HSBI

Hochschule
Bielefeld
University of
Applied Sciences
and Arts

Study Programme Examination Regulations (SPO) for the Master's Degree Programme "Research Master Data Science" at Hochschule Bielefeld – University of Applied Sciences and Arts

Faculty of Engineering and
Mathematics

Study Programme Examination Regulations (SPO) for the Master's Degree Programme "Research Master Data Science" at Hochschule Bielefeld – University of Applied Sciences and Arts of 6 September 2024

Pursuant to Section 22(1) no. 3, Section 2(4) and Section 64(1) of the Higher Education Act of the State of North Rhine-Westphalia (*Hochschulgesetz* – HG) of 16 September 2014 (GV. NRW. p. 547) as last amended by Article 2 of the Act of 5 December 2023 (GV. NRW p. 1278) in conjunction with the General Examination Regulations (MA-RPO) for Master's Degree Programmes at Hochschule Bielefeld University of Applied Sciences and Arts of 10 June 2016 (Announcement Bulletin of HSBI – Official Notices – 2016, No. 24, pp. 292–312) in the version of the amendment dated 5 October 2021 (Announcement Bulletin of HSBI – Official Notices – 2021, No. 72, pp. 816–824), the Faculty Council of the Faculty of Engineering and Mathematics at HSBI has issued the following Study Programme Examination Regulations (SPO):

Contents

I. General Aspects

Section 1 Scope of the Study Programme Examination Regulations

These Study Programme Examination Regulations (SPO) are valid for the Master's Degree Programme "Research Master Data Science" at Hochschule Bielefeld – University of Applied Sciences and Arts (HSBI). They specify the General Examination Regulations for Master's Degree Programmes at HSBI (*Rahmenprüfungsordnung für die Masterstudiengänge der Hochschule Bielefeld* – MA-RPO).

Section 2 Qualification Objective of the Programme

(1) In accordance with Section 58 HG, the studies leading to the master examination are intended to enable students to theoretically explore contents from engineering and mathematics according to the study programme and to analyse processes and problems of engineering and mathematical practice on this basis and to find solutions independently, also taking into account extracurricular references. The studies enhance students' existing qualifications by means of interdisciplinary teaching content. They are designed to develop the students' creative and planning skills and prepare them for the master examination.

(2) Graduates of the Research Master Data Science programme are able to independently carry out scientifically based, application-oriented research, transfer and development work in the field of data science. They are able to independently acquire methodological knowledge from the fields of data analysis, machine learning and artificial intelligence and apply it to new and unknown problems. In addition, they have the ability to expand their existing methodological knowledge, taking into account and observing generally accepted scientific research standards and methods. They are able to communicate the results of their research clearly and unambiguously to both specialists and non-specialists.

(3) The graduates are able to independently prepare a scientific publication. They can process and structure their own quantitative results and relate them to the current state of research. They can select conferences according to the thematic focus and the valence.

(4) Graduates possess analytical, creative and design skills, can think strategically and in a networked manner and recognise multidisciplinary relationships. In particular, they take into account legal, ethical and data protection aspects. They are conceptually and methodically able to successfully handle research, transfer and development tasks.

(5) Graduates are able to plan, organise and control projects (especially software development projects) in an agile research environment. They know methods of agile project management and can select, adapt and apply them to concrete projects and their contexts. They are able to work in a multidisciplinary team, especially in an agile project environment. They can develop and implement structured and team-oriented solutions for problems arising in the project context.

(6) Graduates are able to work out organised, structured and process-oriented problem solutions in interdisciplinary projects.

Section 3 Academic Degree

As a result of the passed master examination, HSBI awards the academic degree "Master of Science" (M.Sc.) in the Research Master Data Science programme.

Section 4 Admission Requirements

(1) The requirements for the admission to the Data Science master's degree programme are

a) Proof of a relevant degree (bachelor or comparable degree programme at a state or state-recognised university) with a minimum of 180 credit points.

b) The degree's overall grade according to (a) must be 2.5 or better.
c) Proof of English skills at B2 level.
d) Passed entrance examination according to Section 6.

(2) The master's degree programme build upon the following bachelor's degree programmes at HSBI
a) Business Information Systems
b) Engineering Computer Sciences
c) Computer Science
d) Digital Technologies
e) Digital Logistics
f) Electrical Engineering
g) Mechatronics
h) Mechatronics/Automation
i) Applied Mathematics
j) Biotechnology and Instrumentation Engineering

Other degrees whose contents (modules) correspond to the contents (modules) of the degree programmes referred to in (2) to an extent of at least 80% are also recognised as relevant to the subject. In cases of doubt, the Examination Committee decides on the degree's relevance to the subject.

(3) If an applicant has not yet received a final grade, but has successfully passed all module examinations except for the bachelor thesis and/or the colloquium, a preliminary final grade is determined based on prior achievements. Provisional enrolment is possible if the other admission requirements are also met. If proof of the successful bachelor thesis and/or colloquium is not provided within four months of enrolment, the enrolment expires with effect for the future.

Section 5 Application Procedure

(1) At the beginning of the application period, the Selection Committee will announce the pool of research projects on HSBI's website.

(2) Following the online application, the documents below must be submitted, among others
a) An English-language letter of at least one page indicating the applicant's motivation and suitability for this master's degree programme and the particular suitability for one of the research projects in the project pool.
b) A list of three prioritised research projects from the project pool.
c) The degree certificate of the university degree that qualifies for the master's degree programme and the corresponding documents (transcript of records, diploma supplement, etc.), which provide information about the individual programme structure, the courses and modules attended, the achievements made in this degree programme and their grades as well as the individual profile of the completed degree programme. If the university at which the applicant has obtained the university degree qualifying for the master's degree programme cannot issue a corresponding document, proof of the achievements made as part of the programme must be submitted instead.

(3) When submitting the application documents, applicants bindingly register for the entrance examination.

Section 6 Entrance Examination

(1) Applicants who meet the other admission requirements will be admitted to the entrance examination.

(2) The admitted applicants will be invited to a written entrance examination. The date will be announced at least two weeks in advance by written or electronic invitation. The examination lasts 120 minutes. It serves to determine the applicant's particular suitability for engineering questions and in systematic problem-solving.

(3) The entrance examination is conducted in anonymous form. The assessment criteria are

a) Ability to master a topic in a professional/scientific manner,
b) Methodical approach in developing solutions; systematic way of assessing one's own solutions,
c) Originality of the solution ideas,
d) Ability to structure and present a scientific topic; common thread; focusing on essential information,
e) Verbal skills.

(4) The Selection Committee designates two members of the Selection Committee as examiners. The examination tasks are created by the two examiners.

(5) Suitability is determined when both examiners agree that the applicant is "suitable;" otherwise, the applicant is deemed "unsuitable."

Section 7 Selection Procedure

(1) If the number of suitable applicants exceeds the number of study places available in a research project (project places), places are awarded based on a ranking drawn up by the Selection Committee. In the event of a tie, lots will be drawn.

(2) The ranking is based on a total score as follows

a) For the final grade of the relevant degree according to Section 4(1)(a), 70 (grade 4.0) to 100 points (grade 1.0) are awarded.

(3) Applicants who could not be allocated a project place they had prioritised will be offered free project places according to their place in the ranking as specified in (1).

(4) Applicants who cannot be admitted after the selection procedure has been completed will receive a rejection letter.

Section 8 Examination Committee

(1) Pursuant to Section 9(3) RPO-MA, the Examination Committee is composed as follows:

a) Four members from among the professors, thereof one chair member and one deputy chair member,
b) A member of the teaching and research staff with a university degree,
c) Two students.

(2) It provides suggestions for the reform of this SPO and the corresponding programme structures.

(3) The Examination Committee determines the criteria for a research project.

(4) The Selection Committee will be set up by the Examination Committee. It consists of the Examination Committee's professorial members.

Section 9 Start of Studies, Standard Time to Degree, Programme Structure

(1) The programme starts in the winter and the summer semester and is mainly taught in English.

(2) Courses are usually offered annually, so adherence to the programme structure is strongly recommended.

(3) In order to make the start of studies easier for students, introductory courses should take place at the beginning of the first semester.

(4) The master examination consists of the examinations accompanying studies, the master thesis and the colloquium.

(5) The study programme's standard time to degree is four semesters. The credit points students must achieve during their studies, including the master thesis and colloquium, amount to 120 credits. Each semester and the modules assigned to it generally account for 30 credits (see programme structure in Appendix A). The average workload for one credit point is 30 hours.

(6) The research project will be carried out in the modules Project Phase I–III and Scientific Exchange. The project phases include the Project Colloquium and Research Seminar.

(7) After enrolment, the students and the project supervisors will draw up a Learning Agreement which defines the objectives of the modules Project Phase I–III and Scientific Exchange and the elective modules to be taken. The Learning Agreement will be bindingly confirmed by the chair of the Examination Committee. Upon request, deviations from the Learning Agreement are possible in justified exceptional cases. Approval of the chair of the Examination Committee is required.

(8) According to Section 6(4) RPO-MA, the study programme consists of compulsory, compulsory elective and elective modules. The compulsory modules specified in the programme structure must be completed. Four of the six modules offered must be selected from the compulsory elective modules. The elective modules to be taken are defined in the Learning Agreement in accordance with (7). Students can individualise their competency profiles by choosing appropriate modules. The scope of modules to be taken derives from the programme structure. Additional modules are modules that can be taken outside the programme structure. However, they are not part of the programme structure, will not be considered for the overall grade and are not included in the result of the master examination. Additional modules will be stated in the degree documents. Each module concludes with a module examination. Compulsory, compulsory elective and elective modules with the corresponding course type of the individual study phases as well as the credit points assigned to each module are stated in the programme structure (see Appendix A).

Section 10 Modules

(1) The number of modules and their chronological sequence can be found in the programme structure in Appendix A.

(2) The module contents, the qualification goals, the teaching forms, the participation requirements, the workload and the forms of assessment for the individual modules are specified in the module catalogue (Appendix B).

Section 11 Project Pool

(1) Pursuant to Section 17, professors of HSBI can submit a request to the Selection Committee for research projects to be included in the project pool at any time. The Selection Committee will decide upon the request in accordance with the requirements determined by the Examination Committee.

(2) Research projects that meet the requirements of Section 17 can be included in the project pool. A project profile must be drawn up for this purpose.

Section 12 Assessments, Module Examinations, Partial Examinations, Certificates of Successful Participation

The information on the forms of assessment, partial examinations and certificates of successful participation (preliminary examinations) for the individual modules can be found in the respective module description (Appendix B).

Section 13 Repetition of Examinations

(1) The repeat examination takes place in the following semester.

(2) Project work, the master thesis and the colloquium can each be repeated once.

(3) A failed examination in a module from the compulsory elective or elective catalogue may be compensated and replaced once by passing the examination in another module from the compulsory elective or elective catalogue.

(4) No compensation examination is possible for failed compulsory modules.

II. Further Examination Forms in Accordance with Section 14(4) RPO-MA

Section 14 Term Papers

The regulations in accordance with Section 20 RPO-MA shall apply. Term papers should not exceed 15 pages of text as a rule. Depending on the requirements of the lecturer, term papers can be supplemented by an expert presentation of 15 to 45 minutes. The term paper must be submitted to the lecturer within a deadline to be determined by the lecturer.

Section 15 Project Work

(1) Each project is a comprehensive task (if possible, an interdisciplinary task) that is planned and selected by the lecturer in collaboration with the students. The project is implemented as an individual performance or in groups as independently as possible, with advice from teaching staff. These projects deal with specific problems holistically under practical conditions.

(2) The individual students' examination performances are evaluated by the responsible lecturer after the end of the respective semester.

(3) The examination for the project work is taken at the end of the semester in the form of an oral presentation as an individual or group examination. In the case of group projects, all students involved in the respective project must each present their individual contributions and results. The oral presentation takes place in the presence of the lecturer who supervised the project work.

(4) The written paper must be submitted to the examiner at least one week before the oral presentation.

(5) All interested students will be admitted to the presentation as listeners if the room allows it. Admission does not extend to the consultation and announcement of the examination result.

Section 16 Performance Examinations

(1) In cases that are appropriate to the subject, a module examination can be taken in the form of a performance examination.

(2) A performance examination consists of a theoretical and a practical part. The overall grade is derived as an arithmetic mean from the grades of the individual performances according to a previously determined weighting system. The examination usually lasts no more than two hours.

(3) The performance examination is usually developed by only one examiner and taken in the presence of one or more expert assessors or several examiners.

Section 17 Course Assessment/Certificate of Successful Participation ("Testat")

(1) A study achievement consists either of the participation in specific courses of the module, proven by a participation certificate or of an individually identifiable performance (course assessment/"Testat"), which is made alongside a course and whose subject and requirements relates to the content of the respective course. Regular lecture attendance, active participation in seminars, active participation in exercises, presentations, drafts or internship reports, etc. can be considered course assessments. The form is individually determined by the lecturer responsible for the course and announced at the beginning of the course.

(2) Course assessments are only rated as "passed" or "failed." Failed course assessments can be repeated an unlimited number of times.

(3) The lecturer is responsible for the decision whether a certificate of successful participation is awarded or not. The results must be communicated to the students and the examination office.

(4) The certificate may be a prerequisite for participation in the examinations (preliminary examination).

III. Special Study Elements

Section 18 Research Project

(1) The results of the research project must be published.

(2) The duration of the research project is four semesters.

(3) The topic of the research project is determined and supervised by one of HSBI's professors.

(4) The project proposal for the research project includes

1. Title of the research project
2. Number of students who can work on the project (minimum and maximum)
3. A brief written presentation (abstract, brief description)
4. Type (funded research project, business project, study project) and scope
5. Project responsibility (supervising HSBI professor)
6. Project context (external consortium, internal project organisation)
7. Description of student's task
8. Relevance to data science,
9. Required resources and ensuring availability (data, project partners, hardware/software),
10. Rough project plan of the four semesters,
11. Criteria that can be used to check the suitability of the applicant
12. List of competencies acquired when processing the project

(5) The supervisor offers a consultation hour at least every 14 days.

Section 19 Research Seminar

(1) Students can be grouped into seminar groups. These will meet under the guidance of one or more lecturers to exchange views on subject-specific issues. The seminar serves to exchange technical and methodological knowledge, which is researched, prepared and presented by the students.

(2) The research seminar is part of the Project Phase I–III modules.

Section 20 Project Colloquium

(1) Students regularly present their interim results, discussing existing difficulties and identifying possible solutions. The project colloquium is also intended to address problems and questions that have arisen from the students' individual experiences during the research project.

(2) The project colloquium is part of the Project Phase I–III modules.

Section 21 Master Thesis

(1) The master thesis must demonstrate that the examinee is able to complete a practice-oriented task from the subject area within a specified period of time, both in its subject-specific details and in the interdisciplinary contexts, working independently and according to scientific methods. The master thesis is a written or design work. The master thesis is a scientific work and its topic and contents build upon the Project Phase I–III modules. It contains a description and explanation of the problem and its solution. It can also be carried out through an empirical investigation or through conceptual or design tasks or through an evaluation of existing sources. A combination of these is possible. The master thesis should not exceed 70 pages of text in length. The time for completion (period from setting the topic to submission of the master thesis) is five months at most.

(2) Students are admitted to the master thesis if they have acquired at least 79 credits in their current studies, if they have fulfilled all the criteria listed in Section 4(5) and if they have successfully completed the Project Phase I–III modules.

(3) The request for admission may be withdrawn in writing until the decision on accepting the request has been made without counting towards the number of possible examination attempts.

(4) 24 credits will be awarded for a master thesis that is graded as at least "sufficient."

Section 22 Colloquium

(1) The colloquium complements the master thesis and is to be assessed independently. It serves to determine whether the candidate is capable of orally presenting and independently justifying the results of the master thesis, its subject-related foundations, its interdisciplinary connections and its extracurricular references, and of assessing its relevance for research and/or practice. Moreover, it also provides an opportunity to discuss how the topic of the master thesis was processed.

(2) At the beginning of the colloquium, the master thesis will be presented orally.

(3) Students will only be admitted to the colloquium

a) If the requirements for admission to the master thesis as specified in Section 20(2) have been proven,

b) All examinations accompanying the studies have been passed (90 credits without master thesis and colloquium),

c) The master thesis has been graded as at least "sufficient" (4.0).

(4) The request for admission must be addressed to the Examination Committee. The application must include proof of the admission requirements referred to in (3), provided that they are not already available to the examination committee, and by a statement of previous attempts for taking the relevant examination and of whether listeners will be allowed to sit in on the examination. Admission to the colloquium can also be applied for when registering the master thesis; in this case, admission to the colloquium takes place as soon as all the necessary documents are available to the examination committee. Otherwise, Section 20(4) shall apply to the admission to the colloquium and its refusal.

(5) The colloquium is usually conducted as an oral examination within eight weeks of the submission of the master thesis. If the examinee is prevented, a reasoned written request must be submitted immediately to the chair of the Examination Committee who will decide on an extension of the deadline.

(6) The examiners of the master thesis will conduct and assess the colloquium together. In the case of Section 29(2) RPO-MA, the colloquium is conducted by the examiners whose individual assessments formed the grade of the master thesis.

(7) The colloquium, including the presentation, will last no less than 45 minutes and no more than 75 minutes. For the conduct of the colloquium, the regulations applicable to oral examinations shall apply mutatis mutandis.

(8) Deviating from the regulations for oral examinations, the colloquium is in principle an event that is open to all university members.

(9) If there are reasons for confidential treatment of the presentation of the master thesis's results in the colloquium, the Examination Committee will decide on the exclusion of the public at the request of one of the supervisors of the master thesis or of the student.

(10) Persons who are connected to the content of the master thesis (e.g. as external co-supervisors) may be admitted to the colloquium by the chair of the Examination Committee on request, provided that (9) does not contradict this.

(11) Six credits will be awarded for a colloquium that is graded as at least "sufficient."

IV. Degree

Section 23 Result of the Master Examination

(1) In the four-semester structure, the master examination is considered passed when 120 credit points have been reached.

(2) The master examination is considered failed if the overall grade is not at least "sufficient" (4.0) or if the master thesis is not considered passed in the second attempt or is considered failed.

Section 24 Overall Grade

In order to determine the overall grade for the master's degree, the grades for each graded examination are multiplied by the respective credit points reported. The sum of the weighted grades is then divided by the total number of credit points included.

V. Final Provisions

Section 25 Inspection of the Examination Files

(1) An official inspection date for the inspection of the examination files relating to a module examination is set and published by the Examination Office after the respective examination has been completed. If the examination files cannot be inspected on the set date, a request for inspection can be made to the Examination Office within one month after the official inspection date.

(2) Inspection of the examination files pursuant to the MA-RPO must be requested within one year from issuance of the examination certificate or the notice of the failed master examination. Section 32 of the Administrative Procedure Act for the State of North Rhine-Westphalia (*Verwaltungsverfahrensgesetz*) on the application for restitutio in integrum applies. The request must be made to the Examination Office.

Section 26 Entry into Force, Publication

These Examination Regulations shall be announced in the Announcement Bulletin of HSBI – Official Notices ("Verkündungsblatt der Hochschule Bielefeld – Amtliche Bekanntmachungen"). They shall enter into force one day after their publication.

Issued on the basis of the decision of the Faculty Council of the Faculty of Engineering and Mathematics at HSBI of 13 March 2024.
Bielefeld, 6 September 2024

The President of HSBI

Prof. Dr. Ingeborg Schramm-Wölk

Appendix A

Course Schedule for the Study Programme Research Master Data Science

First semester			L	SL	E	P/S	SSS	CP
Module number	Module title	Module ID						
4072	Compulsory Elective Subject	DS				0		6
2052	Introduction to Applied Science	EAF	0	2	2	0	0	6
2055	Project Phase I	PP1	0	0	0	2	0	12
9029	Project-Specific Elective Module	PSWM				0		5
2059	Scientific Exchange	WA	0	0	0	0	0	1
							Total CP:	30
Second semester			L	SL	E	P/S	SSS	CP
Module number	Module title	Module ID						
2048	Agile Research Project Management	AFPM	2	0	2	0	0	6
4072	Compulsory Elective Subject	DS				0		6
4072	Compulsory Elective Subject	DS				0		6
2056	Project Phase II	PP2	0	0	0	2	0	7
9029	Project-Specific Elective Module	PSWM				0		5
							Total CP:	30
Third semester			L	SL	E	P/S	SSS	CP
Module number	Module title	Module ID						
4072	Compulsory Elective Subject	DS				0		6
2057	Project Phase III	PP3	0	0	0	2	0	12
9029	Project-Specific Elective Module	PSWM				0		5
2059	Scientific Exchange	WA	0	0	0	0	0	1
2053	Social Implications of Data Science	GIDS	2	0	0	2	0	6
							Total CP:	30
Fourth semester			L	SL	E	P/S	SSS	CP
Module number	Module title	Module ID						
12	Colloquium	MKFM				0		6
11	Master Thesis	MAFM				0		24
							Total CP:	30

Abbreviations of the teaching forms: L = lecture, SL = seminar lessons, E = exercise,
S = seminar, P = practical, SSS = supervised self-study (specified in weekly hours per semester);
CP= credit points
W/S= winter/summer semester
The practical project can optionally be replaced by a semester abroad

Elective Modules Data Science									
Module number	Module title	Module ID	W/S	L	ST	E	P/S	SSS	CP
2060	Advanced Machine Learning	AML	w	2		1	1		6
2054	Artificial Intelligence	AI	s	2	0	1	1	0	6
2063	Artificial Intelligence for Robotics	AIR	s	2		1	1		6
2049	Big Data Architectures	BDA	s	2	0	1	1	0	6
2050	Data Mining & Machine Learning	DMML	w	2	0	1	1	0	6
2051	Introduction to Data Science	IDS	w	2	0	1	1	0	6

Appendix B

Module Catalogue for the Study Programme Research Master Data Science

Module list

Agile Research Project Management									AFPM
Identification number:		Workload:		Credits:		Study semester:		Frequency of the offer	Duration:
2048		180 h		6		2nd semester or 3rd semester		Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	2	weekly hours	30	h	60	h
	Practical or seminar	15 students	0	weekly hours	0	h	0	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students are able to plan, organize and manage projects (especially software development projects) in an agile research environment
- Students are familiar with agile project management methods and can select, adapt and apply these for specific projects and their contexts
- Students can apply procedures and tools for configuration management and software testing in the context of operational software development
- Students have understood the special features of research projects. In an accompanying group exercise, they have applied the methods they have learned and gained experience with non-hierarchical teamwork and conflict resolution.

3 Contents:

- Introduction to project management
  - Resources, time and content
  - Project acquisition
  - Project planning
  - Effort estimation
  - Gantcharts
  - Project organization
  - Project management
  - Project completion
  - Project review
- Project management
- Team composition
- Conflict management
- Stakeholder management
- Special features of agile project management
- Differentiation from traditional project management
- The Agile Manifesto
- SCRUM, Extreme Programming, Rapid Prototyping
  - Software project management
- Configuration management
- Testing and test procedures
- Special features of innovation, development and research projects
- Accompanying exercise:
  - Planning and implementation of a mini software project in Python in group work

4 Forms of teaching:

Lecture, exercise

5 Participation requirements:

Formal:	
Content:	

6	Forms of assessment: Term paper or oral examination
7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes): Research Master Data Science
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: - N. N.
11	Other information: Literature will be announced at the beginning of the course.
12	Language: English

Advanced Machine Learning									AML
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2060	180 h	6	1st semester, 2nd semester or 3rd semester			Annual (Winter)			1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students		weekly hours		h		h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students		weekly hours		h		h

2 Learning outcomes/competences:

- Students have acquired the competence to transfer practical problems to the areas of recurrent neural networks, generative methods and graph machine learning and to solve them using the corresponding algorithms
- Students have understood the mathematical principles of the methods and algorithms and can adapt them independently.
- They know the advantages and disadvantages of various methods from the fields of recurrent neural networks, generative methods and graph machine learning and can implement them with the help of software libraries and apply them to practical problems.
- They can analyze time series, texts and images using recurrent neural networks and generate them using generative methods.
- They can transfer practical problems into graphs and analyze them using GML,
- They have practiced the scientific way of working (recognizing, formulating and solving problems), trained their ability to abstract and their communication skills through free speech in the group.

3 Contents:

- Recurrent Neural Networks
  - Long short-term memory
  - Gated recurrent unit
  - Differentiable neural computer
- Generative Methods
  - Generative Adversarial Networks
  - Variational Autoencoder
  - Diffusion Models
  - Generative pre-trained transformer
- Graph Machine Learning
  - Introduction to GML
  - Graph Neural Networks

4 Forms of teaching:

Lecture, exercise, practical course

5 Participation requirements:

Formal:	
Content:	

6 Forms of assessment:

Term paper, written examination or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8	Application of the module (in the following study programmes):
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede
11	Other information:
12	Language: English

Artificial Intelligence									**AI**
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2054	180 h	6	1st semester, 2nd semester or 3rd semester			Annual (Summer)			1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students have acquired the competence to transfer practical problems to the conceptual world of artificial intelligence and to solve them with the help of intelligent agents and the corresponding algorithms
- Students have understood the mathematical foundations of the methods and algorithms and can adapt them independently.
- They know the advantages and disadvantages of different agent types and can derive environmental properties of practical problems, as well as select and implement the appropriate agent.
- They can develop software agents for complex stochastic, non-fully observable (multi-agent) environments with Python
- You will be able to apply reinforcement learning to real-world problems and understand its basic concepts. Methods of deep reinforcement learning in the field of policy learning can be selected, implemented and trained for specific problems.
- They have practiced the scientific way of working (recognizing, formulating and solving problems), trained their ability to abstract and their communication skills through free speech in the group.

3 Contents:

- Intelligent agents
  - Types of agents
  - Properties of environments
- Problem-solving agents
  - Uninformed and informed search
  - Search methods (e.g. A* search)
  - Full and partial observability
  - Searches based on real states and belief states
  - Adversarial search
  - Multi-agent environments and game trees
- Logical agents
  - Knowledge representation for agents
  - Statement logic and first order logic
  - Inference and planning
  - Inference algorithms
  - Planning graphs
  - Prolog
- Probabilistic agents
  - Uncertain knowledge and probabilistic reasoning
  - Bayesian networks
  - Sampling
  - Kalman filters

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Markov decision problems
Bellmann equation
Value and tactic iteration
Partially observable Markov decision problems

Learning agents

Statistical learning (Bayesian learning, MAP and maximum likelihood estimators, EM algorithm)
Reinforcement learning (reward functions, exploration vs. exploitation, temporal difference learning, Q-learning, REINFORCE, PPO, Soft Actor Critic)

Practical exercises with Python especially PyTorch

</td></tr>
<tr><td>4</td><td>Forms of teaching:
Lecture, exercise, practical course</td></tr>
<tr><td rowspan="3">5</td><td colspan="2">Participation requirements:</td></tr>
<tr><td>Formal:</td><td></td></tr>
<tr><td>Content:</td><td>Programming with Python, basics of statistics</td></tr>
<tr><td>6</td><td>Forms of assessment:
Written examination, performance examination or oral examination</td></tr>
<tr><td>7</td><td>Prerequisite for the award of credit points:
Module examination pass</td></tr>
<tr><td>8</td><td>Application of the module (in the following study programmes):
Research Master Data Science</td></tr>
<tr><td>9</td><td>Importance of the grade for the final grade:
according to MRPO</td></tr>
<tr><td>10</td><td>Module coordinator:
Prof. Dr.-Ing. Christian Schwede</td></tr>
<tr><td>11</td><td>Other information:

Russel and Norvig (2020) – Artificial Intelligence: A modern Approach Fourth Edition
</td></tr>
<tr><td>12</td><td>Language:
English</td></tr>
</table>

Artificial Intelligence for Robotics					**AIR**
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
2063	180 h	6	1st semester, 2nd semester or 3rd semester	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students		weekly hours		h		h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students		weekly hours		h		h

2 Learning outcomes/competences:

- Students have acquired the competence to solve practical problems in robotics using artificial intelligence methods.
- Students have understood the mathematical foundations of the methods and algorithms and can adapt them independently.
- They know the challenges of applications of autonomous mobile robots and can transfer the various sub-problems to specific application domains.
- They can implement localization, mapping, path calculation and motion planning for mobile robots.
- Students have internalized the main challenges of multi-agent systems and can transfer them to practical problems
- They can also model planning problems in multi-agent systems and implement them for specific problems.
- They can apply methods of (multi-agent) reinforcement learning to problems in robotics and use them to create control systems for mobile robots.
- They have practiced the scientific way of working (recognizing, formulating and solving problems), trained their ability to abstract and their communication skills through free speech in the group.

3 Contents:

- Introduction to mobile Robots
- Localization
- Mapping
- SLAM
- Planning (PDDL)
- Path Planning and Motion Planning
- Reinforcement Learning for Robotics
- Multi-Agent Systems
- Multi-Agent Planning (MAP)
- Multi-Agent Reinforcement Learning
- Exercise with ROS and Gazebo

4 Forms of teaching:

Lecture, exercise, practical course

5 Participation requirements:

Formal:	
Content:	

6 Forms of assessment:

Term paper, written examination or oral examination

7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes):
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede
11	Other information:
12	Language: English

Big Data Architectures						BDA
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer		Duration:
2049	180 h	6	1st semester, 2nd semester or 3rd semester	Annual (Summer)		1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students know the differences between centralized and distributed systems and can select the right system for the respective application.
- They are familiar with the implementation of information systems and analysis methods for large, complex and volatile data sets and can apply the established concepts for data mining in parallel and distributed systems.
- They are familiar with the Apache Hadoop/Spark ecosystem for managing, processing and distributing data in data science applications, know its essential components and can select and apply the components required in a project in a targeted manner. This includes both batch and streaming processing.
- They know the principles of NoSQL databases and their characteristics as document-oriented databases, key-value databases, graph databases and column-oriented databases.
- They distinguish between the different types of NoSQL databases based on their area of application and assess when which type of NoSQL database should be used and apply them in practice.
- Students are informed about the information technology requirements that are important for handling large data science projects in the cloud.
- By applying and evaluating the technologies, they have increased their practical IT skills and trained their teamwork skills through group work.

3 Contents:

- Introduction to Big Data Computing
- NoSQL databases
  - CAP theorem
  - ACID vs. BASE
  - Key-value database (e.g. Redis)
  - Document-oriented database (e.g. MongoDB)
  - Wide-Column Store (e.g. Cassandra)
  - Graph database (e.g. Neo4J)
- Big data architectures
  - Batch processing vs. stream processing
  - Lambda and Kappa architecture
- The Apache Big Data Ecosystem
  - Batch data processing using the example of Hadoop
  - Online data processing using the example of Spark
- Cloud-based big data systems

	○ Serverless computing ○ Cloud vs. edge computing	
4	Forms of teaching: Lecture, exercise, practical course	
5	Participation requirements:	
	Formal:	
	Content:	
6	Forms of assessment: Performance examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass	
8	Application of the module (in the following study programmes): Research Master Data Science	
9	Importance of the grade for the final grade: according to MRPO	
10	Module coordinator: Prof. Dr. rer. nat. Alexander Maier	
11	Other information: Literature will be announced at the beginning of the course.	
12	Language: English	

Colloquium									MKFM
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
12	180 h	6	4th semester			each semester			1 semester
1	Course:	Planned group sizes	Scope			Actual contact time / classroom teaching		Self-study	
	Lecture	60 students		weekly hours		h		h	
	Seminar lessons	30 students		weekly hours		h		h	
	Exercise	20 students		weekly hours		h		h	
	Practical or seminar	15 students	0	weekly hours	0	h	0	h	
	Supervised self-study	60 students		weekly hours		h	180	h	
2	Learning outcomes/competences: • The colloquium supplements the Master's thesis and must be assessed independently. It serves to determine whether the candidate is able to orally present and independently justify the results of the Master's thesis, its subject-specific foundations, its interdisciplinary connections and its non-subject-specific references and to assess its significance for practice. • Attendance at each colloquium of the Research Master is open to all other Research Master students.								
3	Contents: • Content of the thesis according to the topic • Disputation on the procedure for writing the thesis and the issues that arose in the context of the thesis								
4	Forms of teaching: Oral examination for Master thesis								
5	Participation requirements:								
	Formal:	Module: 2057 Project Phase III;							
	Content:								
6	Forms of assessment: Oral examination								
7	Prerequisite for the award of credit points: Module examination pass								
8	Application of the module (in the following study programmes): Research Master Data Science								
9	Importance of the grade for the final grade: according to MRPO								
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede								
11	Other information:								
12	Language: English								

Compulsory Elective Subject					DS
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
4072	180 h	6	1st semester, 2nd semester or 3rd semester	each semester	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students		weekly hours		h		h
	Seminar lessons	30 students		weekly hours		h		h
	Exercise	20 students		weekly hours		h		h
	Practical or seminar	15 students	0	weekly hours	0	h	0	h
	Supervised self-study	60 students		weekly hours		h		h

2	Learning outcomes/competences:	
	The learning outcomes and competencies of the selected module are achieved.	
3	Contents:	
	The contents of the selected module are taught.	
4	Forms of teaching:	
5	Participation requirements:	
	Formal:	
	Content:	
6	Forms of assessment:	
7	Prerequisite for the award of credit points:	
8	Application of the module (in the following study programmes):	
	Forschungsmaster Data Science and Research Master Data Science	
9	Importance of the grade for the final grade:	
10	Module coordinator:	
	Prof. Dr.-Ing. Christian Schwede	
11	Other information:	
12	Language:	
	English	

Data Mining & Machine Learning									DMML
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2050	180 h	6	1st semester, 2nd semester or 3rd semester			Annual (Winter)			1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students gain a sound insight into the techniques, possibilities and applicability of data mining and machine learning. After successful participation, they will be able to identify potential fields of application of data mining methods and machine learning methods in the company, select suitable procedures and apply them.
- Students know all the steps of the data mining process to generate knowledge from data using algorithms and can apply the individual steps in practical exercises on larger data sets
- Students are familiar with the different types of machine learning and can apply supervised and unsupervised learning methods to practical problems in particular
- They understand the theoretical background of the methods learned and are able to configure them for the respective application context and adapt them if necessary.
- By applying and evaluating the technologies, students have increased their practical IT competence and trained their teamwork skills through group work.

3 Contents:

- Introduction to data mining
- Overview of the data mining process
- Pre-processing
  - Data acquisition/generation
  - Data selection
  - Errors in data
  - Standardization
  - Cleaning/ filtering
  - Outlier detection
  - Feature selection
  - Dimension reduction (PCA, autoencoder)
- Basics of machine learning
- Introduction to supervised learning
  - Regression and classification
  - Error and loss functions
  - Approach and evaluation
- Methods of supervised learning
  - k-Nearest Neighbors
  - Naiver Bayes classifier
  - Decision trees
  - Random Forest
  - Support Vector Machines
- Artificial Neural Networks
  - Perceptron and Hebbian learning rule
  - Multi-layer perceptron and backpropagation

<table>
<tr><td></td><td>

Deep Neural Networks
Learning algorithms
Overfitting and countermeasures
Convolutional Neural Networks

Explainable AI

Layer-wise relevance propagation
Local interpretable model-agnostic explanations (LIME)
Generalized Additive Model

Unsupervised learning

Cluster analysis
Partitioning methods
Hierarchical methods
Density-based methods

Application and implementation of selected methods

Python, in particular TensorFlow

</td></tr>
<tr><td>4</td><td>Forms of teaching:
Lecture, exercise, practical course</td></tr>
<tr><td rowspan="3">5</td><td colspan="2">Participation requirements:</td></tr>
<tr><td>Formal:</td><td></td></tr>
<tr><td>Content:</td><td>Programming with Python, basics of statistics</td></tr>
<tr><td>6</td><td>Forms of assessment:
Written examination or oral examination</td></tr>
<tr><td>7</td><td>Prerequisite for the award of credit points:
Module examination pass</td></tr>
<tr><td>8</td><td>Application of the module (in the following study programmes):
Research Master Data Science</td></tr>
<tr><td>9</td><td>Importance of the grade for the final grade:
according to MRPO</td></tr>
<tr><td>10</td><td>Module coordinator:
Prof. Dr.-Ing. Christian Schwede</td></tr>
<tr><td>11</td><td>Other information:

Svensén, M. and Bishop, C.M. (2009): Pattern Recognition and Machine Learning. Springer
Goodfellow, Ian; Bengio, Yoshua; Courville, Aaron (2016): Deep learning. Cambridge, Massachusetts, London, England: MIT Press.

</td></tr>
<tr><td>12</td><td>Language:
English</td></tr>
</table>

Introduction to Applied Science									EAF
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2052	180 h	6	1st semester			each semester			1 semester
1	Course:	Planned group sizes	Scope			Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	weekly hours		0	h	0	h
	Seminar lessons	30 students	2	weekly hours		30	h	60	h
	Exercise	20 students	2	weekly hours		30	h	60	h
	Practical or seminar	15 students	0	weekly hours		0	h	0	h
	Supervised self-study	60 students	0	weekly hours		0	h	0	h
2	Learning outcomes/competences: • Students have a deep understanding of applied scientific working methods. This includes the selection of a research method, the formulation of research questions, literature research, the writing of scientific texts and the presentation of validated results. • You have internalized the basic rules of scientific writing and have the knowledge to apply them to a specific research question • They understand how the scientific community is structured and functions and can therefore classify organizations, events and activities. They know possible career paths and are able to define milestones for their individual path • They know how and where research funding can be acquired in order to finance their own research projects • They know ways to exploit research results • Students have fundamentally dealt with the search for truth and can critically scrutinize their own findings								
3	Contents: • Introduction to epistemology and philosophy of science • Research methods and research design • Deriving research questions • Validation • Scientific writing and presentation • Research • Publication process • Introduction to the scientific community • Acquiring research funding • Utilization of research results • Practice ○ Research, presentation and discussion of scientific texts								
4	Forms of teaching: Seminar lessons, exercise								
5	Participation requirements:								
	Formal:								
	Content:								
6	Forms of assessment: Written examination or oral examination								
7	Prerequisite for the award of credit points: Module examination pass								
8	Application of the module (in the following study programmes): Research Master Data Science								
9	Importance of the grade for the final grade: according to MRPO								

10	Module coordinator: - N. N. Prof. Dr. rer. oec. Thomas Süße
11	Other information: • Gabbay, D. M., Thagard, P., Woods, J., & Meijers, A. W. (2009). Philosophy of technology and engineering sciences. Elsevier.
12	Language: English

Introduction to Data Science									IDS
Identification number:		Workload:		Credits:		Study semester:		Frequency of the offer	Duration:
2051		180 h		6		1st semester or 2nd semester		Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	1	weekly hours	15	h	30	h
	Practical or seminar	15 students	1	weekly hours	15	h	30	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students have gained an overview of the scientific field of data science and are familiar with a framework for categorizing problems, algorithms, processes and procedures.
- They understand the importance of data for today's living and working environment, know job profiles and tasks of a data scientist
- Students understand the essential concepts of object-oriented and numerical programming in Python and can implement programs independently on this basis. They know important standard Python libraries and can operate JupyterNotebook and Pycharm.
- Students understand the most important terms and can apply the basic methods of descriptive, explorative and inductive statistics, which they need as a basis for the other courses in the Master's program. They use Python for statistical data analysis, master the most important functions and know the most important libraries.

3 Contents:

- Introduction to data science
  - Historical classification
  - Overview of areas of data science
  - Career paths as a data scientist
- Introduction to Python
  - Fundamental concepts and data structures
  - Object-oriented programming with Python
  - Advanced Python
  - JupyterNotebook and Pycharm
  - Introduction and application of standard libraries (e.g. NumPy, Pandas, Matplotlib)
- Statistical analysis with Python
  - Descriptive statistics
  - Exploratory statistics
  - Inductive statistics

4 Forms of teaching:

Lecture, exercise, practical course

5 Participation requirements:

Formal:	
Content:	

6 Forms of assessment:

Written examination, performance examination or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes):

Research Master Data Science

9 Importance of the grade for the final grade:

according to MRPO

10	Module coordinator: Prof. Dr.-Ing. Christian Schwede
11	Other information:
12	Language: English

Master Thesis									**MAFM**
Identification number:		Workload:		Credits:		Study semester:		Frequency of the offer	Duration:
11		720 h		24		4th semester		each semester	1 semester
1	Course:		Planned group sizes		Scope		Actual contact time / classroom teaching		Self-study	
	Lecture		60 students			weekly hours		h		h
	Seminar lessons		30 students			weekly hours		h		h
	Exercise		20 students			weekly hours		h		h
	Practical or seminar		15 students		0	weekly hours	0	h	0	h
	Supervised self-study		60 students			weekly hours		h	720	h
2	Learning outcomes/competences: • The Master thesis is intended to show that the candidate is capable of independently working on a practice-oriented task from his or her subject area, both in its technical details and in its interdisciplinary contexts, using scientific methods within a specified period of time.*The Master thesis continues the work in the project phases and leads to a degree									
3	Contents: • The Master thesis is an independent scientific work in the field of data science with a description and explanation of its solution. It builds on the project phase and brings it to an end.									
4	Forms of teaching: Written elaboration with supervision									
5	Participation requirements:									
	Formal:	Module: 2057 Project Phase III;								
	Content:									
6	Forms of assessment: Project work									
7	Prerequisite for the award of credit points: Module examination pass									
8	Application of the module (in the following study programmes): Research Master Data Science									
9	Importance of the grade for the final grade: according to MRPO									
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede									
11	Other information:									
12	Language: English									

Project Phase I									**PP1**
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2055	360 h	12	1st semester			each semester			1 semester
1	Course:	Planned group sizes	Scope			Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	weekly hours		0	h	0	h
	Seminar lessons	30 students	0	weekly hours		0	h	0	h
	Exercise	20 students	0	weekly hours		0	h	0	h
	Practical or seminar	15 students	2	weekly hours		30	h	180	h
	Supervised self-study	60 students	0	weekly hours		0	h	0	h
2	Learning outcomes/competences: • Students are able to conceptualize and structure an application-oriented scientific paper and transform it into a research exposé. They can create work plans, derive research questions and objectives and select research methods • Students have gained initial experience of working in interdisciplinary research teams and can contribute their work in a targeted manner • Students can critically question and discuss results with others in the context of a scientific exchange								
3	Contents: • Project work o First practical work in the research project o Development of a research exposé, which defines the framework of the scientific work for the following three semesters and includes the initial situation, problem definition, objectives, work plan, research questions and research design. When preparing the exposé, the findings from the course "Introduction to Applied Science" are implemented, among other things • Project colloquium o Professional/scientific exchange between all students and the project owners on problems and questions from the projects, discussion of interim results. The focus in the first phase is on learning through participant observation. • Research seminar o Various scientific methods and tools are prepared and presented in this cross-semester course. Students learn from students in other semesters through participant observation and discussion.								
4	Forms of teaching: Project, seminar and colloquium								
5	Participation requirements:								
	Formal:								
	Content:								
6	Forms of assessment: Project work								
7	Prerequisite for the award of credit points: Module examination pass								
8	Application of the module (in the following study programmes): Research Master Data Science								
9	Importance of the grade for the final grade: according to MRPO								
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede								

11	Other information: Students are supported by the Project Owner in independently researching knowledge sources and learning to acquire skills on their own.
12	Language: English

Project Phase II									PP2
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer			Duration:
2056	210 h	7	2nd semester			each semester			1 semester
1	Course:	Planned group sizes	Scope			Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	weekly hours		0	h	0	h
	Seminar lessons	30 students	0	weekly hours		0	h	0	h
	Exercise	20 students	0	weekly hours		0	h	0	h
	Practical or seminar	15 students	2	weekly hours		30	h	330	h
	Supervised self-study	60 students	0	weekly hours		0	h	0	h
2	Learning outcomes/competences: • Students are able to develop and implement structured and team-oriented solutions to problems arising in the project context • Students are able to independently produce a scientific publication. They can carry out a comprehensive literature search and evaluate, correlate and restructure the results. They can assess and select conferences according to the focus and value of the topic. • Students can critically question and discuss results in the context of a scientific exchange. They can prepare their own research results for presentation and present and defend them in front of a scientific audience. • Students can prepare and present scientifically researched knowledge in the form of a presentation.								
3	Contents: • Project work ○ Development of initial practical results (e.g. data collection, processing, cleansing, creation of user stories and mock-ups) ○ Composition of a written contribution on the state of research in the respective field of work. The contribution should be written with a view to submission to a scientific conference and, ideally, should also be submitted there • Project colloquium ○ Professional/scientific exchange between all students and the project owners on problems and questions from the projects, discussion of interim results. The focus in the second phase is on the presentation of your own project based on the research exposé. • Research seminar ○ In this cross-semester course, various scientific methods and tools are prepared and presented. Students independently research a method or tool from their field of research and present it in such a way that the other students internalize the content presented.								
4	Forms of teaching: Project, seminar and colloquium								
5	Participation requirements:								
	Formal:	Module: 2055 Project Phase I;							
	Content:	Module: 2052 Introduction to Applied Research;							
6	Forms of assessment: Project work								
7	Prerequisite for the award of credit points: Module examination pass								

8	Application of the module (in the following study programmes): Research Master Data Science
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede
11	Other information: Students are supported by the Project Owner in independently researching knowledge sources and learning to acquire skills on their own.
12	Language: English

Project Phase III									**PP3**
Identification number:	Workload:	Credits:	Study semester:			Frequency of the offer		Duration:	
2057	360 h	12	3rd semester			each semester		1 semester	
1	Course:	Planned group sizes	Scope			Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	weekly hours		0	h	0	h
	Seminar lessons	30 students	0	weekly hours		0	h	0	h
	Exercise	20 students	0	weekly hours		0	h	0	h
	Practical or seminar	15 students	2	weekly hours		30	h	330	h
	Supervised self-study	60 students	0	weekly hours		0	h	0	h
2	Learning outcomes/competences: • Students are able to work independently and in a scientifically sound manner in the context of an application-oriented research project. They are able to acquire and acquire technical and methodological knowledge from the field of data science independently, also through exchange with other project members and partners. They have the ability to assess the theoretical methodological knowledge from the other courses of the Master's program with regard to its suitability for use in a specific case and to transfer and apply it to new practical problems. • Students are able to work in a multidisciplinary team, particularly in an agile project environment. They receive regular feedback and suggestions for improvement from the project owner and can implement these directly. • Students can develop and implement structured and team-oriented solutions to problems arising in the project context • Students are able to independently produce a scientific publication. They can prepare and structure their own quantitative results and relate them to the state of research. They can select conferences according to topic focus and value • Students can critically question and discuss results in the context of a scientific exchange. They can prepare their own research results for presentation and present and defend them in front of a scientific audience. • Students can prepare and present scientifically researched knowledge in the form of a presentation.								
3	Contents: • Project work o Development of practical, quantitative results using data science methods and algorithms o Writing a paper on the results obtained. The paper should be written with a view to submission to a scientific conference and in the best case should also be submitted • Project colloquium o Professional/scientific exchange between all students and the project owners on problems and questions from the projects, discussion of interim results. The focus in the third phase is on the presentation of the interim results of the project and the defense in the subsequent discussion. • Research seminar o Various scientific methods and tools are prepared and presented in this cross-semester course. Students independently research a method or tool from their field of research and present it in such a way that the other students internalize the content presented.								
4	Forms of teaching: Project, seminar and colloquium								

5	Participation requirements:	
	Formal:	Module: 2056 Project Phase II;
	Content:	Module: 2052 Introduction to Applied Research;
6	Forms of assessment: Project work	
7	Prerequisite for the award of credit points: Module examination pass	
8	Application of the module (in the following study programmes): Research Master Data Science	
9	Importance of the grade for the final grade: according to MRPO	
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede	
11	Other information: Students are supported by the Project Owner in independently researching knowledge sources and learning to acquire skills on their own.	
12	Language: English	

Project-Specific Elective Module					**PSWM**
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
9029	150 h	5	1st semester, 2nd semester or 3rd semester	each semester	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students		weekly hours		h		h
	Seminar lessons	30 students		weekly hours		h		h
	Exercise	20 students		weekly hours		h		h
	Practical or seminar	15 students	0	weekly hours	0	h	0	h
	Supervised self-study	60 students		weekly hours		h		h

2	Learning outcomes/competences: • The students have acquired methods and tool knowledge or specific specialist knowledge that they can transfer and apply to a practical problem in their project.
3	Contents: • In consultation with the project owner, students select 1-3 elective modules from the Master's courses offered by the university and possibly other courses that match the content of their project and close existing knowledge gaps. • Students can also complete the coursework as part of a project, which is assessed by the project owner if no suitable courses are available. • Elective modules from the Bachelor's area can be selected if they do not fall within the area of Data Science or can be supplemented by an additional achievement at Master's level. • Students attend the selected courses, internalize the content and complete the required examinations.
4	Forms of teaching: According to the selected courses, e.g. lecture, seminar-based teaching, seminar and practical course
5	Participation requirements: Formal: Content:
6	Forms of assessment:
7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes): Research Master Data Science
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede
11	Other information: Literature according to the selected courses.
12	Language: English

Scientific Exchange									WA
Identification number:		Workload:		Credits:		Study semester:		Frequency of the offer	Duration:
2059		60 h		2		1st semester or 3rd semester		each semester	2 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	weekly hours	0	h	0	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	0	weekly hours	0	h	0	h
	Practical or seminar	15 students	0	weekly hours	0	h	60	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h
2	Learning outcomes/competences: • Students can critically question and discuss results in the context of a scientific exchange. • Students can discuss with experts from the business world and are familiar with possible future job profiles. • Students can summarize the knowledge they have acquired and convey it to others through presentations.							
3	Contents: Excursions (conferences, research institutions, trade fairs, companies, project meetings) once per semester in coordination with the project owner. The aim of the excursion is to exchange ideas with the scientific community, to get to know the possible future working environment and to build up specific specialist knowledge. After the visit, the students summarize what they have learned in a short presentation and present it to the project owner.							
4	Forms of teaching: Practical training							
5	Participation requirements:							
	Formal:							
	Content:							
6	Forms of assessment:							
7	Prerequisite for the award of credit points: Course assessment							
8	Application of the module (in the following study programmes): Research Master Data Science							
9	Importance of the grade for the final grade: according to MRPO							
10	Module coordinator: Prof. Dr.-Ing. Christian Schwede							
11	Other information:							
12	Language: English							

Social Implications of Data Science									GIDS
Identification number:		Workload:		Credits:		Study semester:		Frequency of the offer	Duration:
2053		180 h		6		2nd semester or 3rd semester		Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	weekly hours	30	h	60	h
	Seminar lessons	30 students	0	weekly hours	0	h	0	h
	Exercise	20 students	0	weekly hours	0	h	0	h
	Practical or seminar	15 students	2	weekly hours	30	h	60	h
	Supervised self-study	60 students	0	weekly hours	0	h	0	h

2 Learning outcomes/competences:

- Students are able to evaluate and critically reflect on the social impact of their academic work, in particular the ethical implications.
- They are sensitized to consider data protection and personal rights in their own work and to observe applicable law.
- Students are aware of the responsibility of the data scientist and the necessity of open discourse in democratic constitutional states.
- Students can conduct ethical discussions on the topic of data science and classify and justify their own findings against this background.
- Students are aware of the effect of discrimination through machine learning methods and know how it can be prevented.
- Students can independently research, summarize and present research findings from the field of science and technology reflection.

3 Contents:

- Ethical principles
  - What is a good action?
  - Basic ethical theories (deontology, cosequentialism)
  - Ethical dilemmas
- Ethical implications of artificial intelligence
  - Programmer as ethical decision-maker
  - Weak vs. strong AI
  - Technical anthropology
- Data protection and personal rights
  - Why data protection?
  - Introduction to the right to privacy
  - Dilemma: data value vs. data protection
  - Methods for anonymization and pseudonymization of data
  - GDPR
- Impact of digitalization on the world of work and life
  - Global networking or digital isolation
  - Home office or complete accessibility
  - Participatory democracy or fake news
  - Production without people or the next economic miracle
- Data science and diversity
  - Gender and racial profiling
  - Diversity in MINT professions

4 Forms of teaching:

Lecture, seminar

5 Participation requirements:

Formal:	
Content:	

6	Forms of assessment: Term paper, combination examination or oral examination
7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes): Research Master Data Science
9	Importance of the grade for the final grade: according to MRPO
10	Module coordinator: - N. N. Prof. Dr.-Ing. Christian Schwede
11	Other information: Literature will be announced at the beginning of the course
12	Language: English