EURO-INF

FRAMEWORK STANDARDS

AND

ACCREDITATION CRITERIA

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TABLE OF CONTENTS

Preamble

Principal Aim

This document is intended to provide a means for reviewing the quality of higher education informatics* qualifications in the European Higher Education Area (EHEA), in a way that encourages the dissemination of good practice and a culture of continuous improvement of informatics degree programmes. They have been developed within the Euro-Inf Project, the principal aim of which is to develop a framework for the accreditation of informatics degree programmes in the EHEA. Given the great diversity of informatics education across Europe, the attempt to create framework standards comprising all areas of the informatics discipline appears ambitious. The Euro-Inf Framework is thus intended as a broad common denominator, or overarching reference point, for the variety of informatics degree programmes. In order to allow for possible inclusion of existing informatics specialisations within European Higher Education Institutions (HEIs), the framework must be formulated in rather general terms. The Standards and Criteria contained in this document represent a quality threshold. All graduates of degree programmes assessed against the Euro-Inf Standards are expected to achieve the programme learning outcomes stated therein.

Background

The objective of the Lisbon strategy to create a “knowledge-based society”, and thus to enhance competitiveness and employability throughout Europe, requires reform of higher education systems within Europe. In this context, the Bologna Process aims at establishing a European Higher Education Area by 2010. The European Commission is supporting projects aiming to contribute to this reform process. As outlined by the European Ministers of Education in Berlin in September 2003, the quality of higher education is "at the heart of the setting up of a European Higher Education Area". Informatics is certainly to be ranked as a strategically important discipline given the new global competitive challenge Europe faces. It is thus particularly important in the informatics area to develop quality standards for Higher Education programmes and to create and disseminate mechanisms to encourage improvement of the quality of education.

Accreditation

Accreditation of an informatics degree programme is the primary result of a process used to ensure the suitability of that programme as providing the education base for the entry route to professional practice. It involves a periodic assessment against accepted standards of informatics higher education. Independent, third-party Accreditation is essentially based on a peer review process, undertaken by appropriately trained and independent teams comprising peers from both academia and informatics practice, in accordance with agreed principles. It is important that Accreditation

processes go beyond judgement on the achievement of a minimum standard and effectively promote the idea of continuous improvement of the quality of Higher Education programmes.

Standards

This document can be used in both the design and the evaluation of degree programmes in all specialisations of informatics. Accreditation Criteria are expressed as broad generic programme learning outcomes that describe in general terms the capabilities required of graduates from accredited *First Cycle* and *Second Cycle* informatics degree programmes, as defined in the Framework for Qualifications of the European Higher Education Area. Consequently, they can be interpreted and elaborated by users to reflect the specific demands of different cycles and specialisations.

Application Fields

Although this document is expressed in terms of accrediting degree programmes, it can also be used in relation to recognition of agencies that accredit (or intend to accredit) informatics programmes, in assessing the consistency of their rules and standards with the requirements of this document ('meta-accreditation'); alternatively, it can be used as a guideline for the design and development of Standards and Procedures for new Accreditation agencies. The Standards and Criteria are intended to be widely applicable and inclusive, in order to recognise the diversity of degree programmes around Europe that provide the education necessary for a graduate to enter work as an ICT (informatics) professional.

HEI Autonomy

This document describes the programme (learning) outcomes of an accredited Higher Education programme but allow for considerable variation in the emphasis of individual programmes. The development of new programmes of study or of new and different ways of delivering the curriculum is to be encouraged. HEIs are also encouraged to provide incentives for excellence in programme development and refinement but it is left to the responsibility of the HEI as to how these incentives are provided. This document does not address conditions of access to degree programmes: these are handled by HEIs, in accordance with national regulations and/or requirements including new and innovative programmes.

Professional Recognition

Throughout this document, the term "informatics graduate" is used to describe someone who successfully completes an accredited degree programme in informatics. It is for the appropriate authority in each country to decide if a qualification, accredited or not, is sufficient for professional practice in ICT (the field of informatics) in that country, or if further education, training or industrial experience are necessary. The Euro-Inf accreditation label will assist such decisions, and particularly those that involve transnational recognition.

Relevant Official Documents

The development of the programme learning outcomes has been informed by the report 'A Framework for Qualifications of the European Higher Education Area' agreed by the Ministerial Conference in Bergen in May 2005, and by the Dublin Descriptors referred to therein. It is also assumed that all programmes to be accredited fulfil the criteria set out in the ENQA 'Standards and Guidelines for Quality Assurance in the European Higher Education Area' and also agreed by the Bergen Conference. Furthermore, it has been informed by the European Qualifications Framework for lifelong learning, proposed by the European Commission for a Recommendation of the European Parliament and of the Council.

1. Standards and Guidelines for Programme Assessment and Programme Accreditation

Each informatics programme for which a Higher Education Institution seeks accreditation or reaccreditation against Euro-Inf Standards must be consistent with legal and national requirements.

The Euro-Inf Framework contains two sets of criteria: firstly the generic criteria valid for both First and Second Cycle programme, and secondly, the programme outcomes for accreditation. They will be used by EQANIE review teams when EQANIE is charged with carrying out an accreditation procedure for the award of the Euro-Inf label.

The table below contains the detailed, generic criteria to be assessed within this framework and the associated “requirements” listed in the following table. Additional questions and possible evidence should be addressed when assessing a particular informatics programme for accreditation.

The Programme Outcomes for Accreditation (cf. section 1.2) currently contain sets of intended learning outcomes for informatics degrees. Section 1.3 contains a set of intended learning outcomes for business informatics degrees. It is planned that additional sets of intended learning outcomes for informatics-related subject areas will be added.

1.2 General Criteria

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
1.Programme Design and Development	1.1. Learning Outcomes	The intended learning outcomes for the programme are consistent with the mission and objectives of the Higher Education Institution (HEI) and the faculty, department or school responsible for the programme. The intended learning outcomes of the degree cover the programme outcomes for accreditation specified in the EURO-INF Standards (cf. Section 1.2). They are valid, feasible and up-to-date. The intended learning outcomes for the programme are easily accessible to the relevant stakeholders and are included in the Diploma Supplement.	*Possible questions for analysis* • How does the higher education institution correlate the competence profile of the programme with the Programme Outcomes of Euro-Inf? (Note: Please use the attached Objectives-Module-Matrix for this correlation.) • Have the learning outcomes of the degree programme been checked against the overarching mission and objective and verified within the last few years? If so, for what reasons were any adjustments made? *Possible evidence* • Euro-Inf Objectives-Module-Matrix • Course Catalogue • Programme Website • Sample Diploma Supplement	ESG 1.2
	1.2. Labour Market/Graduates/Stakeholders	The needs of relevant stakeholders (such as students, potential employers, graduates, informatics societies, etc.) have been explicitly identified and are taken into account. Graduates have clear labour market prospects. Relevant stakeholders are involved in the programme design and further development.	*Possible questions for analysis* • How does the intended competence profile comply with specific areas of the profession? • How has the intended competence profile of the degree programme been developed (regarding launch of the process, procedure, participants)? • Are there any peculiarities within the qualitative or quantitative data/information of the higher education institution with regard to the acceptance of the competence profile on the labour market? *Possible evidence* • Internal records that document the participation of the different stakeholders, e.g. standards, process descriptions, results from questionnaires, records of meetings • Results of labour market analysis, stakeholder consultations and surveys	*ESG 1.2*

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
	1.3. Curriculum	The curriculum is adequate to enable the achievement of the defined programme outcomes. There is a link between the individual educational units, their intended learning outcomes and the overall programme outcomes. The curriculum covers an educational level that corresponds to the correct level of the national qualifications framework for higher education and the Framework for Qualifications of the European Higher Education Area (QF-EHEA)[1].	*Possible questions for analysis* • How do those responsible for the programme assure themselves that the curriculum facilitates the achievement of learning outcomes? • How do those responsible ensure that the educational components complement or build up on each other? • How do those responsible for the degree programme react if single modules do not fit (anymore) into the general concept of the degree programme? *Possible evidence* • Overview of the curricular structure • Course (module) descriptions • Course material	*ESG 1.2, ESG 1.3*
		The curriculum contains practical elements (e.g. internship, placements, laboratories, projects, etc.) and a graduation project (thesis, dissertation, final project or similar) which is conducted in such a way as to ensure that each individual student acquires, and is assessed on, the relevant learning outcomes.	*Possible questions for analysis* • How are practical elements included in the curriculum? • How do those responsible for programme design and development recognize that the practical elements are targeted towards the objectives? • What is done to ensure the quality of external working practice or internships? • How is it ensured that the level of the graduation projects is appropriate? *Possible evidence* • Regulations for practical elements, e.g. internship • Regulations for final projects • Course (module) descriptions • Results from internal quality assurance activities dealing with practical elements • Final project reports made available during the onsite visit	
		The curriculum supports students' mobility.	*Possible questions for analysis* • To what extent is mobility planned for in the curriculum?	

[1] http://www.ehea.info/uploads/qf/050520_framework_qualifications.pdf, Bergen Communiqué, May 2005

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
			• How do students and staff view the mobility opportunities? Have there been any problems, and if so, what was the reaction? • What experiences have there been with regard to recognition of external periods of study? *Possible evidence* • Rules for recognition • Results from internal quality assurance activities dealing with mobility	
2. Programme Management and Implementation	2.1. Admission and enrolment	Students seeking enrolment in the programme have the right knowledge and attitudes to enable achievement of the programme outcomes in the expected time. Admission requirements are transparent, binding and consistently applied.	*Possible questions for analysis* • How do those responsible ensure that the admission requirements support the achievement of the intended programme outcomes? *Possible evidence* • Published admission requirements and procedures • Information about applicants' and admitted students' profiles	*ESG 1.4*
	2.2. Workload and ECTS	Student workload is realistic so that studies can be completed in the time officially allocated to them. A full-time academic year normally corresponds to the equivalent of 60 ECTS[2].	*Possible questions for analysis* • On what basis does credit allocation take place? • How is it ensured that the workload is realistic? • Have problems occurred, and, if so, what has been done? *Possible evidence* • Course (module) descriptions • Data and results from internal quality management activities dealing with student workload • Guidelines for allocating and revising credits • ECTS conversion tables, if applicable	*ESG 1.2*
	2.3. Teaching Methods / Didactic Concept	A sound didactic concept is in place taking into account a student-centred approach to learning and teaching. In line with the intended learning outcomes, there is a balance between attendance and self-study.	*Possible questions for analysis* • How do those responsible recognize that the teaching methods used are adequate for the achievement of the intended learning outcomes?	*ESG 1.3*

[2] European Commission, DG Education & Culture, http://ec.europa.eu/education/library/publications/2015/ects-users-guide_en.pdf

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
			• How is it ensured that all staff members use a student-centred teaching approach? *Possible evidence* • Documentation of the didactical concept • Course (module) descriptions • Results from internal quality assurance activities dealing with teaching methodology	
	2.4. Assessment	Examinations, projects and other assessment methods are designed to evaluate the extent to which students can demonstrate achievement of the learning outcomes of individual modules and programme outcomes throughout the programme and at its conclusion. Where possible, more than one examiner should carry out student assessment. Students are informed about the assessment methods, grading system and weight contribution of each educational unit at or before the beginning of the unit.	*Possible questions for analysis* • How do those responsible recognized that the assessment methods are suitable to ascertain the achievement of the intended learning outcomes? • How are exam types and exam organisation viewed by students and staff? • If there are external examiners, how do they contribute to the assessment process? *Possible evidence* • Course (module) descriptions • Exam / assessment regulations • Guidelines for assessment and grading • Results from internal quality management activities dealing with assessment • Samples of exams and/or exam transcripts made available during the onsite visit	*ESG 1.3*
3. Resources	3.1. Staff	The number and qualification of academic staff are adequate to facilitate students' accomplishment of the programme outcomes. The link between education and research is facilitated. Recruitment processes are transparent and fair. Opportunities for staff training and further development are in place.	*Possible questions for analysis* • How do those responsible assure themselves that the number and qualification of staff is adequate? • How does the organisation react to possible current or expected shortcomings, if applicable? • How are the research activities related to teaching? • How is the necessity for staff development recognized? *Possible evidence* • CVs of academic staff members • Short description of research activities relevant to the	*ESG 1.5*

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
			programme • Documentation of training and development policies and opportunities for staff members	
		Technical and administrative support staff are adequate to support the achievement of the programme outcomes.	*Possible questions for analysis* • How do those responsible ensure that the number and qualification of staff are adequate? • How does the organisation react to possible current or expected shortcomings, if applicable? *Possible evidence* • List of technical and admin staff (with full-time equivalence contribution)	
	3.2. Student Support	Counselling and support are provided for students and sufficiently funded. This includes support for students learning activities at home (e.g. e-tutorials, accessibility of academic staff via email).	*Possible questions for analysis* • How is the support viewed by the students and staff? *Possible evidence* • Documentation of support services • Results from internal quality assurance activities regarding support	*ESG 1.6*
	3.3. Facilities	Facilities (lecture, computing, laboratories, workshops and associated equipment, libraries and associated equipment) are adequate to enable the programme outcomes to be accomplished.	*Possible questions for analysis* • How do students and staff view the facilities available? • Have any (future) difficulties been identified or anticipated? If so, what is being done about them? *Possible evidence* • Documentation of facilities and equipment • Results from internal quality assurance activities regarding facilities • Tour of facilities during onsite visit	*ESG 1.6*
		Available financial resources are adequate to enable the programme outcomes to be accomplished.	*Possible questions for analysis* • How do those responsible assure the financial stability and sustainability of the programme? *Possible evidence* • Documentation of current and planned budget • Documentation of strategic planning	

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
4. Programme Information and Transparency	4.1. Rules and regulations	Student admission, exam, recognition, progression and graduation regulations are transparent. They ensure that studies can be completed in the time officially allocated to them. They include regulations for mitigating circumstances (such as re-sits, illness, etc.) and for student appeals	*Possible questions for analysis* • How do those responsible ensure that all rules and regulations are adequate, up-to-date and transparent? • Are responsibilities for the maintenance and revision of rules and regulations clearly allocated? *Possible evidence* • Link to rules and regulations on website • If applicable, results from students appeals	*ESG 1.4, ESG 1.8*
		Policies are in place to ensure academic integrity and freedom and to protect against plagiarism, fraud, and any form of discrimination.	*Possible questions for analysis* • How do the stakeholders, in particular staff, view their situation with regard to academic integrity and freedom? • How to those responsible ensure that plagiarism, fraud and discrimination are avoided? *Possible evidence* • Documentation of relevant policies • If applicable, results from internal quality assurance processes regarding academic freedom, anti-discrimination and fraud	
		Recognition of qualifications, periods of study and prior learning is ensured, based on the principles of the Lisbon Recognition Convention.[3]	*Possible questions for analysis* • What are the experiences of the stakeholders (students, academic and administrative staff) with recognition of externally acquired competences? *Possible evidence* • Documents in which the recognition policies are stipulated • If applicable, results of recognition procedures	
	4.2. Certification and Documentation	Information about the educational units (modules) is available for all stakeholders. It contains information about – nature of the unit (compulsory/optional)	*Possible evidence* • module descriptions • link to website where descriptions are published	*ESG 1.8*

[3] Convention on the Recognition of Qualifications concerning Higher Education in the European Region, Council of Europe/ UNESCO, 8 - 11 April 1997, http://www.coe.int/t/dg4/highereducation/recognition/lrc_EN.asp

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
		– cycle, year of study, and/or semester when the component is delivered, if applicable – number of ECTS credits allocated – name of the lecturer(s) – intended learning outcomes – method of delivery (face-to-face/ distance learning etc.) – prerequisites (mandatory and/or suggested), if applicable – content – recommended and/or required literature and other learning resources – planned learning activities and teaching methods – assessment methods and criteria – language of delivery		
		Students receive documentation about the qualification gained, containing information about their individual achievements, as well as the intended and individual achieved learning outcomes, context, level, content and status of the studies. In the European Union, normally a Diploma Supplement is issued.[4]	*Possible evidence* • Rules regarding the award of qualifications • Sample of the programme-specific Diploma Supplement	
		Information about the programme is publicly available, including – Programme objectives and curricula – Qualification to be gained – Teaching, learning and assessment policies – Pass rates – Learning opportunities available – Graduate employment	*Possible questions for analysis* • How do those responsible ensure that the information made available is complete, transparent and helpful? *Possible evidence* • link to programme website	

[4] European Commission, Council of Europe and UNESCO/CEPES: http://ec.europa.eu/education/tools/diploma-supplement_en.htm; https://europass.cedefop.europa.eu/en/documents/european-skills-passport/diploma-supplement

Guidelines for Assessment	Criteria to be Assessed	Requirements	What the Self-Assessment Report should give evidence of and the Review Team should check	Corresponding ESG Standard
5. Quality Management	5.1. QM-Policy	Quality management policies are in place. They translate into measures and responsibilities for the continuous improvement of educational programmes. All relevant stakeholders, in particular students, are involved in the quality assurance activities. The results of quality management activities are communicated back to the relevant stakeholders.	*Possible questions for analysis* • How do the stakeholders view the quality management system with regard to their participation? • How and by whom are quality management policies and related activities revised? Has this been the case in the past few years? • Do stakeholders consider that improvements have been made to the programmes? • What feedback loops exist? *Possible evidence* • Internal quality management policy and guidelines or regulations	*ESG 1.1*
	5.2. Programme monitoring and review	Programmes are regularly monitored, reviewed and updated as part of quality management activities. Elements to be considered in this process are: – needs of the stakeholders and up-to-date profession requirements – achievement of intended learning outcomes and effectiveness of student assessment – students workload, progression and completion – learning resources and available support – graduate employment and career paths	*Possible questions for analysis* • To what extent does achievement of the intended learning outcomes play a role in the quality management system? • To what extent are results from surveys and analysis fed back into programme development activities? *Possible evidence* • Sample information about the quality management and its results (e.g. internal reports)	*ESG 1.1, ESG 1.9*
		Information and data are collected as input into quality management decisions. This normally includes: – Key performance indicators – Student statistics (profile of student population; student progression, success and drop-out rates) – Reasons for non-completion of studies	*Possible questions for analysis* • How do those responsible ensure that meaningful data is collected? • Do the stakeholders consider the data collected to be informative and relevant and enable them to take quality-based decisions? *Possible evidence* • Quantitative and qualitative statistical data from evaluations, study progression statistics, number of graduates, and their distribution etc.	*ESG 1.1, ESG 1.7*

1.3 Subject Specific Criteria: Programme Outcomes for Informatics Degrees

Programme Outcomes can be described as quality standards for knowledge, skills and competences that graduates of an accredited course should have achieved as the educational base for practising their profession or for post-graduate studies. They will vary in extent and intensity in accordance with the differing objectives of First and Second Cycle degree (FCD and SCD) programmes. In the Euro-Inf Framework they are arranged into the following six categories:

- Underlying Conceptual Basis for Informatics
- Analysis
- Design and Implementation
- Economic, Legal, Social, Ethical and Environmental context
- Informatics Practice
- Other Professional Competences

A wide range of degree programmes fall within the general area of informatics but all graduates should be aware of the wider spectrum of informatics and of the underlying concepts relevant to their programmes of study. The detailed description of these areas, and their typical instantiation at First and Second cycles, are given in the following chapters 1.3.1 & 1.3.2.

The first category **"Underlying Conceptual Basis for Informatics"** therefore identifies capabilities that are essential to satisfying the other programme outcomes, independently from the specific informatics specialisation and application context.

"Analysis" means explaining or classifying facts and problems based on models and theories commonly used in informatics, assessing solution methods and evaluating proposed or existing solutions.

"Design and Implementation" involve the creation and development of an economically viable product, process or system to meet a defined need. These involve significant technical and intellectual challenges and can be used to integrate informatics knowledge and skills to the solution of real and complex problems.

Computing activity can have impacts on individuals, on commerce, on society and on the environment. The **"Economic, legal, social, ethical and environmental context"** category identifies the skills that graduates need to manage their activities and to be aware of the various legal and ethical constraints under which they are expected to operate. It includes an understanding of the need for a high level of professional and ethical conduct in informatics and a knowledge of professional codes of conduct and a commitment on different aspects (e.g., product and services safety, sustainability, inclusion, etc.) with relevant benefits to the society.

"Informatics practice" identifies the practical capabilities that graduates should have demonstrated through the application of informatics skills in a variety of situations. They should have demonstrated that they have an understanding of the contexts in which informatics knowledge can be applied (e.g. development and application of hardware and software, operation

and management of informatics systems, etc), and have functioned successfully in at least one of these contexts.

Transversal behavioural skills (sometimes included in the popularly known group of soft skills but also mentioned as “non-cognitive”, “socioemotional”, “key" and “core” skills) are crucial for effective action in virtually any kind of work, learning or life activity. They are “transversal” because they are not exclusively related to any particular context. These skills listed under the category **“Other Professional Competences”** include thinking skills that allow the individual to deal with abstract cognitive concepts (e.g., critical thinking, analytic thinking, etc.), self-management skills and competences linked to the ability of individuals to make use of own potential (e.g., working efficiently, adopting a proactive approach, etc.) and social and communication skills that enable the individual to interact with other people (e.g., communicate, collaborate with others in teams, lead others, etc.). The same arrangement of categories is maintained for the programme outcomes of Second Cycle Degree (SCD) programmes. They apply in addition to the competences described for graduates of FCD programmes. Although all six outcome categories are used to describe expected outcomes of both FC and SC programmes, there are important differences in the requirements at the two levels.

These differences in the levels of First and Second Cycle accredited informatics programmes should be considered in the interpretation of the programme outcomes by HEIs and by review teams. For instance, whereas First Cycle graduates should be able to formally specify, conceptualize, implement and roll out solutions to complex and unpredictable real-world problems using informatics, Second Cycle graduates are, in addition, expected to conduct independent professional work. They are able to develop new insights and approaches and to integrate knowledge from different disciplines, as required in research and innovation (for reference, see Appendix 4.4 regarding the e-CF levels of proficiency in competences’).

No restriction is implied or intended by this document in the design of programmes to meet the specified programme outcomes. For example, the requirements of more than one outcome could be satisfied within a single module or unit such as individual or group project work. Similarly, it is possible that some programmes are designed such that the requirements of the Other Professional Competences category are taught and assessed entirely within modules or units designed to satisfy the requirements of other outcomes, whereas in other programmes the Other Professional Competences requirements are taught and assessed in modules or units designed specifically for this purpose.

1.3.1 Outcomes for First Cycle Degree (FCD) Programmes

Underlying Conceptual Basis for Informatics

Graduates of a FCD programme should be able to:

- describe and explain the essential facts, concepts, theories and mathematical methods relevant to computing, computing equipment, computer communication and informatics applications as appropriate to their programme of study
- outline the characteristics of relevant state-of-the-art hardware and software and their practical application
- think algorithmically and develop larger software programs in a structured way
- outline relevant historical and current developments in informatics and show insight into possible future trends and developments
- demonstrate awareness of the fact that the creation of interdisciplinary informatics applications also requires in-depth specialist knowledge of other disciplines and to acquire and integrate this knowledge into their own specialist area(s)

Analysis

Graduates of a FCD programme should be able to:

- communicate and cooperate with task owners and future system users and to quickly familiarize with new application contexts
- use a range of techniques to identify the requirements of real-world problems in their overall context, assess their complexity and evaluate the feasibility of their solution using informatics techniques
- describe a problem and its solution approach at varying levels of abstraction
- model informatics systems using suitable decomposition strategies and define interfaces in such a way that the systems are maintainable, expandable and reliable
- select and use relevant analytic, modelling and simulation methods
- investigate the extent to which an informatics system meets the criteria defined for its current use and future development

Design and Implementation

Graduates of a FCD programme should be able to:

- specify and design computing/network hardware/software which meet specified requirements including time and budget constraints
- describe the phases involved in different life cycle models used for specifying, building, testing and commissioning new systems and for maintaining existing systems
- select and use appropriate process models, programming environments and data management techniques for projects involving traditional applications as well as emerging application areas
- describe and explain the design of systems and interfaces for human-computer and computer-computer interaction
- apply relevant practical and programming skills to the creation of computer programs and/or other informatics artefacts
- identify and implement appropriate solution patterns, algorithms, and data structures, and apply systematic quality assurance
- use tools, processes, and algorithms for drawing knowledge and insight from data, as well as for creating Artificial Intelligence systems performing tasks typically associated with human intelligence

Economic, legal, social, ethical and environmental context

Graduates of a FCD programme should be able to:

- demonstrate awareness of the need for a high level of professional and ethical conduct in informatics and a knowledge of professional codes of conduct
- explain how commercial, industrial, economic and social contexts affect informatics practice
- identify relevant legal requirements governing informatics activities, including data protection, intellectual property rights, contracts, product safety and liability issues, personnel issues, sustainability (environmental, economic and social) and health, accessibility and safety
- explain the importance of information privacy and security issues in relation to the design, development, maintenance, monitoring and use of informatics-based systems

Informatics practice

Graduates of a FCD programme should be able to:

- demonstrate an awareness of appropriate technical codes of practice and industry standards, including cybersecurity standards
- describe and explain management techniques appropriate to the design, implementation, testing, deployment and maintenance of informatics systems, including project management, configuration management, change management, etc., including relevant automated techniques
- identify technical risk issues, including security, and demonstrate risk reduction and risk management techniques
- design and conduct appropriate practical investigations (e.g. of system performance or system security), to interpret data and draw conclusions

Other Professional Skills and Competences

Graduates of a FCD programme should be able to:

- adopt self-learning and develop personal potential as a foundation for professional development
- organise their own work independently, demonstrate initiative and exercise personal responsibility
- communicate effectively both verbally and using a variety of communications media to a variety of different audiences
- identify different ways of organising teams and the various roles within a team
- participate effectively in informatics teamworking and networking
- undertake literature searches and reviews using databases and other sources of information

1.3.2 Outcomes for Second Cycle Degree (SCD) Programmes

Underlying Conceptual Basis for Informatics

Graduates of a SCD programme should be able to:

- demonstrate either deepened knowledge of a chosen specialisation or broadened knowledge of informatics in general
- explain in depth relevant concepts and scientific principles appropriate to their programme of study, some of which may be from outside informatics
- demonstrate awareness of topics at the forefront of their specialisation and evaluate their significance

Analysis

Graduates of a SCD programme should be able to:

- transfer, adapt or acquire suitable analysis methods in order to assess informatics solutions for complex, unpredictable problems at the interface between different specialist areas or disciplines
- use fundamental knowledge to investigate new and emerging technologies and methodologies

Design and Implementation

Graduates of a SCD programme should be able to:

- describe and explain design processes and methodologies relevant to their subject area and be able to apply and adapt them in unfamiliar situations
- specify and complete informatics tasks that are complex, incompletely defined or unfamiliar ensuring a proper quality assurance
- apply state-of-the-art or innovative methods in problem solving, possibly involving the use of other disciplines
- demonstrate that they can think creatively to develop new and original designs, approaches, methods, etc

Economic, legal, social, ethical and environmental context

Graduates of a SCD programme should be able to:

- demonstrate awareness of the need for a high level of professional and ethical and principled conduct in informatics
- identify relevant legal, commercial, industrial, economic and/or social contexts appropriate to their area of study and practice and explain their relevance and consequences in practical terms for adaptation and compliance in professional activities
- evaluate risk and information security and privacy issues relevant to their area of study to adopt appropriate measures

Informatics practice

Graduates of a SCD programme should be able to:

- describe and explain applicable techniques, including AI-based techniques, and methods for their particular area of study and identify their limitations, including in the area of cybersecurity
- apply informatics techniques to new application areas, considering relevant commercial, industrial, social, and sustainability constraints
- contribute to the further development of informatics

Other Professional Competences

Graduates of a SCD programme should be able to

- plan self-learning and improve personal performance as a foundation for lifelong learning and ongoing professional development
- organise their own work independently and with efficiency, demonstrating initiative and exercising personal responsibility
- communicate effectively both verbally and using a variety of communications media to a variety of different audiences and preferably also in a second language
- identify and develop the skills required to work with and lead a team that may be composed of people from different disciplines and different levels of qualification
- conduct comprehensive and critically informed literature reviews using advanced information and analytical methods

1.4 Subject Specific Criteria: Programme Outcomes for Business Informatics Degrees[5]

Programme Outcomes can be described as quality standards for knowledge, skills and competences that graduates of an accredited course should have achieved as the educational base for practising their profession or for post-graduate studies. They will vary in extent and intensity in accordance with the differing objectives of First and Second Cycle degree (FCD and SCD) programmes. In the Euro-BusInf Framework they are arranged into the following six categories:

- Business Informatics Fundamentals
- Analysis
- Design and Implementation
- Economic, Legal, Social, Ethical and Cultural context
- Business Informatics Practice
- Other Professional Skills and Competences

Information systems are used in many types of organisation but all graduates from an information systems programme should be aware of the underlying concepts relevant to their programmes of study. The first category “Business Informatics Fundamentals” therefore identifies capabilities that are essential to satisfying the other programme outcomes, independently from the specific specialisation and application context.

“Analysis” involves the application of informatics concepts and tools to the analysis of both problems and their solutions, while “Design and Implementation” involve the creation and development of an economically viable information system to meet a defined need. It involves significant technical and intellectual challenges and can be used to integrate knowledge of organisational processes with informatics knowledge and skills to produce solutions for real and complex problems.

The use of information systems can have impacts on individuals, on commerce, on society and on the environment. The “Economic, legal, social, ethical and cultural context” category identifies the skills that graduates need to manage their activities and to be aware of the various legal and ethical constraints under which they are expected to operate, including an understanding of the need for a high level of professional and ethical conduct in relation to activities in informatics and a knowledge of professional codes of conduct.

“Business Informatics Practice” identifies the practical capabilities that graduates should have demonstrated through the application of their skills in a variety of situations. They should have demonstrated that they have an understanding of the contexts in which information systems may be used.

[5] This is without prejudice to the name of the degree programme under review.

Social or soft competences, listed under the category “Other Professional Competences” are crucial to communicate information, ideas, problems and solutions. Besides the so-called soft skills, the category also includes personal organisational skills, team working and life-long learning.

The same arrangement of categories is maintained for the programme outcomes of Second Cycle Degree (SCD) programmes. They apply in addition to the competences described for graduates of FCD programmes. Although all six outcome categories are used to describe expected outcomes of both FC and SC programmes, there are important differences in the requirements at the two levels. These differences in the levels of First and Second Cycle accredited informatics programmes should inform the interpretation of the programme outcomes by HEIs and by auditing teams. For instance, whereas First Cycle graduates should be able to formalise and specify real-world problems whose solution involves the use of informatics, Second Cycle graduates are, in addition, expected to have demonstrated their ability to specify and complete informatics tasks that are complex, incompletely defined or unfamiliar.

No restriction is implied or intended by this document in the design of programmes to meet the specified programme outcomes. For example, the requirements of more than one outcome could be satisfied within a single module or unit such as individual or group project work. Similarly, it is possible that some programmes are designed such that the requirements of the Other Professional Competences category are taught and assessed entirely within modules or units designed to satisfy the requirements of other outcomes, whereas in other programmes the Other Professional Competences requirements are taught and assessed in modules or units designed specifically for this purpose.

1.4.1 Outcomes for First Cycle Degree (FCD) Programmes

Business Informatics Fundamentals

Graduates of a First Cycle degree should be able to:

- describe the fundamental concepts related to organisational strategies, structures and behaviours
- describe and explain the opportunities, challenges and risks of digital transformation and industry evolution
- outline relevant historical and current developments in information systems and show insight into possible future trends and developments
- explain the principles of process analysis and relate them to specific contexts
- describe and explain the essential facts and concepts relevant to hardware and software, IT equipment and digital communications
- outline the characteristics of state-of-the-art hardware, software and communications technology
- explain how organisational models, data, applications and IT infrastructure are related as elements of an enterprise architecture

Analysis

Graduates of a First Cycle degree should be able to:

- use a range of information systems techniques to identify the requirements of real-world problems, analyse their complexity and assess the feasibility of potential solutions
- extract data from multiple data sources and conduct descriptive and predictive analysis using, where appropriate, statistics and probability techniques
- apply modern business process modelling, documentation and analysis tools and techniques to the knowledge drawn from their domain observation, stakeholder interviews, prior document analysis, etc.
- describe a problem and its solution at varying levels of abstraction
- use relevant analytic, modelling and simulation methods to assess the performance and risks of business processes
- analyse the extent to which an information system meets the criteria defined for its current use and future development

Design and Implementation

Graduates of a First Cycle degree should be able to:

- design and develop applications, application architectures and integrated systems that satisfy organisational requirements, user needs, usability and accessibility requirements, and provide a high-quality user experience
- select an appropriate life cycle model for specifying, building, testing and commissioning new information systems and for maintaining existing systems
- select and use appropriate programming environments and data management techniques for projects involving traditional applications as well as emerging application areas
- describe and explain solution patterns, algorithms and data structures appropriate to the creation of a particular information system
- apply relevant practical and programming skills to the creation of basic software systems

Economic, Legal, Social, Ethical and Cultural Context

Graduates of a First Cycle degree should be able to:

- demonstrate awareness of the need for a high level of professional and ethical conduct in information systems practice and a knowledge of professional codes of conduct
- explain how commercial, economic, cultural and social considerations affect information systems deployment
- identify relevant legal requirements governing information systems, including data protection, intellectual property rights, contracts, product safety and liability issues, sustainability issues, personnel issues and health & safety
- explain the importance of information privacy and security issues in relation to the design, development, maintenance, monitoring and use of information systems

Business Informatics Practice

Graduates of a First Cycle degree should be able to:

- compare and select industry reference models and best practices for IT governance
- describe and explain IT governance processes, for example, financial planning and control, demand management and maintenance of information systems
- describe and compare management techniques relevant to the design, implementation, procurement, sourcing, testing and deployment of information systems including configuration management and change management
- apply project management techniques to IT projects
- identify risk issues, including security, health & safety, environmental and commercial risk, and explain risk assessment, risk reduction and risk management and disaster recovery techniques
- undertake literature searches and reviews using databases and other sources of information
- design and conduct appropriate practical investigations of application performance and scalability

Other Professional Skills and Competences

Graduates of a First Cycle degree should be able to:

- organise their own work independently, demonstrate initiative and exercise personal responsibility
- communicate effectively both verbally and using a variety of communications media to a variety of different audiences
- plan self-learning and improve personal performance as a foundation for lifelong learning and ongoing professional development
- identify different ways of organising teams and the various roles within a team
- participate effectively in collaborative discussions and in information systems group-working

1.4.2 Outcomes for Second Cycle Degree (SCD) Programmes

Business Informatics Fundamentals

Graduates of a Second Cycle degree should be able to:

- demonstrate either deepened knowledge of a chosen specialisation or broadened knowledge of information systems in general
- explain in depth relevant concepts and principles appropriate to their programme of study, some of which may be from outside information systems
- demonstrate awareness of topics at the forefront of their specialisation and evaluate their significance

Analysis

Graduates of a Second Cycle degree should be able to:

- apply appropriate analysis methods to the solution of complex problems in information systems and to assess their limitations
- use fundamental knowledge to investigate new and emerging technologies and methodologies
- collect and analyse research data and use appropriate analysis tools in tackling unfamiliar problems, such as those with uncertain or incomplete data or specifications, by the appropriate innovation, use or adaptation of analytical methods.

Design and Implementation

Graduates of a Second Cycle degree should be able to:

- describe and explain design processes and methodologies relevant to their subject area and be able to apply and adapt them in unfamiliar situations
- specify and complete information systems tasks that are complex, incompletely defined or unfamiliar
- apply state-of-the-art or innovative methods in problem solving, possibly involving the use of other disciplines
- demonstrate that they can think creatively to develop new and original designs, approaches, methods, etc

Economic, Legal, Social, Ethical and Cultural Context

Graduates of a Second Cycle degree should be able to:

- demonstrate awareness of the need for a high level of professional and ethical conduct in information systems
- identify relevant legal, commercial, economic, cultural and/or social contexts appropriate to their area of study and explain their relevance
- evaluate risk and information security issues relevant to their area of study

Business Informatics Practice

Graduates of a Second Cycle degree should be able to:

- describe and explain applicable techniques and methods for their particular area of study and identify their limitations
- apply information systems techniques to new application areas, taking account of relevant commercial, cultural, social and environmental constraints
- contribute to the further development of information systems

Other Professional Skills and Competences

Graduates of a Second Cycle degree should be able to:

- organise their own work independently, demonstrate initiative and exercise personal organise their own work independently, demonstrate initiative and exercise personal responsibility
- appreciate the skills required to work with and lead a team that may be composed of people from different disciplines and different levels of qualification
- undertake literature searches and reviews using databases and other sources of information
- communicate effectively both verbally and using a variety of communications media to a variety of different audiences and preferably also in a second language
- plan self-learning and improve personal performance as a foundation for lifelong learning and ongoing professional development

2 Standards and Guidelines for External Quality Assurance Procedures

This section lists the steps the programme assessment (based on self-assessment followed by external review) and programme accreditation procedures should follow.[6] In principle, this means compliance with Part 2 of the ESG. These procedures will be used by EQANIE when it is charged with carrying out an accreditation procedure for the award of the Euro-Inf label.

External quality assurance agencies seeking authorization to award the Euro-Inf label in the frame of their national procedures should demonstrate compliance with these procedures. Nevertheless, they may add further requirements to respond to nationally and culturally distinctive features of higher education in informatics and to ensure compliance with national legislation.

2.2 Guidelines for the External Assessment (ESG 2.1, 2.3)

The external quality assurance process should contain the following elements:

2.2.1 Application by a Higher Education Institution (HEI)

The detailed self-assessment report and documentation is submitted before the visit of the review team (sufficient time should be allowed for review of the report).

An application will only be considered when there is at least one cohort of graduates.

The table in Section 1.1 serves as a guideline for the HEI in producing (and for members of the review team in reviewing) the self-assessment report and documentation. In any case, the self-assessment report should provide adequate information against all the questions listed in the table in Section 1.1, taking into account at least all the items listed in the last column of the table.

2.2.2 Accreditation Visit

The accreditation visit normally lasts at least two days, including both any preliminary meetings of the review team and the visit to the HEI.

The visit normally includes:

- a preliminary meeting of the review team prior to the visit to identify what additional information is to be obtained during the visit
- a meeting with head of department / university
- a meeting with academic staff members
- a meeting with a representative group of students
- if applicable, meetings with other relevant stakeholders such as support staff members, former students, representatives of relevant employers / industry / professional informatics organisations

[6] Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG). (2015). Brussels, Belgium

URL: http://eqar.eu/fileadmin/documents/bologna/ESG_2015.pdf (2016-03-01).

- a visit of relevant facilities (libraries, laboratories, etc.)
- a review of project work, final thesis, examination papers and other assessed work (with regard to the standard and modes of assessment as well as to the learning achievements of the students)
- feedback by the review team at the end of the visit.

2.3 Guidelines for the Peer Review Team (ESG 2.4)

The external review team (peer group) should consist of at least four persons, preferably more, representing a balance of relevant experience and expertise. At least two members of the review team should be academics, at least one a practitioner with a SCD or equivalent in informatics, and at least one a student enrolled in a First or Second Cycle study programme in informatics. All members of the review team should be made aware of the roles and responsibilities of external peers in the conduct of the accreditation process. As a norm, at least one member of the team should have previous experience in EQANIE accreditation. In this regard accreditation institutions should provide (or ensure provision of) adequate training or briefing.

To facilitate the dissemination of good practice in assessment, the accreditation agency should offer the option to include external observers from outside the respective economic region.

Each member of the review team must provide a statement indicating that no conflict of interest exists between the department at which one or more programmes are being accredited and the review team members themselves. This statement should be received prior to any documentation being distributed.

2.4 Standards for Reporting and Publication (ESG 2.6)

The review team prepares and agrees on an assessment report based on the general and specific criteria (cf. section 2). The assessment report is then submitted to the HEI for checking of factual errors and (should the HEI desire) submit a statement on the report. The statement of the HEI is transmitted to the members of the review team for possible revision of the assessment report and formulation of any recommendations concerning the accreditation decision.

The accreditation decision will be published, together with, normally, the full report of the experts, including any statements from the HEI.

2.5 Standards for Decision-Making (ESG 2.2, 2.3, 2.5)

The final decision on accreditation should be taken by a designated body of the accreditation agency. This body should include representation of all relevant stakeholders and be responsible for the definition and design of quality standards and procedures.

The accreditation decision must clearly define the period of validity and whether it refers to year of entry or year of graduation (the duration of which should normally not exceed a maximum of six

years). The accreditation decision is communicated to the HEI. At the end of the validity period of the accreditation, the programme must be submitted for re-accreditation.

When EQANIE is asked to implement an accreditation procedure for the award of the Euro-Inf label, the EQANIE Accreditation Committee is the decision-making body. It awards the Euro-Inf label for a period of either five years, referring to all students who have or will have studied the accredited degree during that period, or for a period in line with relevant national accreditation.

Where national accreditation guidelines allow graduates from the year prior to the period of accreditation to be included, this will apply to the Euro-Inf label unless the terms of accreditation include requirements that cannot be applied retrospectively to the programme.

2.5.1 Guidelines for the Evaluation of Individual Requirements

When assessing the achievement of individual requirements for the programme review, a scale with at least the following three categories should be used:

a. Acceptable without reservation
b. Acceptable with adjustment requirements
c. Unacceptable.

The outcome “acceptable without reservation” should be awarded to requirements that have been fully met, even if improvements are still possible.

The outcome “acceptable with adjustment requirements” should be awarded to requirements that have not been fully met, but are judged to be achievable within a reasonable period of time (as a rule no longer than half the regular full period of accreditation).

The outcome “unacceptable” should be awarded to requirements that have not been met or not fully met, and are judged not to be achievable within a reasonable period of time.

2.5.2 Guidelines for the Criteria of Programme Accreditation

An informatics programme is accredited if it fulfils the requirements specified under Section 1.

To record the assessment outcome concerning the overall achievement of the requirements, a scale with at least the following three points should be used:

a. Accredited without reservation
b. Accredited with adjustment requirements
c. Not accredited.

Accreditation without reservation, with possible specification of recommendations for the improvement of the programme, should be awarded to programmes for which all requirements are judged to be “acceptable without reservation”. In this case, accreditation should be awarded for the full period of accreditation.

Accreditation with adjustment requirements, with specification of adjustments and the time in which these must be carried out, should be awarded if one or more requirements are judged to be “acceptable with adjustment requirements”. If a programme is rated as “accredited with adjustment requirements”, accreditation must be awarded for a shorter period of time than the full period of

accreditation. In the follow-up procedure, compliance with the adjustment requirements is verified. If the adjustment requirements are not achieved within the set period of time, the review team can recommend that accreditation be withheld.

If the assessment outcome is unacceptable, the degree programme is not accredited.

2.6 Appeal Mechanism (ESG 2.7)

Agencies or other national competent authorities that make accreditation decisions on the basis of the Euro-Inf Standards and Criteria should have an appeals procedure. The nature and form of the appeals procedure should be determined in the light of the constitution of each agency.

It should be evident from the documentation to what extent the appeals system is based on a hearing process through which the agency can provide those under evaluation with a means to comment on and question the outcomes of the evaluation. Basically, the agency should provide evidence that the appeals system provides for those under evaluation an opportunity to express opinions about the evaluation outcomes.

3 Standards and Guidelines for External Quality Assurance Agencies

Agencies applying for authorization to award the Euro-Inf® Quality Labels should demonstrate compliance with the standards of Part 3 of the ESG[7].

[7] ESG (2015), Part 3.

4 Appendix

4.2 Terminology

- **Informatics** is the systematic study of algorithmic processes - their theory, analysis, design, efficiency, implementation, and application - that describe and transform information (ACM, 1989).
- **Awareness**: for some of the topics included in these outcomes, graduates need to have some familiarity with the topic and to know why it is important within the general context of informatics, but not necessarily in-depth knowledge of that topic.
- **Complex**: problems, artefacts or systems that are complex involve dealing simultaneously with a sizeable number of factors that interact and require deep understanding, in relation both to their analysis and to their design and implementation.
- **Quality Assurance**: A structured and systematic process encompassing testing, evaluation, and review activities to verify that software or systems conform to specified functional and non-functional requirements—including performance, usability, and security. It ensures that systems operate reliably under defined conditions and meet the expectations of users and stakeholders. Quality assurance supports continuous improvement and accountability in the development lifecycle, contributing to the delivery of robust, maintainable, and high-quality informatics solutions.

4.3 Selection of some titles of Informatics-related degree programmes

Although Informatics degree programmes all educate the same typical skills at their core, they vary in terms of their programme titles, module combinations in their curricula, or different divisions of the curriculum between Informatics content and application knowledge.

This results in a wide variety of Informatics degree programmes on offer, which is reflected in the different titles of the programmes, even if the titles only allow rough conclusions about the programme content.

According to the ASIIN Subject-Specific Supplementary Guidelines[8] and the GI recommendations[9] of 2000-2016, three groups of Informatics-related degree programmes can be distinguished:

- Type 1: degree programmes with a clear focus on Informatics
- Type 2: degree programmes which are mainly Informatics programmes but are focusing on a specific area of application
- Type 3: Interdisciplinary degree programmes with a proportion of Informatics that is equal to the proportion of the other disciplines involved.

[8] https://www.asiin.de/files/content/kriterien/ASIIN_FEH_04_Informatik_2018-03-29.pdf
[9] https://gi.de/fileadmin/GI/Hauptseite/Service/Publikationen/Empfehlungen/akkreditierung.pdf; confirmed in https://dl.gi.de/items/0986c100-a3b9-47c8-8173-54c16d16c24e (2016-07-01)

Table 1 lists a selection of customary titles of Informatics-related degree programmes for which the criteria mentioned in this document can be applied with varying degrees of emphasis. For Type 3-degree programmes, special attention must be paid to ensuring that the Informatics content is not too short in order to be able to certify the degree programme as Informatics-related.

Type	Degree Programme title	
1	Informatics,	Computer Science
	Computer Engineering,	Digital Engineering
	Software Engineering, Software Design, Software Technology	Software Systems, Mobile and Distributed Computing,
2	Artificial Intelligence, Machine Learning, Cognitive Systems, Applied Statistics	Data Science, Cognitive Computing, Applied Mathematics,
	Cyber Security, Information Security,	IT Security, Digital Forensics
	Web Development,	Web Engineering
	Media Informatics, Human-Computer Interaction, User Experience Design,	Digital Media, Interactive Media Design, Usability Engineering
	Visual Computing	
	Games Engineering, Game Technologies	Virtual Reality & Game Development,
3	Business Informatics, Administrative Informatics	Business Information Systems,
	Medical Informatics, Healthcare Information Systems Biomedical Informatics, Ecoinformatics, Life Science Informatics,	Health Informatics, Clinical Informatics, Bioinformatics, Computational Life Sciences, Nursing Informatics
	Neuroinformatics	
	Computational Engineering	Engineering Informatics
	Automotive Informatics, Aircraft and Vehicle Informatics, Autonomous Systems, Robotics,	Automotive Software Engineering, Aerospace informatics, Smart Mobility Systems, Embedded Systems
	Production Informatics,	Industrial Informatics
	Construction Informatics	
	Geoinformatics	
	Agricultural Informatics,	Food Informatics
	Environmental Informatics	
	Social Informatics,	Socioinformatics
	Legal Informatics,	Digital Law
	Music Informatics	
	Digital Humanities,	Computational Linguistics

Table 1: Overview of some customary Informatics-related degree programme titles

4.4 e-CF levels of proficiency in competences

The structure of levels used by the standard EN16234:2019 (e-CF, e-Competence Framework, Annex A) could serve as a good and detailed reference for the competences to be developed in higher education programme in informatics. This scale can provide an orientation on the type of competences established as target in the different educational levels applicable to EQANIE. As a general orientation, the following could be a guiding scheme related to professional e-competences.

- EQF5 (out of EQANIE scope): main target e-CF level is 1
- EQF6: main target levels are 2 and 3
- EQF7: main target levels are 4 and 5

It is relevant to note that this guide is not determining that all learning outcomes in an educational EQF level should belong to the corresponding e-CF level (as each level has many courses and partial learning objectives that may refer to other e-CF levels) but the typical final e-competences acquired will be associated to the levels mentioned above. It is also important to note that while first cycle students (EQF 6) will mostly use standard design and implementation methods to solve problems that are already well known and clearly defined, students in the Second Cycle (EQF 7-8), must be placed in situations where they need to investigate the problem, justify and adapt their methodological choices, and propose creative solutions, coping as much as possible with real contexts. This is consistent to the concepts of highest levels in e-CF 8 (e.g., 4 and 5): they usually require solving problems in contexts similar to real situations (or directly in real situations) as only traditional learning would not be enough to reach such levels for competences.

e-CF level	Level description	Influence	Complexity	Autonomy	Behaviour
e-5	Overall accountability and responsibility; recognised inside and outside the organisation for innovative solutions and for shaping the future using outstanding leading edge thinking and knowledge.	Determines strategy	Unpredictable - unstructured	Demonstrates substantial leadership and independence in contexts which are novel requiring the solving of issues that involve many interacting factors.	Conceiving, transforming, innovating, finding creative solutions by application of a wide range of technical and/or management principles.
e-4	Extensive scope of responsibilities deploying specialised integration capability in complex environments; full responsibility for strategic development of staff working in unfamiliar and unpredictable situations.	Provides executive leadership		Demonstrates leadership and innovation in unfamiliar, complex and unpredictable environments. Addresses issues involving many interacting factors.	
e-3	Respected for innovative methods and use of initiative in specific technical or business areas; providing leadership and taking responsibility for team performances and development in unpredictable environments.	Consults	Structured – unpredictable	Works independently to resolve interactive problems and addresses complex issues. Has a positive effect on team performance.	Planning, making decisions, supervising, building teams, forming people, reviewing performances, finding creative solutions by application of specific technical or business knowledge / skills.
e-2	Operates with capability and independence in specified boundaries and may supervise others in this environment; conceptual and abstract model building using creative thinking; uses theoretical knowledge and practical skills to solve complex problems within a predictable and sometimes unpredictable context.	Applies and adapts	Structured – predictable	Works under general guidance in an environment where unpredictable change occurs. Independently resolves interactive issues which arise from project activities.	Designing, managing, surveying, monitoring, evaluating, improving, finding non-standard solutions. Scheduling, organising, integrating, finding standard solutions, interacting, communicating, working in team.
e-1	Able to apply knowledge and skills to solve straight forward problems; responsible for own actions; operating in a stable environment.	Implements instructions		Demonstrates limited independence where contexts are generally stable with few variable factors	Applying, adapting, developing, deploying, maintaining, repairing, finding basic-simple solutions.

4.5 Illustrative examples of modules for each category regarding Informatics Degrees

The subject topics listed here represent typical topics that can support the acquisition of the skills mentioned in the main document. They are not mandatory, and the list will not be used by evaluators to find a significant or even complete match. The expected skills can also be acquired through other topics.

Underlying Conceptual Basis for Informatics

Typical modules that can be used to develop these skills within **FCD programmes** include, e.g.:

- Mathematics and Stochastics
- Formal fundamentals, Logic and Algorithm theory
- Programming languages, Data types, Data structures and Objects
- Automata, machine models, and Computer architectures
- Operating systems
- Computer and communication networks
- Basics of the specialisation or the second discipline (e.g. Business management, Biological and medical basics, Design psychology, Game design, Basics of automotive technology, …),
- …

In **SCD programmes**, typical modules focus on the conceptual foundations of the programme's specialisation or on additional fundamentals of informatics that were not covered in the preceding FCD programmes.

Analysis

Regarding **FCD programmes**, typical modules that can be used to develop these skills are, e.g.:

- Software engineering and System architectures
- Modelling and Simulation
- Systems theory
- Data Analytics
- Computer and Communication networks
- Machine Learning
- Information security
- …

In **SCD programmes,** typical modules include analytical methods from the special focus of the Master's programme.

Design and Implementation

Typical courses of a FCD programme contributing to the learning outcome "specify and design computing/network hardware/software which meet specified requirements including time and budget constraints" include, e.g.:

- Computer Architecture and Organization
- Digital Systems Design
- Embedded Systems
- Network Design and Management
- Systems Engineering
- Software Engineering Fundamentals

Typical Courses contributing to the learning outcome "describe the phases involved in different life cycle models used for specifying, building, testing and commissioning new systems and for maintaining existing systems" include e.g.:

- Software Engineering
- Systems Analysis and Design
- Software Project Management
- IT Service Management
- Agile and DevOps Practices

Typical Courses contributing to the learning outcome "select and use appropriate process models, programming environments and data management techniques for projects involving traditional applications as well as emerging application areas" include e.g.:

- Software Development Methodologies
- Programming Paradigms
- Database System
- Cloud Computing
- Web and Mobile Application Development

Typical Courses contributing to the learning outcome "describe and explain the design of systems and interfaces for human-computer and computer-computer interaction" include e.g.:

- Human-Computer Interaction (HCI)
- User Interface Design
- Computer Networks
- Distributed Systems
- Internet of Things (IoT)

Typical Courses contributing to the learning outcome "apply relevant practical and programming skills to the creation of computer programs and/or other informatics artefacts" include e.g.:

- Introduction to Programming (e.g., Python, Java, C++)
- Object-Oriented Programming
- Software Development Lab
- Capstone Project
- Mobile App Development
- Web Programming

Typical Courses contributing to the learning outcome "identify and implement appropriate solution patterns, algorithms, and data structures, and apply systematic quality assurance" include e.g.:

- Data Structures and Algorithms
- Software Design and Architecture
- Software Testing and Quality Assurance
- Object-Oriented Programming
- Software Engineering
- Capstone Project / Software Development Lab

Typical Courses contributing to the learning outcome "use tools, processes, and algorithms for drawing knowledge and insight from data, as well as for creating Artificial Intelligence systems performing tasks typically associated with human intelligence" include e.g.:

- Data Science Fundamentals
- Machine Learning
- Artificial Intelligence
- Data Mining
- Neural Networks and Deep Learning
- Natural Language Processing

While First Cycle students typically use standard design and implementation methods to solve problems that are already well known and clearly defined, students in the **Second Cycle**, on the other hand, must be placed in situations where they need to investigate problems, justify and adapt their methodological choices, and propose creative solutions.

Economic, legal, social, ethical and environmental context

Although many aspects of this category have a transversal nature that make them relevant or recommendable in other categories as well, it is recommended that they be addressed in a specific module in each cycle, preferably at its beginning, so that other modules could assume the students have already acquired some basic concepts and skills, which allows to address more specific aspects:

For Graduates of a **First Cycle degree programme** this includes, e.g.:

- Awareness of recommended professional and ethical conduct and a knowledge of possible professional codes including applicable legal regulations
- Awareness of legal and compliance requirements in informatics including data protection, intellectual property rights, contracts, product safety and liability issues, personnel issues, sustainability (environmental, economic and social) and health, digital accessibility and safety
- Awareness on the need of adaptation of informatics practice to commercial, industrial, economic and social contexts
- Methods to embed compliance requisites (such as information privacy, security, accessibility, etc.) in the whole life cycle of informatics-based systems

Contents recommended for Graduates of a **Second Cycle degree** programme assuming they are already competent in first cycle contents, includes e.g.:

- Awareness and methods to promote a high level of professional and ethical and principled conduct in informatics teams
- Identification and analysis and explanation of impact of relevant legal, commercial, industrial, economic and/or social contexts related to a specific area of study and practice to lead adaptation of activities
- Identification, evaluation and management of the most relevant risks in any compliance aspect in a specific context or area of study

Informatics practice

An understanding of informatics practice can be achieved in a variety of ways, depending on both the student's and the department's situation. The key outcome is that the student (generally but not always as part of a team) is involved (not just as a spectator, or doing small tasks without understanding the bigger picture) in the informatics aspects of the production of an informatics artefact, which may be the informatics part of a larger whole.

"The informatics aspects" means that contributions consisting mainly of market surveys, literature reviews or product documentation are ruled out, however essential these may be. If Informatics Practice is done and assessed as group work, care must be taken to ensure that all students participate in the informatics aspects, and do not just work as, for example, "the documentation expert".

In **First Cycle degree programmes**, practical work typically first takes place in the department's laboratories. In lab courses, students practise, apply, and deepen their understanding of the contents they have learned in their lectures. Later in the curriculum, students participate in project work, in which larger groups of students typically tackle more comprehensive informatics tasks that require the integration of several different informatics skills. These tasks may already reflect real-world professional practice, such as the tasks of a virtual software organization producing products for customers (which may well be internal to the university).

In application-oriented programmes, a practical phase lasting several weeks or an entire practical semester is typically integrated, during which students gain insight into everyday professional practice in an industrial, governmental, charitable or other organisation that is mainly working on informatics tasks.

At the completion of their studies and as an integrative practical experience, graduating students will carry out a capstone project or perform some other major exercise (e.g. author a thesis) which provides an equivalent demonstration of Informatics Practice.

In **Second Cycle degree programmes**, lab courses primarily serve to practise and apply the skills that were newly acquired as part of the programme's specialization. In an individual project, which should generally account for at least 25% of an academic year, students are required to develop an informatics artefact to an agreed specification.

Projects and theses can be increasingly focused on research aspects, provided that the First Cycle pre-requisites have covered Informatics Practice adequately. Second Cycle programmes which take student from non-computing First Cycle programmes will need to include adequate Informatics Practice in the style of First Cycle computing and programming modules.

Other Professional Competences

The development of this type of competences is not always allocated to specific modules and courses, as they are inherently cross-disciplinary; therefore, it is not always possible or recommendable to rely solely on specific modules. However, it should be noted that relying on the transversal embedding in other modules (e.g., communication skills through presentations in a module on Software Project Management or in module on Mobile App Development) could imply several risks, including inconsistencies in the recommendations or the methodology for competency development, as well as reduced emphasis by instructors who focus more on technical aspects, etc. Therefore, this could require a really sophisticated coordination and specific training for instructors. One possible solution could be an introductory module at each cycle that addresses some of the most important behavioural skills necessary for succeeding in other modules and courses as in professional practice.

Typical contents for behavioural related to academic success in the **First Cycle** and for the targeted professional profile include, e.g.:

- Self-organisation and time management for autonomous learning and work
- Written communication for different types of audiences and contexts (plans, reports, documents, etc.)
- Oral communication, including effective presentations, for different types of audiences and context
- Awareness and methods for effective teamwork and collaboration in diverse teams and settings
- Information search and management with appropriate capacity of analysis and critical thinking

Contents recommended for Graduates of a **Second Cycle degree** programme, provided they are already competent in First Cycles contents, include, e.g.:

- Awareness and methods for continuous quality and learning improvement
- Methods for self-organisation for efficiency, initiative and exercising personal accountability
- Effective communication skills through diverse channels and media for a variety of audiences and preferably also in a second language
- Methods for leadership and management of teams composed of people from different disciplines and different levels of qualification
- Advanced information and analytical methods for comprehensive, critical and informed reviews of the state of the art in specific topics

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