ASIIN

12

Subject-Specific Criteria of the Technical Committee 12 – Mathematics

For the accreditation of Bachelor and Master Degree Programmes in the field of Mathematics

(adopted: 09 December 2016)

The following specifications are complementary to the „ASIIN General Criteria for the Accreditation of Degree Programmes”.

1 Preliminary note

1.1 Function and Context

The subject-specific criteria (SSC) of the Technical Committee 12 Mathematics exist under the premise that the intended learning outcomes submitted for accreditation of degree programmes, as formulated by the higher education institutions under their own responsibility and according to their institutional profile, form the central standard for their curricular review.

Furthermore, the subject-specific criteria of all ASIIN Technical Committees have a number of important functions:

The SSC are the result of regularly planned assessments by the ASIIN Technical Committees, that summarise what is considered good practice between academics and practitioners of the professional community, or, what is required as future-oriented educational quality by the labour market. The expectations regarding the achievement of study objectives, learning outcomes and competency profiles as formulated in the SSC are not intended to be static. They are rather subject to continuous reviewing in close cooperation with organisations from the professional community such as faculty and subject area meetings, expert associations and federations of professional practice. Applicant institutions are requested to critically reflect on the interaction between their own formulated intended learning outcomes, their curricula and the associated quality expectations, as well as on how they position themselves with regards to their own institutional objectives.

In addition, within the accreditation process, the SSC provide a professionally elaborated basis for discussion among experts, higher education institutions and ASIIN panels. They are meant to contribute significantly to the comparability of national and international accreditation procedures. The choice of professional parameters that influence the discussion and individual evaluation should not be subject to random professional interpretation of the individual experts. At the same time, the SSC designate the abilities, skills and competencies that can be counted as current 'state of the art' within a typical subject area, but which can and should also be exceeded and varied according to the definition of objectives of the institution.

For interdisciplinary and multidisciplinary degree programmes, the ASIIN SSC can provide reference points for presentation and orientation. They are, however, fundamentally focused on the respective core subjects of the individual disciplines.

The ASIIN SSC contribute to the realisation of a unified European higher education area. They address the quality requirements to formulate subject-specific, discipline-oriented learning outcomes as one of the most important promotional tools for academic and professional mobility in Europe. The SSC take into account the diverse preparatory work that has been done within the framework of European projects and professional networks.

1.2 Objectives

The SSC describe standards regarding professional abilities, skills and competencies that should be mastered by graduates of accredited mathematical degree programmes. As such, they equally provide an orientation framework for institutions, experts and companies.

The diversity of degree programme profiles has increased enormously in recent years. This especially applies to degree programmes in which Mathematics plays an important role. To further comparability, a system of categorisation can offer an important guide. The ASIIN SSC 12 Mathematics thus also describe criteria for the distinction of mathematical degree programmes on the one hand, and degree programmes with mathematical components (i.a. interdisciplinary degree programmes) on the other. This distinction will be indicated henceforth by the definition types **M**, **xM** and **iM**. It has to be emphasised that the categorisation into these types cannot be clear-cut, as the transitions are fluid. The scope of prioritisation and development of institutions is also reflected in this blurriness.

Still, this categorisation should serve the responsible persons of these programmes as a guide to classify the competency profiles of a degree programme with significant proportions of Mathematics, as defined by the institution. In this respect, these SSC systematise available concepts of degree programmes; **they do not formulate regulations or rules in any way**. The categorisation is the result of the respective degree programme profiles as chosen by the institutions as well as their conversion into curricula – in this way, the persons responsible for the programme determine the type of degree programme.

Depending on the classification of the degree programme into type **M**, **xM** or **iM**, the Technical Committee for Mathematics will play a leading or supporting role in the accreditation process.

For teacher training programmes, the ASIIN „Subject-specific Criteria for the Accreditation of Bachelor and Master Degree Programmes that convey the educational requirements for teacher training in Germany“ are applicable, dated 9 December 2011.

2 Mathematical and Interdisciplinary Degree Programmes

The SSC of the ASIIN Technical Committee 12 Mathematics concern the above described mathematical degree programmes as well as interdisciplinary degree programmes with a large mathematical proportion and the possibility of a specialisation within selected areas of mathematics that are to be accredited by ASIIN. This general classification is mainly focused on the proportion and depth of the mathematical content as well as on the role of other disciplines, i.e. on the mathematical competencies to be conveyed and not necessarily on their curricular proportion in the form of credit points.

The mathematical competencies to be imparted do however demand a certain minimum of curricular content. To that extent, a certain curricular proportion as measured in credit points is a necessary consequence of the classification as a mathematical degree programme (see also Chapter 4). A proportion as such, however, is not sufficient, as the following example shows: A degree programme, that includes only mathematical modules that convey the content fully without any evidence and solely focuses on the application of mathematical methods, would not be considered a mathematical degree programme in the eyes of the Technical Committee.

In the following paragraphs, we define this general classification knowing that an absolute 100% distinction is neither possible or sensible.

Type M (Degree programme in Mathematics with a minor or an applied subject): Mathematics as such is clearly the main focus; structural mathematics[1] and formal argumentation are core components of the curriculum. The necessary scope and depth of the mathematical content leads to an average maximum of 20% of credit points being reserved for another subject or other subjects. This other subject or subjects can largely be freely elected by the students and do not necessarily need to be directly related to mathematical curricular content.

Type xM (Degree Programme in Mathematics with applied orientation): [2] There is a close interconnection with one or more applied subjects that contain requirements on which the mathematical programme is oriented (generally this is in the form of an integrated degree programme). Besides fundamental training in abstract and applied mathematics, mathematics including formal argumentation is firmly anchored in the curriculum; at least in those areas of mathematics where this is relevant. Examples are Statistics, Business Mathematics, Technical Mathematics or Biomathematics.

Type iM (Interdisciplinary Degree Programme with a large mathematical proportion): [3] These are interdisciplinary degree programmes in which generally at least three subjects are studied that represent mathematics as the core of the mandatory curriculum and where it is possible to opt for a mathematical specialisation. The amount of structural mathematics is focused on the interdisciplinary content. Mathematics is being pursued not as the end in itself, but with a clear focus on its applications. Examples are Business Calculations, Computer Science and Engineering (CSE), Biometrics, Biostatistics, Data Science, etc.

The Technical Committee considers type **M and xM** degree programmes as **mathematical degree programmes**, and will take a leading or supporting role in the accreditation process. Graduates of these degree programmes would be called “mathematicians”, respectively including a specialisation, e.g. “business mathematician” or “technical mathematician”. **Type iM degree programmes are not considered mathematical degree programmes** within this classification, and their graduates would not be called “mathematicians”. Based on the large mathematical content within the curriculum, the Technical Committee would be involved in the accreditation in a supporting role, but not necessarily in a leading role.

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[1] “Structural Mathematics” means Mathematics with an orientation in argumentation and abstracts.

[2] The indication xM is related to Business, Bio or Technical Mathematics, where “x” stands for the respective specification of the mathematical degree programme.

[3] The indication iM is related to “interdisciplinary with Mathematics”.

Degree programmes that should be separated from **Types M, xM and iM**, are those that require mathematical competencies as methodological tool for their own disciplines, but do not aim for a mathematical specialisation. These SSC cannot be applied to those degree programmes. Thus, the Technical Committee Mathematics will not be involved in these accreditations. Examples are Physics, Informatics or Mechanical Engineering.

In principle, it is the institution's responsibility that the name of a degree programme is commensurate with its intended competency profile. To this extent, it is possible for the above-mentioned classification to be an indicator for mathematically oriented degree programmes.

3 Study Objectives and Learning Outcomes

„High technology is mathematical technology" – this sentence from the position paper of the National Academy of Sciences in the United States of America shows that mathematics plays an increasingly important role in virtually all areas of Natural Sciences and engineering, but also in the fields of business and finance, social sciences and also in medicine.

This explains the above described diversity in mathematically oriented degree programmes. Types M, xM and iM should be characterised based on study objectives and learning outcomes.

Study objectives are clarified by describing those learning outcomes – i.e. abilities, skills and competencies – that graduates need in their professional career or in their further studies. These outcomes are developed according to the various objectives of Bachelor and Master Degree programmes regarding scope and depth.

3.1 Requirements for Bachelor Degree programmes

Type **M**, **xM** and **iM** degree programmes not only equip students for being accepted into a consecutive Master programme, but in principle they also prepare them for entering the professional field. This not only requires professional competencies with adequate scope and depth, but also generic competencies and aspects of personal development.

The following will cite examples of specialist and generic learning outcomes for mathematically oriented Bachelor Degree programmes and will categorise them into types M, xM and iM. This results in a more specific categorisation of the three types.

Examples of specialist learning outcomes for Bachelor degree programmes

<table>
<tr><th colspan="2">Bachelor</th><th>M</th><th>xM</th><th>iM</th></tr>
<tr><td rowspan="4">Knowledge</td><td rowspan="4">Remember</td><td colspan="3">• Possesses profound knowledge of the fundamentals ...</td></tr>
<tr><td colspan="2">... of abstract and applied mathematics</td><td rowspan="2">... in selected chapters of abstract and/or applied mathematics as well as in the respective applied subjects</td></tr>
<tr><td>As well as at least one minor subject</td><td>As well as in the respective applied subject</td></tr>
<tr><td></td><td colspan="2">• Is familiar with relevant practical standard software</td></tr>
</table>

<table>
<tr><td rowspan="3">Ability</td><td>Comprehend</td><td colspan="3">• Is able to identify and explain the quality of simple[4] mathematical problems
• Is able to generalise simple mathematical problems</td><td>• Is able to formulate simple mathematical problems</td></tr>
<tr><td>Apply</td><td>• Is able to use fundamental mathematical statements to solve simple mathematical problems
• Is able to formulate fundamental mathematical hypotheses</td><td colspan="2">• Is able to solve simple practical problems by applying fundamental mathematical methods</td><td>• Is able to solve simple practical problems by applying fundamental mathematical methods (where applicable only with software)</td></tr>
<tr><td>Analyse</td><td colspan="3">• Recognises the formal structure of simple mathematical problems</td><td>• Is able to allocate practical problems to a mathematical category</td></tr>
<tr><td rowspan="7">Competency</td><td rowspan="2">Evaluate</td><td colspan="3">• Formally and correctly proves simple mathematical statements with facts and methods that students are familiar with</td><td></td></tr>
<tr><td colspan="2">• Masters fundamental strategies for transferring methods in the area of Mathematics</td><td colspan="2">• Masters fundamental strategies for transferring methods in selected areas of Mathematics, depending on the practical application</td></tr>
<tr><td rowspan="5">Create</td><td></td><td colspan="3">• Creates simple, realistic mathematical problems under supervision</td></tr>
<tr><td colspan="4">• Implements simple, mathematical processes on the computer</td></tr>
<tr><td></td><td colspan="3">• Additionally, utilises elementary mathematical software</td></tr>
<tr><td colspan="4">• Within the framework of Bachelor activities, works on a simple and clearly defined scientific task and is able to adequately present the results orally and in writing</td></tr>
<tr><td>• ... in the area of abstract or applied mathematics or from a minor subject with a large mathematical proportion</td><td colspan="2">• ... in an applied area with a large mathematical proportion</td><td>• ... in an applied area with a generally mathematical proportion</td></tr>
</table>

[4] "Simple" means in this context with a differentiation from Master programme problems and content of manageable complexity.

Examples of Interdisciplinary Learning Outcomes

Bachelor graduates of degree programmes of Type M, xM and iM have built experience with interdisciplinary skills with regard to entering the professional field and are able to further develop the acquired abilities.

This includes, among others:

- the fundamental ability to independently deepen and expand the acquired knowledge (Lifelong Learning). For this, graduates are mainly familiar with fundamental learning and work strategies and have built their first experiences with handling scientific literature,
- the ability to adequately communicate about topics within their discipline orally as well as in writing, as suited to their audience (Communicative Competencies)
- first experiences with teamwork

Furthermore, graduates have gotten a first impression on how effects of their own subject area are impacting the economy and society. They are able to adequately reflect on the moral and ethical dimensions of their future professional work.

3.2 Requirements of Master Degree programmes

Building on a first higher education degree, the Master degree programme imparts enhanced analytical and methodological competencies. Simultaneously, the attained professional competencies acquired in the bachelor degree programme are being expanded and deepened. The Master Degree programme enables graduates to independently work as a professional in science and industry, but also to achieve a further academic qualification in the form of a doctorate.

The following will cite examples of specialist and generic learning outcomes for mathematically oriented Master degree programmes and categorise them into types M, xM and iM. This results in a more specific categorisation of the three types.

Examples of specialist learning outcomes for Master degree programmes

<table>
<tr><th colspan="2">Master</th><th>M</th><th>xM</th><th>iM</th></tr>
<tr><td rowspan="3">Knowledge</td><td rowspan="2">Remember</td><td colspan="3">• possesses further knowledge ...</td></tr>
<tr><td>... of abstract and applied mathematics as well as at least one minor</td><td>... of the relevant mathematics for the applied subject as well as in the respective applied subject</td><td>... in selected chapters of abstract and/or applied mathematics as well as in the respective applied subjects</td></tr>
<tr><td>Comprehend</td><td>• is able to identify and explain the quality of complex mathematical problems
• is able to generalise complex math-</td><td colspan="2">• is able to mathematically formulate complex, applied problems</td></tr>
</table>

		ematical problems		
Ability	Apply	• is able to use mathematical statements to solve mathematical problems • is able to formulate mathematical hypotheses and verify them	• is able to solve problems in the applied area with the help of mathematical	• is able to solve problems in the applied area with mathematical methods (where applicable with software)
	Analyse	• recognises the mathematically abstract structure of problems and is able to analyse this	• recognises the mathematically abstract structure of applied problems	• is able to allocate complex problems in the applied subject to a mathematical
Competency	Evaluate	• Formally and correctly proves mathematical statements	• Formally and correctly proves mathematical statements from selected areas	
		• Masters strategies to transfer methods within a wide area of Mathematics	• Masters strategies to transfer methods in selected areas of Mathematics, depending on the area of application	
	Create		• Masters the mathematical creation of realistic problems	
		• Implements mathematical processes for complex problems on the computer		
		… by applying mathematical standard software	… by applying relevant standard software	
		• Is able to scientifically work on and present mathematical problems		
		• Within the area of abstract and applied mathematics or a minor with a close mathematical relation	• Within an area of application with a large mathematical proportion	• Within an area of application with a generally mathematical proportion
		• Within the framework of Master activities, independently works on an advanced scientific		
		• … within the area of abstract and applied mathe-	• … with an area of application with a large mathemati-	• … Within an area of application with a generally

		matics or a minor with a large mathematical proportion	cal proportion	mathematical proportion
		• ... and is able to adequately present and scientifically discuss the results both orally and in writing		

Examples of Interdisciplinary Learning Outcomes

Master graduates of degree programmes of **Types M, xM and iM** have suitably expanded and deepened the interdisciplinary competencies that they acquired during the Bachelor programme and are therefore particularly well equipped to take on professionally and/or scientifically challenging tasks.

4 Curriculum

In principle, it is up to the institution to translate their defined competency profile into a curriculum. The accreditation serves solely to assess this conversion. This is why these SSC cannot provide any guidelines for the curricular development of degree programmes. Below, we will present several curricular conversion methods as well as the resulting characteristics and distinguishing features of mathematically oriented degree programmes.

4.1 Fundamental Distinguishing Features of type M, xM and iM Degree Programmes

The curricular structure of a degree programme first and foremost follows the study objectives and learning outcomes as defined by the institution itself.

Even when a clear distinction is not always possible or sensible, certain curricular specifics of the above explained **Types M, xM and iM** of degree programmes will generally be the result:

Type M (Mathematics degree programme with a minor or application subject):

The mathematical modules are developed in such a way that they impart the knowledge of abstract and applied mathematics (with adequate depth) as well as structurally mathematical competencies (including abstraction and formal argumentation) in broad areas of mathematics, in accordance with the respective level.

Type xM (Mathematics Degree programme with applied orientation):

The mathematical modules are developed in such a way that they impart the knowledge of abstract and applied mathematics as well as structurally mathematical competencies (including abstraction and formal argumentation) in selected, sub-areas of Mathematics that are directly related to the area of application.

Type iM (Interdisciplinary Degree programme with a large mathematical proportion):

Although the mathematical modules are focused on imparting mathematical methods in the respective interdisciplinary context, they go beyond their mere *application*. Structurally mathematical competencies are also imparted with respect to a possible specialisation in further studies in selected, and for the interdisciplinary context relevant, sub-areas of Mathematics.

4.2 Curricula of Bachelor- und Master Degree programmes

Bachelor Degree programmes

In Bachelor Degree programmes of **Types M, xM and iM**, it is usually the professional fundamentals of structural Mathematics that are being imparted. For **Type M and xM** degree programmes this generally includes multi-semester cycles of Analysis and Linear Algebra including Argumentation and Abstraction. This mathematical fundamental education can in **Type iM** degree programmes be restricted to selected content and could for instance be oriented at mathematical education for physicists.

The basic mathematical training will be complemented by content from the area of Algebra/Geometry, Advanced Analysis, Numerical Mathematics, Optimisation and Stochastics. While **Type M** degree programmes impart a broad education in these areas, **Type xM** degree programmes are limited to those areas that are of importance to the relevant applied subject (e.g. Financial or Insurance Mathematics or Optimisation in degree programmes on Business Mathematics). A certain mathematical scope however is often the objective. This supplementary mathematical training is exclusively related to the mathematical areas relevant to the application subjects of **Type iM** degree programmes, and can contain mandatory elements (e.g. Numerics of partial differential equations in degree programmes on Scientific Calculations). Even when these contents are being learned in applied form in some circumstances, it should be ensured that a mathematical specialisation in these areas is possible.

After the basic mathematical training, **Type M** degree programmes are typically characterised by a high number of **options** to choose from. The curriculum of this section of the programme should cover many of the sub-areas as mentioned above. To ensure the acquisition of mathematical competencies in suitable broadness, one should see to it that despite many options, students will come into contact with an appropriate selection of these sub-areas. The same goes in principle for **Type xM and iM** degree programmes, in which the options for mathematical modules follow the respective contents of the basic mathematical training and the orientation of the degree programme. When designing, the necessary prior knowledge should be taken into account.

The optional modules in **minor and applied subjects** for students should be identified in the study guide. Of course, it is possible to select additional modules apart from the mandatory requirements. For **Type M** degree programmes, it is not expected that there is a connection between the course and the minor or applied subjects with mathematical content (these subjects also serve to expand the scientific horizon), whereas integrated elements are expected in **Type xM and iM** degree programmes.

Al least **Type xM and iM** Bachelor degree programmes are generally characterised by a supervised industrial placement or an equivalently applied project. Their specific development follows the superordinate learning objectives and contributes not least to the professional qualification of Bachelor graduates. For **Type M** degree programmes, the curriculum should be designed in such a way that a voluntary internship phase can be integrated without causing delaying effects in the Bachelor Degree programme.

A semester abroad is recommended based on the intended goal of Internationalisation. It should be possible to integrate this without any delaying effects (“mobility window”).

Interdisciplinary contents should serve professional qualification with the respective study objectives of the Bachelor degree programme (key qualifications) and will offer students further options.

The Bachelor thesis should contain a maximum of 12 credit points, according to the KMK structural requirements in Germany. To attain a maximum range of mathematical competencies, the full utilisation of this framework is strongly recommended. The competencies to be attained within the Bachelor thesis can be expanded and deepened by an additional colloquium or a seminar. The Bachelor thesis can be prepared in cooperation with a company or a research facility, while the institution will lastly guarantee standard and quality.

Master Degree Programmes

Master degree programmes are often categorised into science or applied orientations. **Type M** Master degree programmes are generally science oriented, **xM and iM** Master degree programmes can be science oriented or applied oriented. Both orientations should clearly show a more open structure as a Bachelor Degree programme. They could consecutively build on a Bachelor Degree programme or they could be designed for students based on other related disciplines. **Type iM** degree programmes in particular should be structured as such that graduates from related Bachelor Degree programmes can enter a Master Degree programme almost seamlessly.

Despite a high rate of specialisation, **Type M degree programmes** aim at a professional expansion and deepening in *various* areas of mathematics (particularly in abstract *and* applied mathematics). This could for instance be attained by an adequate division of the course between the areas Analysis/Algebra/Geometry or Numerical Mathematics/Optimisation/Stochastics.

A minor also has a substantial part in Master education. Regarding the design of **xM degree programmes**, there should be a balance between the necessary scope (in the relevant mathematical areas as well as in the applied area) and depth according to the level. This can contain mandatory elements (e.g. Business Mathematics) as well as a mandatory elective course within blocks (e.g. at least 18 credit points in Mathematics, Informatics, Life Sciences in degree programmes in Biomathematics).

The Master thesis generally has a total of 30 credit points with a preparation time of 6 months. The full utilisation of the framework of **Type M, xM and iM** degree programmes is also strongly recommended here. For research oriented Master degree programmes, the final thesis should make reference to current research topics in Mathematics (if necessary focused on the respective application area). For applied Master Degree programmes, the topic of the Master thesis should refer to the application, where the respective problem should require the application of modern mathematical solution methods. The Master thesis can be prepared in cooperation with companies or a research facility, while the institution will lastly guarantee standard and quality.

Placement periods should only be mandatory for applied Master Degree programmes. A direct connection to the respective superordinated study objectives should be without question, as well as the allotting of credit points to the actual work load. In any case should the curriculum be designed as such, that a placement period or time abroad can be integrated without delaying effects.

The use of Bachelor courses in the Master is essentially possible, but has to be closely focused on the qualification objectives of the Master programme (e.g. towards completing a broad mathematical education). A double allotment of credit points for learning units in both the bachelor and the Master is excluded in any case.

4.3 Lectures and Examinations

The selection of the type of lecture should focus on the learning objectives of the (sub) course and should support the independent solving of mathematical problems according to the respective competency level.

The finalisation of a course requires a marked or unmarked assessment. The possibility of a first repeat examination should be organised so that further progress in the degree programme is not hindered. The selection of the type of examination should follow the learning objectives of the respective (sub) course. Overall, various types of examinations should be applied in the course of the entire programme.

4.4 Possible Differentiating Characteristics in the curriculum

Based on the formulated example learning outcomes in Chapter 2, the following table summarises **possible differentiating characteristics** in the curriculum of **Type M, xM and iM** degree programmes. In favour of a simplified illustration, the content refers to selected concrete and consecutive Bachelor/Master degree programmes. **The respective information is explicitly neither binding nor mandatory, but should only serve as a guideline. As a *suggestion* for a possible credit weight, credit point in brackets have been added to the respective competency areas.**

Indicated in small print are suggestions for possible courses for the selected examples (the information can directly be applied to other combinations, e.g. Mathematics with NF Mechanical Engineering / Technical Mathematics / Computational science and Engineering or Mathematics with NF Life sciences / Biomathematics / Biostatistics).

M **(e.g. Mathematics with NF Economics)**	**xM** **(e.g. Business Mathematics)**	**iM** **(e.g. Mathematical Econometrics)**
This table contains possible differentiating characteristics of curricula of mathematically oriented degree programmes. The information is intended as a guideline and is neither binding nor mandatory!		
Structurally oriented basic mathematical course in Analysis (27) and Linear Algebra (18) (Analysis 1-3, Linear Algebra 1-2)	Structurally oriented basic mathematical course in Analysis (27) and Linear Algebra (9) (Analysis 1-3, Linear Algebra 1)	Mathematical basic course, that is structurally oriented at least in the important subareas (20) (Higher Mathematics 1-3)
Mandatory course in the areas of Analysis / Algebra / Geometry (18) as well as Numerics / Optimisation / Stochastics (18) (Algebra, Number Theory, Function	Mandatory course in the areas of Mathematics that are important for the applied subject. (18) (Stochastics 1-2)	Applied mandatory course with mathematical content related to the applied subjects (10) (Statistical Methods including R-

theory, Stochastics 1, Numerics 1, Optimisation 1)		internship)
Mandatory course of at least one minor subject (18), not necessarily related to Mathematics (18) (BWL 1, VWL 1)	Mandatory course from the applied subject, integrally related to Mathematics (18) (BWL 1, Financing)	Mandatory course from the applied subjects integrally related to Mathematics (25) (Econometrics, Business Analytics)
Mandatory elective course in abstract or applied Mathematics (each at least 18) (Topology, Function Analysis, Stochastics 2, Numerics 2)	Mandatory elective course in the areas of importance for the applied subject (each at least 18) (Financial Mathematics, Optimisation and Operations Research	Elective course in the areas of importance for the applied subject. (Time series, experimental Design)
Specialisation course in abstract or applied Mathematics (18) (Mathematical Specialist Lectures)	Specialisation course in the areas of importance for the applied subject (Risk Theory, Game Theory, Partial Differential Equations)	Specialisation course in the areas of importance for the applied subjects (Multivariate Statistics)
Programming course	Training standard software; applied Informatics course integrated	Training standard software; applied Informatics course integrated
Professional internship or similar. Voluntary seamless possible	Professional internship or similar. Generally mandatory.	Professional internship or similar. Generally mandatory.
Final thesis with clear mathematical content, topic can be from a minor subject.	Final thesis with strong mathematical relation, topic is generally motivated by an applied subject.	Final thesis generally utilises mathematical methods, but can also originate from a related sub-area of Mathematics