2.1.2 Module developmentM02 Digital Technologies

Module Specification:

Digital Technologies.

Within the Erasmus+ KA2 Capacity Building Project (CBHE)

WORK4CE – Cross-domain competences for healthy and safe work in the 21st century

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1. Summary

Summary:

Digital Technologies module is designed to understand, communicate, and adapt to a digital world as it impacts learners personal life, society, and the business world. Students will not only understand the concepts, but apply their knowledge to situations and defend their actions/decisions/choices through the knowledge and skills acquired in this course. Employability skills are integrated into activities, tasks, and projects throughout the course standards to demonstrate the skills required by business and industry. Various forms of technologies will be highlighted to expose students to the emerging technologies impacting the digital world. Professional communication skills and practices, problem-solving, ethical and legal issues, and the impact of effective presentation skills are gained in this module as a knowledge to prepare students to the careers in business and industry.

The module starts with cloud/edge computing, that introduces the latest Cloud computing, Edge computing technologies.

After the cloud/edge computing technologies, the module continues with embedded systems which is growing rapidly, driven by the continued development of Artificial Intelligence (AI), Virtual Reality (VR) and Augmented Reality (AR), and the Internet of Things (IoT). This course is designed to enable students develop theoretical and practical knowledge about embedded systems hardware as well as acquire skills in programming embedded processors.

After that the module continues with elective courses including Robotics/cyber physical systems, Block chain technology, Cyber security, Data/digital /Tele communication and Augmented/virtual reality.

Robotics/cyber physical systems course introduces students to the principles underlying the design and analysis of cyber-physical systems. The students will gain both in-depth knowledge and hands-on experience on the specification, modeling, design, and analysis of representative cyber-physical systems.

Block chain technology course provides a broad overview of the essential concepts of blockchain technology which is an emerging technology platform for developing decentralized applications and data storage, over and beyond its role as the technology underlying the cryptocurrencies.

Cyber Security course will provide a basic introduction to of all aspects of cyber-security including business, policy and procedures, communications security, network security, security management, legal issues, political issues, and technical issues. With this course students will understand the different types of malware and security breaches and develop effective prevention methods which will increase overall security. They will also understand the basic concepts associated with Cyber Security and what a company needs to stay secure.

Data/digital/Tele communication course familiarizes the students with the basics of data communications, OSI model and techniques, applications and control of modern data communications networks.

Augmented/virtual reality course covers the technical and experiential design foundation required for the implementation of immersive environments in current and future virtual, augmented and mixed reality platforms. The
course covers a wide range of literature and practice including the evolution of all supporting technologies including visual displays for VR, AR and MR, motion tracking, interactive 3D graphics, multimodal sensory integration, immersive audio and user interfaces.

The core courses and electives include:

- Cloud/edge computer (core)
- Embedded systems (core)
- Robotics
- Block chain
- Cyber security
- Data/digital/Tele communication
- Augmented/virtual reality
- (AI: development in M01)

Table of Content

2. Introduction to the module

Digital Technologies module is designed to understand, communicate, and adapt to a digital world as it impacts learners personal life, society, and the business world. Students will not only understand the concepts, but apply their knowledge to situations and defend their actions/decisions/choices through the knowledge and skills acquired in this course. Various forms of technologies will be highlighted to expose students to the emerging technologies impacting the digital world. Professional communication skills and practices, problem-solving, ethical and legal issues, and the impact of effective presentation skills are gained in this module as a knowledge to prepare students to the careers in business and industry.

The module starts with cloud/edge computing, that introduces the latest Cloud computing, Edge computing technologies. Cloud computing enables on-demand access to computing and data storage resources that can be configured to meet unique constraints of the clients with minimal management overhead. The recent rise in the availability of cloud services makes them attractive and economically sensible for clients with limited computing or storage resources who are unwilling or unable to procure and maintain their own computing infrastructure. Amazon Elastic Cloud, Microsoft's Azure, Google App Engine, and many other Cloud offerings give mature software vendors the option to deploy their applications to systems of infinite computational power with practically no initial capital investment and with modest operating costs proportional to the actual use.

The objective of this course is to provide students with the comprehensive and in-depth knowledge of Cloud Computing concepts, technologies, architecture and applications by introducing and researching state-of-the-art in Cloud Computing fundamental issues, technologies, applications and implementations. Completing this course should provide students with a good understanding of cloud computing and a systematic knowledge of the fundamental technologies, architecture, storage services, virtualization, cloud performance, security and privacy Issues, edge computing.

After the cloud/edge computing technologies, the module continues with embedded systems which is growing rapidly. This course is designed to enable students develop theoretical and practical knowledge about embedded systems hardware as well as acquire skills in programming embedded processors.

After that the module continues with elective courses including Robotics/cyber physical systems, Block chain technology, Cyber security, Data/digital /Tele communication and Augmented/virtual reality.

Robotics/cyber-physical systems integrate calculations, communication and physical processes, and can thereby give rise to completely new systems, from small-scale applications to large-scale, such as intelligent transport and energy systems. By integrating new technology and connected it with new business models, cyber-physical systems are given novel abilities, leading to unimagined possibilities for innovation, but also to new risks. Cyber-physical systems are increasingly being used in open societal context and various sectors. This course introduces students to the principles underlying the design and analysis of cyber-physical systems. The students will gain both in-depth knowledge and hands-on experience on the specification, modeling, design, and analysis of representative cyber-physical systems.

Blockchain is an emerging technology platform for developing decentralized applications and data storage, over and beyond its role as the technology underlying the cryptocurrencies. The basic tenet of this platform is that it allows one to create a distributed and replicated ledger of events, transactions, and data generated through various IT processes with strong cryptographic guarantees of tamper resistance, immutability, and verifiability. Considering the need to disseminate the emerging concepts for students, the content of this course is covered with the necessary knowledge and skills related to blockchain technology such that it covers topics as decentralization using blockchain, basic distributed computing & crypto primitives, bitcoin basics, Ethereum basics, privacy, security issues in blockchain.

Cybersecurity has become instrumental to economic activity and human rights alike. But as digital technologies penetrate deeply into almost every aspect of human experience, a broad range of social-political-economic-legal-ethical-military and other considerations have come to envelop the cybersecurity landscape. This course will provide a basic introduction to of all aspects of cyber-security including communications security, network security, security management, legal issues, political issues, and technical issues. With this course students will understand the different types of malware and security breaches and develop effective prevention methods which will increase overall security.

Data communication field has been growing with rapid technological progress. By considering, importance of networking in day today life, it is essential for students to know the basic concept of data communication like network classification, signals and signal encoding techniques, transmission media, error detection and correction techniques, communication technologies.The aim of this course is to help the student to attain industry identified competencies through various teaching learning experiences given in this program description.

Virtual Reality (VR) has been the "next big thing" for several years, but its time has finally come as a way to generate realistic images, sounds, and other sensations that put you smack in the middle of a spectacular imaginary world. Augmented Reality (AR), which adds virtual stuff to the real world environment, is contributing to the buzz, and both technologies should become a big part of our future. Augmented/virtual reality course covers the technical and experiential design foundation required for the implementation of immersive environments in current and future virtual, augmented and mixed reality platforms.

3. Module Description

3.1 Overall Learning Outcomes

This chapter summarizes the main learning outcomes and learning goals of the module.

Learning outcomes are defined as statements of what a learner knows, understands and is able to do upon completion of a learning process. In the European Qualification Framework (EQF) [1,2], learning outcomes are therefore defined in terms of knowledge, skills and competence which are understood as follows [3]:

- **Knowledge** means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual.
- **Skills** means the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive or practical skills.
- **Competence** means the proven ability to use knowledge, skills and personal, social and methodological abilities in work or study situations and in professional and/or personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy.

Learning Outcomes, Competences and Qualifications should be formulated according to the **European Qualification Framework (EQF)** [1] and the **European Standards and Guidelines (ESG)** [2]. A guideline for the formulation of learning outcomes is given in [3].

Learning Outcomes/Competences need to consider several competence domains [4]:

- **Technical Competence**: This reflects the domain-specific competences, e.g. in engineering or software development. It is beyond tool skills, reflecting the full competence range (knowledge, skills, ability) in order to perform a job in a certain job domain (e.g. engineering competence for developing an engine, business competences for implementing a marketing plan).
- **Professional Competence**: This covers competences relevant for professional life, e.g. management competences, negotiation and presentation skills, team-related competences, legal topics, but also personal competences, e.g. critical thinking.
- **Global Competence**: This covers all intercultural and international competences, e.g. language skills, knowledge of different markets /countries, but also citizen competences, e.g. ethics, political and social awareness.

The concept of **Overarching Learning Outcomes (OLO)** combines mainly professional and global competences with some technical skills (e.g. IT literacy) into a competence portfolio which is learned/taught/delivered over several modules or inherently by using certain didactic formats (e.g. projects, presentations, team work) [5].

Therefore, this chapter should summarize the **Core Learning Outcomes** (mainly technical and professional competences) and the **Overarching Learning Outcomes** (mainly professional and global competences). This should be connected to the **Key Topics** of the module and the **Philosophy**, e.g. a more scientific/theoretical module, practically/project-oriented, focussed on learning experience (e.g. OLOs), with external partners, etc..

3.2 Target Group Analysis

This chapters lists the target groups (e.g. students, professionals, executives) with respect to the learners and the teachers addressed by the module. The target groups are assessed and described in terms of their specific:

- Characteristics,
- Previous competence and Prerequisites
- Needs (content, didactics, formats, time budget, …)
- Competence Goals
- Prospective Job Field

Target groups should be clustered into max. 3-4 groups since these groups will be the base for the tailoring options (see 3.7) of the module. The module will be like a portfolio which can be tailored to the needs and preferences of each of the target groups.

3.3 Competences & Learning Outcomes

3.3.1 Module technical course "Cloud/edge computing" (Core course: obligatory)

Knowledge:

- The student will learn the fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits, as well as current and future challenges;
- The student will be introduced to different virtualization techniques that serve in offering cloud services on the cloud;
- The student learn how to manage cloud storage technologies

Skills:

- Student can explain the core concepts of the cloud computing paradigm.
- Identify the architecture and services and deployment models of cloud computing.
- Explain security and privacy issues of cloud computing.
- Identify problems, and explain, analyze, and evaluate various cloud computing solutions.
- Discuss virtualization and outline their role in enabling the cloud computing system model.

General competences:

- Completing this course should provide students with a good understanding of cloud/edge computing and a systematic knowledge of the fundamental technologies, architecture, and security.

3.3.2 Module technical course "Embedded systems" (Core course: obligatory)

Knowledge:

- The student will learn definition, history and elements of an embedded system
- Understand the characteristics of Embedded system
- Understand in general the difference in programming software for general purpose computers and embedded systems
- Know the difficulties involved in programming embedded systems

Skills:

- Underline the history of embedded systems
- Classify embedded systems based on performance, complexity and the era in which they evolved
- Explain the domains and areas of applications of embedded systems
- Identify the different purposes of embedded systems
- Explain characteristics, operational and nonoperational quality attributes, application specific embedded systems.
- Differentiate between embedded and general computing systems

General competences:

- Completing this course should provide students with a good understanding of the basic building blocks of embedded systems and be able to use embedded system development platforms and environments.

3.3.3 Module technical course "Robotics/cyber physical systems" (Technical course: elective)

Knowledge:

- Have an overview of the characteristics of cyber-physical systems, as well as the role of collaborative and robotics in the improvement of industrial processes
- The candidate can explain the structure and purpose of industrial robots
- the term kinematics in the context of robotics
- the purpose of and the general functionality of ROS

Skills:

- Student can define what cyber-physical systems are and highlight the main challenges they currently face
- Enumerate several fields where cyber-physical systems are widely used nowadays or are bound to become relevant in the near future
- Identify the different types of robots and indicate which are best suited for a given application
- Be familiar with the main sensors used in a robot
- Understand and be able to implement the most common localization algorithms
- Explain why when a robot is placed in an unknown position of a previously unexplored environment, it has to estimate its current location and build the map simultaneously
- Deal with unexpected obstacles during navigation
- Understand the structure of the Robot Operating System
- Develop, implement, and test algorithms in an autonomous manner

General competences:

- Design and implementation of robot systems

3.3.4 Module technical course "Block chain technology" (Technical course: elective)

Knowledge:

- The student will learn core Blockchain concepts, the benefits, and the limitations of blockchain technologies
- The student will state the key differentiators for blockchain from other technology systems
- Demonstrate knowledge of the key stakeholders in the blockchain ecosystem

Skills:

- Student can describe the basic concepts and technology used for blockchain
- Describe the primitives of the distributed computing and cryptography related to blockchain
- Illustrate the concepts of Bitcoin and their usage
- Implement Ethereum block chain contract
- Apply security features in blockchain technologies

General competences:

- Completing this course Students will have full understanding of Blockchain technology.

3.3.5 Module technical course "Cyber security" (Technical course: elective)

General competences:

- Completing this course Students will learn basic knowledge and skills in the fundamental theories and practices of Cyber Security.

Knowledge:

- The student will learn all aspects of cyber-security including communications security, network security, security management, legal political and technical issues.
- The student should be able to describe typical threats to modern digital systems, and to outline techniques of defense against each threat.
- The student should be able to describe the popular computer and network security mechanisms and protocols
- The student should be aware of the difficulty of security problems

Skills:

- Student can understand the broad set of technical, social & political aspects of Cyber Security
- Appreciate the vulnerabilities and threats posed by criminals, terrorist and nation states to national infrastructure
- Understand the nature of secure software development, operating systems and database design
- Recognized the role security management plays in cyber security defense
- Understand the security management methods to maintain security protection
- Understand the legal and social issues at play in developing solutions.

General competences:

- Completing this course Students will learn basic knowledge and skills in the fundamental theories and practices of Cyber Security.

3.3.6 Module technical course "Data/digital/Tele communication" (Technical course: elective)

Knowledge:

- The student should be able to explain reference models for data communications, their layers and corresponding functions, services and protocols
- The student should be able to describe the protocol techniques, local area networks and how Internet is built
- The student will learn information sharing and networks
- Introduce flow of data, categories of network, different topologies
- Having clear idea of signals, transmission media, errors in data communications and their correction, networks classes and devices, etc.

Skills:

- Student will have the basic knowledge of computer networks.
- Understanding of the basic concepts of data communications and networking
- Demonstrate understanding of the basic concepts of error detection, checking, and correction
- Demonstrate understanding of the various switching methodologies, networking concepts.
- Analyze data communication systems and its impact on individuals, organizations and society.
- Understand the use of LAN components
- Analyze various modulation techniques

General competences:

- Understand importance of data communication systems and fundamentals.

3.3.7 Module technical course "Augmented/virtual reality" (Technical course: elective)

Knowledge:

- The student will learn historical and modern overviews and perspectives on virtual reality
- The student will learn fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems.
- The student will learn fast growing field of AR and be aware of the various AR devices.

Skills:

- Describe how VR systems work and list the applications of VR.
- Understand the system of human vision and its implication on perception and rendering
- Explain the concepts of motion and tracking in VR systems
- Describe the importance of interaction and audio in VR systems
- Describe how AR systems work and list the applications of AR.
- Understand and analyze the hardware requirement of AR.
- Use computer vision concepts for AR and describe AR techniques

General competences:

- Completing this course the student will learn historical and modern overviews and perspectives of virtual reality and augmented reality

3.4 Content

The Module M02 Digital technolgies (8ECTS)

- Cloud/edge computing (2 ECTS)
- Embedded Systems (2 ECTS)

And electives on the technical topics (minimum 2 electives)

Core courses:

1. Cloud/edge computing (2 ECTS)
    - Introduction to Cloud Computing
    - Cloud Architecture
    - Cloud Deployment Models
    - Cloud Service Models
    - Cloud Service Providers
    - Introduction to Edge Computing
    - Edge Architecture
2. Embedded Systems (2 ECTS)

    - Introduction to Embedded Systems
    - Core components
    - Characteristics and quality attributes of embedded systems
    - Programming Embedded Systems
    - Embedded hardware and Peripherals
    - Design and Development

Elective courses: (2 ECTS each electives)

1. Robotics/cyber physical systems
    - Cyber-physical systems
    - Introduction to robotics
    - Perception and locomotion
    - Localization
    - Motion planning
    - Robot Operating System (ROS)
2. Block chain technology
    - Introduction to blockchain technology
    - Decentralization using blockchain
    - Basic Distributed Computing & Crypto primitives
    - Bitcoin basics
    - Ethereum basics
    - Privacy, Security issues in Blockchain
3. Cyber security

    - Introduction to Computer Security
    - Authentication and Access Control
    - Secure Programs and Programming
    - The Web Security
    - Operating System Security
    - Network Security
    - Data and Database Security
    - Cloud Security
    - Management and Incidents
    - Legal Issues and Ethics

4. Data/digital/Tele communication

    - Introduction to data communication and networking
    - Data Communication
    - Signals and Encoding Techniques
    - Multiplexing
    - Transmission Media
    - Error Detection and Correction
    - Communication Networks
    - Communication Technologies:

5. Augmented/virtual reality

    - Introduction to Virtual Reality
    - Representing the Virtual World
    - The Geometry of Virtual Worlds
    - Visual Perception & Rendering
    - Motion & Tracking
    - Interaction & Audio
    - Introduction to Augmented Reality (A.R)
    - Augmented Reality Hardware
    - Computer Vision for Augmented Reality
    - AR Software
    - AR Techniques
    - AR Devices & Components

3.5 Teaching & Learning Activity Plan

1. **A) Select Teaching/learning methods per competence**

- **Theoretical knowledge:** virtual lecture, distance learning materials, online module. Learning outcome – performance of given assignments. Main format – e-learning.

- **Practical skills:** case study, workshops, projects. Learning outcome – project presentations, workshop and cases study activities evaluation. Main format – workshop, project presentations.
- **Scientific work:** seminar or homework. Learning outcome: scientific context. Main format: individual scientific contribution.

The module is thought as a tutorized online version where the student will receive an introduction to the basic knowledge which she/he will have to apply to specific assignments.

It will require:

- Participation of students in the online life lecturing
- Individual study of available materials
- Development of individual and team assignments

B) Define didactic concept:

The Module M02 Digital Technologies is conceived as containing 2 compulsary courses:

- Cloud/edge computing (2ECTS)
- Embedded systems (2 ECTS)

And electives on the technical topics (minimum 2 electives)

All courses contain a theoretical part which will be taught with the use of webinars, knowledge clips and local classroom teaching.

For the skills part of the technical courses lab sessions will be used to train hands-on. Labs can be either physical labs, either virtual or remote labs, depending on the course.

For each course a (number of) reference book(s) is given as either compulsory either extra literature.

Most of the lab sessions use a problem-based approach.

- (Virtual) Lecture, Online course, ebook, distance learning …
- Projects, problem-based
- Case-based, challenge-based

C) Define an Activity Plan:

The core courses start at the beginning of the semester. The assignments and study of case studies can be delayed till the last weeks of the semester, to integrate the knowledge of the electives/labs.

Activity 1: Theory classes on **Cloud/edge computing, Embedded systems and all electives** via webinars, knowledge clips and local classroom teaching (15 x 2 h = 30 h).

- The theory classes are complemented with online tutorials and reading materials

Activity 2: Homework: writing a project management manual for a project case study (15 h)

Students write the manual based on an approved project case study (can be provided by university or submitted by student) and by using a given template for the project manual (e.g. IPMA compliant)

Activity 3: Project simulation in teams (e.g. 3-4 students) => 30 h

- Students conduct the example project outlined in one of the project manuals. Roles are assigned and students produce the relevant project documents and artefacts. A “project kick-off presentation” and a “project end presentation” are provided (each one with 15-20 min presentation time).

- Alternative A for Activity 3: Project internship in a company (1 week)

- Alternative B for Activity 3: Present a project case from own job

3.6 Teaching & Learning Resources

- Communication software for collaboration work (Microsoft Teams, Zoom, Google meet)
- Communication technologies for online learning (Moodle)
- Software for presentation (Microsoft PowerPoint, Google Slides)

- High-Speed Internet Connection
- Microphone, web camera, graphics tablet, stream projector
- Hardware and software for the learning process (presentation materials, cooperation work, communication, JIRA)
- Learning Management System (Moodle)

3.7 Tailoring & Educational Tracks

Educational Tracks:

- Practical:
- Entrepreneurial:
- Scientific:

List the main tailoring options foreseen in the module design, e.g. range of ECTS (4-8), tailoring for target groups (students, professionals, …) and possible educational tracks.

3.8 Assessment Methods

Assessment, Self-Assessment, Peer-Assessment

Example (from project management module):

FORM	**%**	**REMARK**
Written exam	30	Based on theory classes
Homework: project manual	30	
Team presentation 1 for project simulation (activity 3)	20	Project kick-off presentation
Team presentation 1 for project simulation (activity 3)	20	Project end presentation

3.9 Curricula Integration

Integrate in which study programmes?

How to integrate into the curriculum?

Educational packages (e.g. minor)?

3.10 Quality Assurance - Evaluation

Quality Assurance - Evaluation

4. Syllabus/Module Handbook

Entry for the Syllabus/Module Handbook (Example for “Managing Digital Change”

Digital Technologies (MOD-E02)

Module Owner	**Workload**	**Credits**	**Semester**	**Frequency**	**Duration**
xxx	180 h	6 ECTS	*2*	*summer semester*	1 Semester

	Course Title	**Contact hours**	**Self-Study**	**Planned Group Size**
1	Digital Technologies	4 hours per week / 60 h in total	120 h	25 students

2 Course Description

Digital Technologies module is designed to understand, communicate, and adapt to a digital world as it impacts learners personal life, society, and the business world. Students will not only understand the concepts, but apply their knowledge to situations and defend their actions/decisions/choices through the knowledge and skills acquired in this course. Employability skills are integrated into activities, tasks, and projects throughout the course standards to demonstrate the skills required by business and industry. Various forms of technologies will be highlighted to expose students to the emerging technologies impacting the digital world. Professional communication skills and practices, problem-solving, ethical and legal issues, and the impact of effective presentation skills are gained in this module as a knowledge to prepare students to the careers in business and industry.

3 Course Structure

1. Cloud/edge computing (2 ECTS)
   - Introduction to Cloud Computing
   - Cloud Architecture
   - Cloud Deployment Models
   - Cloud Service Models
   - Cloud Service Providers
   - Introduction to Edge Computing
   - Edge Architecture
2. Embedded Systems (2 ECTS)
   - Introduction to Embedded Systems
   - Core components
   - Characteristics and quality attributes of embedded systems
   - Programming Embedded Systems
   - Embedded hardware and Peripherals

- Design and Development

Elective courses: (2 ECTS each electives)

1. Robotics/cyber physical systems
   - Cyber-physical systems
   - Introduction to robotics
   - Perception and locomotion
   - Localization
   - Motion planning
   - Robot Operating System (ROS)
2. Block chain technology
   - Introduction to blockchain technology
   - Decentralization using blockchain
   - Basic Distributed Computing & Crypto primitives
   - Bitcoin basics
   - Ethereum basics
   - Privacy, Security issues in Blockchain
3. Cyber security

   - Introduction to Computer Security
   - Authentication and Access Control
   - Secure Programs and Programming
   - The Web Security
   - Operating System Security
   - Network Security
   - Data and Database Security
   - Cloud Security
   - Management and Incidents
   - Legal Issues and Ethics

4. Data/digital/Tele communication

   - Introduction to data communication and networking
   - Data Communication
   - Signals and Encoding Techniques
   - Multiplexing
   - Transmission Media
   - Error Detection and Correction
   - Communication Networks
   - Communication Technologies:

5. Augmented/virtual reality

   - Introduction to Virtual Reality
   - Representing the Virtual World
   - The Geometry of Virtual Worlds
   - Visual Perception & Rendering
   - Motion & Tracking
   - Interaction & Audio
   - Introduction to Augmented Reality (A.R)
   - Augmented Reality Hardware
   - Computer Vision for Augmented Reality
   - AR Software
   - AR Techniques
   - AR Devices & Components

4	**Application Focus** Students will be guided through a case study project where they plan a digital transformation project for an example case. This example case will be taken preferably from a real company project. Companies can bring their digital transformation projects as a case study for a block week or summer school workshop. Students form teams to prepare the respective project and present it in a kick-off presentation to the companies.
5	**Scientific Focus** Literature review and analysis. Deductive own research based on the literature. Scientific reflection and discussion in the teams.
6	**Parameters** • ECTS: 8 • Hours of study in total: 240 • Weekly hours per semester: 8 - Contact hours: 120 - Self-Study hours: 120 • Course characteristics: core (4 ECTS) and elective (4 ECTS) • Course frequency: every year - summer semester • Maximal capacity: 25 students • Course admittance prerequisites: none • Skills trained in this course: theoretical, practical and scientific skills and competences • Assessment of the course: contributions within case study project (team presentation) (50%) and written paper (literature review, report or survey, approx. 25 pages) and presentation (in class or at a student conference, e.g. XXX (PM Kiev)) (50%) • Teaching staff: teachers from Open Community of Practice
7	**Learning outcomes** 6.1 Knowledge • The student will learn definition, history and elements of digital technologies • The student will learn the fundamental ideas behind digital technologies, the evolution of the paradigm, its applicability; benefits, as well as current and future challenges;

	• The student can explain the structure and purpose of digital technologies • The student will learn core concepts, the benefits, and the limitations of digital technologies 6.2 Skills • Student can explain the core concepts of the digital technology paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges. • Identify the architecture and infrastructure of digital technologies. • Explain the core issues of digital technologies. • Identify problems, and explain, analyze, and evaluate various digital technology solutions. 6.3 Competence – ability & attitude • Completing this course should provide students with a good understanding of digital technologies and a systematic knowledge of the fundamental technologies, architecture, and security. • Understand importance of digital technologies
8	**Teaching and training methods** • lectures introducing concepts, methods and tools, own literature reading • group work in the case study project to practice concepts and methods, to develop skills and to work on case studies • presentations to communicate results and do a scientific discussion and reflection
9	**Curricula Integration** None
10	**References** F. Ning, W. Zhou, F. Zhang, Q. Yin and X. Ni, "The architecture of cloud manufacturing and its key technologies research," *2011 IEEE International Conference on Cloud Computing and Intelligence Systems*, 2011, pp. 259-263, doi: 10.1109/CCIS.2011.6045071. HungChang Hsiao; MinHsiung Hung; ChaoChun Chen; YuChuan Lin, "Cloud Computing, Internet of Things (IoT), Edge Computing, and Big Data Infrastructure," in *Industry 4.1: Intelligent Manufacturing with Zero Defects* , IEEE, 2022, pp.129-167, doi: 10.1002/9781119739920.ch4. Y. Kinoshita, Y. Matsuno, H. Takamura and M. Takeyama, "Toward User Oriented Dependability Standard for Future Embedded Systems," *2009 Software Technologies for Future Dependable Distributed Systems*, 2009, pp. 132-137, doi: 10.1109/STFSSD.2009.37. D. P. Plakhotnikov and E. E. Kotova, "Design and Analysis of Cyber-Physical Systems," *2021 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (ElConRus)*, 2021, pp. 589-593, doi: 10.1109/ElConRus51938.2021.9396364. J. Hajny, S. Ricci, E. Piesarskas, O. Levillain, L. Galletta and R. De Nicola, "Framework, Tools and Good Practices for Cybersecurity Curricula," in *IEEE Access*, vol. 9, pp. 94723-94747, 2021, doi: 10.1109/ACCESS.2021.3093952. B. Ravishankar and P. Kulkarni, "When Block Chain and AI Integrates," *2020 International Conference on Mainstreaming Block Chain Implementation (ICOMBI)*, 2020, pp. 1-4, doi: 10.23919/ICOMBI48604.2020.9203037. M. Rath, "A review of Artificial Intelligence Emerging technologies and challenges in Block Chain Technology," *2019 International Conference on Smart Systems and Inventive Technology (ICSSIT)*, 2019, pp. 1031-1035, doi: 10.1109/ICSSIT46314.2019.8987807.

5. References

- http://www.coppeliarobotics.com
- https://mathworks.com/products/computer-vision.html
- https://mathworks.com/products/robotics.html
- http://www.ros.org
- Narayanan, Bonneau, Felten, Miller and Goldfeder, “Bitcoin and Cryptocurrency Technologies – A Comprehensive Introduction”, Princeton University Press, 2016.
- Josh Thompson, ‘Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming’, Create Space Independent Publishing Platform, 2017.
- Imran Bashir, “Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained”, Packt Publishing.
- Merunas Grincalaitis, “Mastering Ethereum: Implement Advanced Blockchain Applications Using Ethereum-supported Tools, Services, and Protocols”, Packt Publishing.
- Prof. Sandip Chakraborty, Dr. Praveen Jayachandran, “Blockchain Architecture Design And Use Cases”[MOOC], NPTEL: https://nptel.ac.in/courses/106/105/106105184/
- Arshdeep Bahga, Vijay Madisetti, “Blockchain Applications: A Hands On Approach”, VPT, 2017.
- Andreas Antonopoulos, Satoshi Nakamoto, “Mastering Bitcoin”, O”Reilly, 2014.
- Roger Wattenhofer, “The Science of the Blockchain” CreateSpace Independent Publishing, 2016.
- Alex Leverington, “Ethereum Programming” Packt Publishing, 2017.
- William Stallings, “ Data & Computer Communications” 10th Edition, 2014, Prentice Hall
- Behrouz Forouzan, Catherine Ann Coombs, Sophia Chung Fegan, “Introduction to Data Communications & Networking", Mcgraw-Hill College; 1st edition (August 1, 1997), ISBN-13: 978-0256230444
- Dr. Tavanam Venkata Rao, Dr. U. Yedukondalu, Dr. S. Ravi Chand, LAP LAMBERT Academic Publishing (August 11, 2021), 188 pages, ISBN-10 ： 6204198327
- Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
- Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)”. Morgan Kaufmann
  Publishers, San Francisco, CA, 2002

- Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
- Allan Fowler-AR Game Development, 1st Edition, A press Publications, 2018, ISBN 978-1484236178
- Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education; First edition (12 October 2016),ISBN-10: 9332578494