Fachausschuss Mathematik

ASIIN

SUBJECT-SPECIFIC CRITERIA

Relating to the accreditation of Bachelor's and Master's degree programmes in the field of mathematics

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The following specifications complement the "ASIIN General Criteria for the Accreditation of Degree Programmes".

1. Classification

1.1 Function

The Subject-Specific Criteria (SSC) of the Technical Committee for Mathematics have the premise that the intended learning outcomes framed by Higher Education Institutions in their own responsibility and according to their academic profile concerning the programmes submitted for accreditation build the main scale for their curricular review.

Above this the Subject-Specific Criteria of all ASIIN Technical Committees meet a number of important functions:

The SSC are the result of an assessment, regularly performed by ASIIN Technical Committees, which summarize what is considered as good practice by a professional community formed equally by academics and professional practitioners in higher education and is required as future-oriented quality of training in the labour market. The expectations outlined in the SSC for the achievement of study objectives, learning outcomes and competency profiles are not developed statically. They are rather subject to constant review in close cooperation with organizations of the professional community, such as associations of faculties and university departments, professional societies and federations relating professional practice. Applicant universities are asked to study critically the interaction between the intended learning outcomes they strive for, the curricula and their relating quality expectations by using SSC and to position themselves in the light of their own higher education goals.

In their role in the accreditation process the SSC also provide a professionally elaborated basis for discussion among experts, Higher Education Institutions and bodies of ASIIN. By this they make an important contribution to the comparability of national and international accreditation procedures, since it should not be left to chance of the characters of the individual evaluators which technical parameters find their way into discussion and individual assessment. Simultaneously the SSC enumerate those abilities, skills and competencies which may typically be considered as state of the art of a discipline, but which can always be exceeded and varied, and also should be in accordance with the objectives of the university.

For inter- and multidisciplinary studies the SSC of ASIIN can provide orientation for presentation and evaluation. However, they are basically aligned on the core subjects of particular disciplines.

The SSC of the ASIIN are positioned and coordinated internationally and thus contribute to the achievement of the unified European Higher Education Area. They act on requirements of the "Bologna 2020" European strategy to formulate subject specialized, discipline-oriented learning outcomes as one of the most important means for the promotion of academic and professional mobility in Europe as quality requirement. The SSC consider, among others, the many preparations in the context of European projects (e.g. "Tuning") and professional networks.

1.2 Collaboration of the Technical Committees

The Technical Committee Mathematics works together with the other Technical Committees of ASIIN, mostly to give consideration to the requirements of interdisciplinary study programmes. The universities are called upon to submit their assessment of the assignment of one or several Technical Committees in the course of the application for an accreditation procedure.

As a rule, the Technical Committee Mathematics is responsible for the supervision of accreditation procedures regarding degree programmes with a share of 50 percent of contents relating to mathematics and appoints technical consultants from other fields of expertise if needed. Interdisciplinary study programmes with a weighted share of contents (below and up to 50%) relating to mathematics the Technical Committee Mathematics and the participating technical disciplines are either jointly responsible or the Technical Committee simply provide auditors.

2. Educational Objectives - Competences

"High technology is mathematical technology" – this sentence from a position assessment by the National Academy of Sciences of the USA shows that mathematics plays an increasingly important role in practically all areas of the natural and engineering sciences, but also in economic, financial and social science areas and in medicine.

The educational objectives are outlined by the description of the learning outcomes, i.e. knowledge, skills and competences, required by the graduates for practising their profession or for post-graduate studies. These outcomes vary in extent and intensity in accordance with the differing objectives of Bachelor's and Master's programmes.

2.1 Requirements for Bachelor's Degree Programmes

The diverse professional opportunities of graduates of degree programmes in mathematics are based on a sound mathematical education and thorough training, encompassing broad basic knowledge as well as scientific work methods. The Bachelor's degree programme facilitates regular completion of a degree with an early career start on the one hand, while on the other hand permitting faster progress of students aiming to do an additional non-mathematical degree (e.g. for consulting, marketing, business, finance, patents etc.).

The **following learning outcomes** (knowledge, skills or competences)[1] are typical of a **Bachelor's degree in mathematics**:

[1] For a definition of educational objectives and learning outcomes, refer to chapter 2.1 of the General Criteria for the Accreditatio of Degree Programmes

a. Specialist learning outcomes

Graduates

- have sound mathematical knowledge. They have a profound overview of the contents of fundamental mathematical disciplines and are able to identify their correlations.
- are able to recognise mathematics-related problems, assess their solvability and solve them within a specified time frame.
- have a basic ability to work in a scientific way. They are in particular able to formulate mathematical hypotheses and have an understanding of how such hypotheses can be verified or falsified using mathematical methods.
- can flexibly apply mathematical methods of fundamental component areas of mathematics and are able to transfer the findings obtained to other component areas or applications.
- have abstraction ability and are able to recognise analogies and basic patterns.
- are able to think in a conceptual, analytical and logical manner.
- have an extensive comprehension of the significance of mathematical modelling. Are able to create mathematical models for mathematical problems as well as for problems in other areas of science or everyday life, and have a selection of problem solving strategies at their disposal.

In addition, the following subject-specific learning outcomes are typical of pure and specialist mathematics degree programmes. Graduates in …

mathematics	technomathematics[1])	business mathematics
can use basic methods of computer-aided simulation, mathematical software and programming to solve mathematical problems	can use basic methods of computer-aided simulation and optimisation, mathematical software and programming to work on engineering and natural science problems	can use basic methods of computer-aided simulation and optimisation, mathematical software and programming to work on economic science problems
	have a command of basic strategies for application-related method transfer	have a command of basic strategies for application-related method transfer
	have a command of basic engineering and natural science terms and concepts	have a command of basic economic science terms and concepts
are in a position to solve more extensive mathematical problems (generally to be proven within the framework of a Bachelor's thesis)	are in a position to solve more extensive mathematical problems using mathematical methods (generally to be proven within the framework of a Bachelor's thesis)	are in a position to solve more extensive mathematical problems using mathematical methods (generally to be proven within the framework of a Bachelor's thesis)

[1]) The information provided for technomathematics correspondingly also applies to other special degree programmes such as biomathematics

b. Social learning outcomes

Graduates can

- classify, recognise, formulate and solve mathematics-related problems.
- use electronic media competently.
- implement lifelong learning strategies. A prerequisite for this is that the students are persevering and that they have developed persistence.

In addition, the following generic learning outcomes are typical of specialist mathematics degree programmes. Graduates in …

mathematics	technomathematics	business mathematics
can recognise, formulate, classify and solve problems in a mathematical context	can recognise, formulate, classify engineering science problems and solve them using mathematical methods	can recognise, formulate, classify economic science problems and solve them using mathematical methods
can communicate, possibly also in a foreign language, and contribute their work effectively in teams	can communicate, possibly also in a foreign language, and contribute their work effectively in interdisciplinary teams	can communicate, possibly also in a foreign language, and contribute their work effectively in interdisciplinary teams
	have basic knowledge of technological project management and understand the necessary project procedures	have basic knowledge of project management and understand the necessary project procedures

2.2 Requirements for Master’s Degree Programmes

Building up on a first higher education degree, a Master’s degree leads to acquisition of advanced analytical and methodological competences. At the same time, the subject-specific competences gained in the first degree are deepened and extended.

It should be noted that an acquisition of extensive specialised knowledge and significant methodological competence is necessary for many fields of activity in research and practice. A Master's degree is intended to meet this aim.

In addition to the learning outcomes specified in 2.1), graduates of Master’s degree programmes in mathematics can

- work out solutions to problems independently on the basis of studying current research literature.
- carry out mathematics-related work in industry and commerce independently and responsibly.
- work successfully as a research assistant or fellow at scientific and public institutions.
- commence doctoral studies.

In addition, the following learning outcomes are aimed for in Master's degree programmes: Graduates in …

mathematics	technomathematics	business mathematics
are familiar with the main mathematical disciplines, their methodological approaches and their interrelations	are familiar with the main mathematical disciplines, their methodological approaches and their relation to the natural and engineering sciences	are familiar with the main mathematical disciplines, their methodological approaches and their relation to the economic sciences
are able to work on and present mathematical problems on a sound scientific basis (generally to be proven within the framework of a Master's thesis)	are able to work on and present mathematical problems related to industrial practice on a sound scientific basis (generally to be proven within the framework of a Master's thesis)	are able to work on and present mathematical problems related to business practice on a sound scientific basis (generally to be proven within the framework of a Master's thesis)

The academic qualification of a Master's degree in mathematics has to correspond to a Diplom degree at universities in Germany.

3. Curriculum

The following key points should be observed:

Depending of the share of purely mathematic contents and the role of other disciplines it is sensible to distinguish between three different types of degree programmes. This classification is only designed for degree programmes in mathematics and not explicitly earmarked in the documentation mentioned above. The following type designations are to be understood as indicators of the approximate percentage of purely mathematic educational contents.

Hereinafter ECTS points are referred to as CP (credit points).

Type 80: Here mathematics proper is clearly in the fore so that a maximum of 6 of 30 CP on average are reserved for other subjects per semester. They can widely be elected by the students and do not have to have a direct relation to the educational contents of mathematics. The study regulations often make specifications with regard to the permitted combination of relevant modules and their minimum scope.

Type 60: Here is a close connection with one or several applied subjects, on the needs of which mathematic education is orientated without neglecting the basic fundamentals. The share of mathematics typically accounts for around 16-20 of 30 CP per semester.

Type 40: They are interdisciplinary degree programmes in which a minimum of three subjects are taught and of which mathematics is predominant. The challenge of this construction is to achieve a conceptual cohesion of the subjects.

Pursuant to the Structural Guidelines of the Standing Conference of the Ministers of Education (KMK), a maximum of 12 credit points may be allocated to a Bachelor's thesis in Germany. The educational objectives in the field of mathematics can best be sustained by making full use of the scope provided. Additional credit points can be gained through a Bachelor's thesis colloquium.

A fundamental education in mathematics is based on analysis and linear algebra and is supplemented by contents in the areas including algebra/geometry, higher analysis, applied mathematics and stochastics. Students typically have a greater extent of options during the study phase building up on these fundamentals. In order to depict the competences to be acquired as well as the breadth of education, the higher education institution should allocate the modules in the area of mathematics to these fields. As far as corresponding modules offered in the second and third academic year are concerned, it has to be ensured that the students are not entirely fixed, but have some degree of choice. A module handbook, in the form of an annex to the Studies or Examination Regulations, provides information about offers and contents. The courses of one module can for example be traditional lectures with exercises. They can also be composed of block courses, or lectures with practicals or with an introductory seminar, of seminars or similar. Proof of successful completion of each module has to be provided. This is mainly achieved by means of a graded examination. An ungraded performance review can however also be used. The option of a first repeat examination has to be organised so that further progress of the course of academic study is not affected negatively. Module examinations can e.g. be conducted in the form of a written examination, an oral examination, a seminar lecture or a written seminar report. Further forms can include posters, practical work reports, project work or presentations.

Modules in **minor and application subjects** have to be set out in the module handbooks. Students can naturally register for additional modules beyond the compulsory components.

At least degree programmes of Type 40 and Type 60 are characterised by a **supervised industrial placement** or an equivalent **application-related project** with a duration and design in compliance with the objectives of the degree programme.

3.1 Bachelor's Degree Programmes

Bachelor's degree programmes in mathematics are generally characterised by a provision of subject-specific fundamentals, and based on these, an extension with applications. With increasing learning progress, options for specialisation open up, culminating in a characteristically individual Bachelor's thesis. Interdisciplinary contents further professionalization in terms of the particular objectives of the Bachelor's degree programme, as well as offering students options.

A semester abroad or practical semester recommended or specified by the study programme, is best integrated in the specialisation phase..

3.2 Master's Degree Programmes

In accordance with German tradition, the structure of Master's degree programmes is significantly freer than that of Bachelor's degree programmes, both in terms of research and application orientation of the course. A Master's degree can build up directly on a Bachelor's degree or be designed for students from different disciplines.

The scope of the programme should correspond to the educational objectives of that level and be conducive to lifelong learning. Even though the degree of specialisation is greater at Master's level, a statement of the contents included in the scope encompassing various areas of mathematics and their applications is necessary. This can be achieved by an appropriate allocation of the available time resources to the areas including analysis/algebra/geometry or/and applied mathematics/stochastics. The proportion of a minor subject in a Master's degree is also substantial.

3.3 Specialised Degree Programmes

In the course of profile development many higher education institutions have introduced specialised degree programmes such as **business mathematics**, **technomathematics** and similar. As far as specialisations of this kind are concerned, an agreement about specific minimum requirements with regard to course contents normally exists. These should be taken into account for accreditation.

4. Annex

The appendix relating subject-specific criteria (SSC) of the Technical Committee 12 – Mathematics takes up learning outcomes and educational objectives for graduates of bachelor and master degree programmes, specified in SSC outlined concerning mechanical, process and chemical engineering. The appendix comprises an exemplary list of curricular contents and possible education and training forms. The following summary should be regarded as orientation for the composition of degree programmes. Its intention is to support higher education institutions in their endeavour to create self-responsibly concrete programme objectives, profile types and forms of particular degree programmes, to underline them with curricular contents and types of adequate education, training and examination. The Technical Committee 12 – Mathematics explicitly welcomes any innovative development of contents or didactic concepts. Ideally, any chosen forms of learning and teaching aim at cultivating intrinsic motivation of students.

4.1 Bachelor's degree programmes

Specialist competences	**Possible curricular contents**
Graduates have sound mathematical knowledge. They have a profound overview of the contents of fundamental mathematical disciplines and are able to identify their correlations.	Fundamentals: 1. Linear algebra as a language and tool for mathematics and its applications in technology, the natural and economic sciences, significant fundamental mathematical terms such as linear map, matrix, eigenvalues, scalar products 2. Analysis: central terms such as function, limit, derivative and integral. These fundamentals make up the focus in the first two semesters. Structure: algebra and geometry, higher analysis, stochastics (data analysis and random modelling), numerical and applied mathematics To ensure the necessary breadth of education in the middle part of the Bachelor's degree, an equally-weighted proportion of both areas, that is analysis/algebra/geometry and applied mathematics/stochastics, is included. The component areas applied mathematics and stochastics are represented appropriately.
They are able to recognise mathematics-related problems, assess their solvability and solve them within a specified time frame.	This is achieved through exercises accompanying lectures and introductory seminars with the curricular contents specified above.
They have a basic ability to work in a scientific way. They are in particular able to formulate mathematical hypotheses and have an understanding of how such hypotheses can be verified or falsified using mathematical methods.	This competence is normally practised in mathematics seminars and demonstrated in the preparation of a Bachelor's thesis.

They can flexibly apply mathematical methods of fundamental component areas of mathematics and are able to transfer the findings obtained to other component areas or applications.	This implies a mathematical education that can only be achieved by means of a broadly structured degree programme. Transfer of findings occurs e.g. through linkage of analysis and linear algebra in differential calculus of functions of several variables. Applications are particularly dealt with in modelling, differential equations and applied mathematics.
They have abstraction ability and are able to recognise analogies and basic patterns.	This is trained in particular in algebra, but also in many other modules.
They are able to think in a conceptual, analytical and logical manner.	These competences are acquired in all of the specified curricular contents, since these are always associated with proofs and logical chains of arguments.
They have an extensive comprehension of the significance of mathematical modelling. They are able to create mathematical models for mathematical problems as well as for problems in other areas of science or everyday life, and have a selection of problem solving strategies at their disposal.	Mathematical modelling is taught e.g. in applied mathematics, in stochastics, in optimization or discrete mathematics. An understanding of differential equations is presumed.
They can use basic methods of computer-aided simulation, mathematical software and programming to solve mathematical problems.	Solving extensive problems by using higher level programming languages is an integral component of a mathematics degree.
They are able to solve more extensive mathematical problems.	This requires advanced study modules in the last stage of the degree programme. The preparation of the Bachelor's thesis not only tests but also trains this.

Social competences	**Possible curricular contents**
Graduates can classify, recognise, formulate and solve mathematics-related problems.	A subsidiary subject such as e.g. physics, informatics or economic science is obligatory.
They can use electronic media competently.	A programming course is obligatory; working with software systems is trained.

They can implement lifelong learning strategies. A prerequisite for this is that the students are persevering and that they have developed persistence.	Opportunities are created for students to familiarise themselves with subject areas independently. Suitable platforms include seminars and exercises, as well as independent preparation for examinations.
They can recognise, formulate, classify and solve problems in a mathematical context.	This is particularly trained in seminars and practical work.
They can communicate, possibly also in a foreign language, and contribute their work effectively in teams.	The relevant specialist language of mathematics is English. Capacity for teamwork can be trained in all components of the degree programme, provided appropriate teaching methods are used.

4.2 Master's Degree Programmes

Objectives	**Possible curricular contents**
Graduates can work out solutions to problems independently on the basis of studying current research literature.	This can be achieved by further advanced study and specialisation in a selected mathematical focus area.
They can carry out mathematics-related work in industry and commerce or in public institutions independently and responsibly.	This is achieved by participation in seminars and independent preparation of a Master's thesis.
They can commence doctoral studies.	This generally requires an above-average degree.
They are familiar with the main mathematical disciplines, their methodological approaches and their interrelations.	A Master's degree serves to deepen as well as broaden knowledge of pure and applied mathematics. In addition to modules in the focus area, equally-weighted advanced study modules in analysis/algebra/geometry and applied mathematics/stochastics are necessary.
They can work on and present mathematical problems on a sound scientific basis.	This is trained and demonstrated by preparation of a Master's thesis.

4.3 Specialised Degree Programmes

"Under revision"