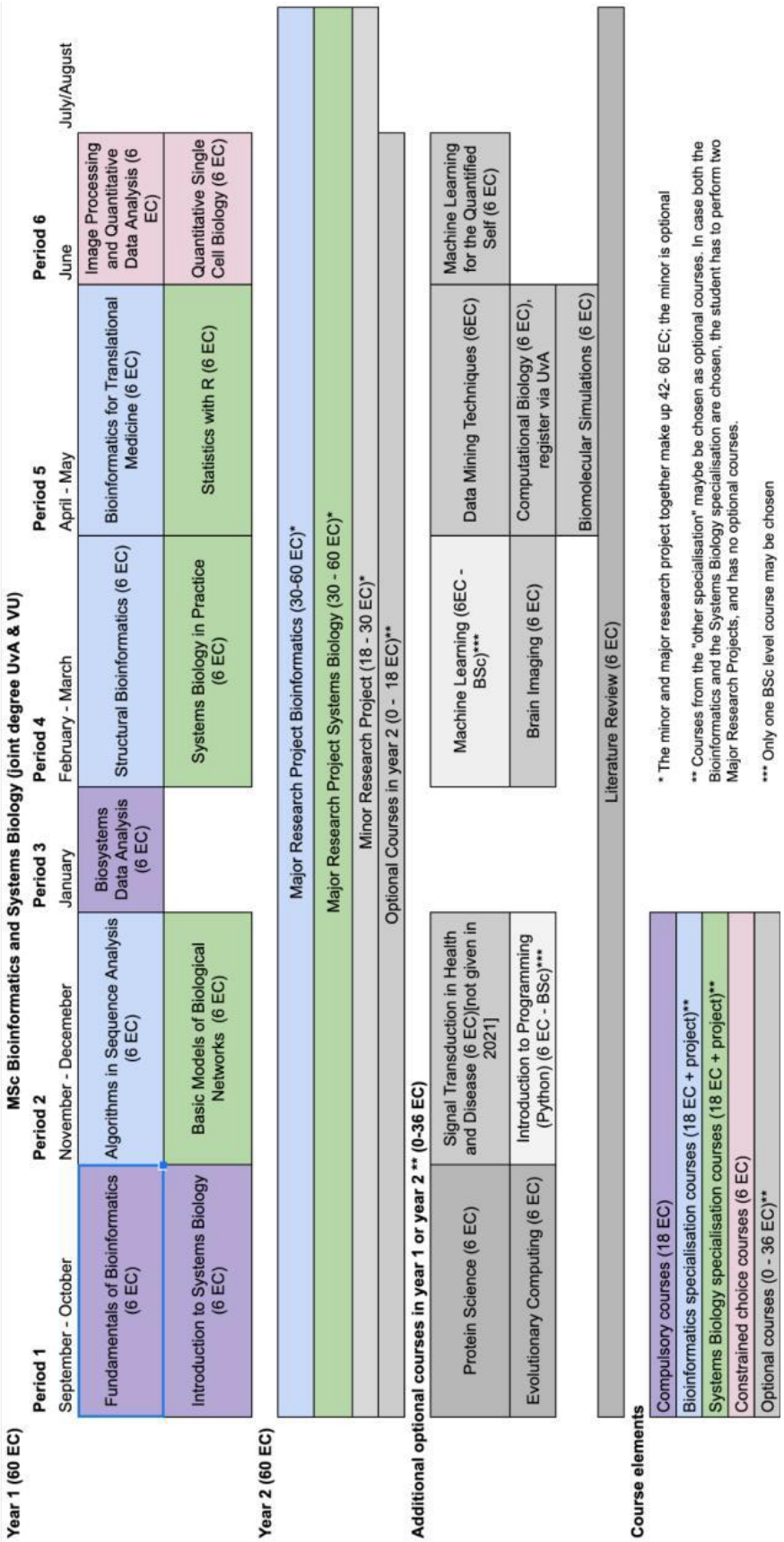
12. the ability to successfully fulfil a position in society requiring an academic qualification as an independently operating professional that has a good knowledge base and attitude towards a biological approach to relevant societal issues [translation];

13. capability of writing research or project proposals on the basis of realistic problem descriptions or to write a critical essay based on literature within a specialised field of study and one's opinion [translate and focus]

Track specific qualifications:

A) A graduate of the track/specialisation Bioinformatics will have the qualification mentioned above in the field of Bioinformatics.
B) A graduate of the track/specialisation Systems Biology will have the qualification mentioned above in the field of Systems Biology.

Appendix 2. Programme curriculum



Appendix 3. Programme of the site visit

THU 16 DEC
16.30 18.00 Preparatory panel meeting
18.00 18.30 Consultation hour

FRI 17 DEC
08.30 09.00 Panel preparation
09.00 09.45 **Interview programme management**
10.00 10.45 **Interview master's students**
11.00 11.45 **Interview alumni & professional field**
12.00 12.45 **Interview teaching staff**
12.45 14.15 Lunch break
14.15 14.45 **Interview Board of Examiners**
14.45 15.15 Internal panel session
15.15 15.45 **Concluding interview programme and faculty management**
15.45 17.15 Panel deliberation
17.15 **Oral feedback and conclusion**

Appendix 4. Materials

Prior to the site visit, the panel studied 15 final research projects. Information on the projects is available from Academion upon request. The panel also studied other materials, which included:

- Teaching and Examination Regulations 2021-2022
- Assessment Plan
- Research Project Assessment Guidelines 2021-2022
- Research Project Grading Rubric
- Assessment Matrix
- Faculty Assessment Policy
- VU Assessment Framework (Toetsbeleid Faculteit der Bètawetenschappen 2019)
- Study Guide
- The Examination's Board Rules and Guideline
- Management information factsheets
- Overview of Staff
- NSE results 2021
- Alumni questionnaire results 2021
- NAE results 2019
- Bioinformatics and Systems Biology bridging the gap
- Training for translation between disciplines
- Curriculum Evaluation
- Summary of the PAB meeting on June 2021