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SEnDIng

D2.3

VOCATIONAL CURRICULA/EDUCATIONAL MODULES FOR DATA SCIENCE AND INTERNET OF THINGS VET PROGRAM

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SEnDIng

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PROJECT SUMMARY

SEnDIng project aims to address the skills' gap of Data Scientists and Internet of Things engineers that has been identified at the ICT and other sectors (e.g. banking and energy) at which Data Science and Internet of Things have broad applications. To achieve this goal, SEnDIng will develop and deliver to the two aforementioned ICT-related occupational profiles two learning outcome-oriented modular VET programmes using innovative teaching and training delivery methodologies.

Each VET program will be provided to employed ICT professionals into three phases that include: (a) 100 hours of on-line asynchronous training, (b) 20 hours of face-to-face training and (c) 4 months of work-based learning. A certification mechanism will be designed and used for the certification of the skills provided to the trainees of the two vocational programs, while recommendations will be outlined for validation, certification & accreditation of provided VET programs.

Furthermore, SEnDIng will define a reference model for the vocational skills, e-competences and qualifications of the targeted occupational profiles that will be compliant with the European eCompetence Framework (eCF) and the ESCO IT occupations, ensuring transparency, comparability and transferability between European countries.

Various dissemination activities will be performed – including the organization of one workshop at Greece, Bulgaria and Cyprus and one additional conference at Greece at the last month of the project – in order to effectively disseminate project's activities and outcomes to the target groups and all stakeholders. Finally, a set of exploitation tools will be developed, giving guides to stakeholders and especially companies and VET providers, on how they can exploit project's results.

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1 Introduction

The scope of the deliverable is present the curriculum of the VET program that will be delivered to ICT professionals who are working with Data Science and Internet of Things technologies. The VET program is divided into three curricula: Data Science, Internet of Things and Transversal skills.

The structure of the deliverable is as follows:

- Section 2 gives the definition of the main terms used at the deliverable.
- Section 3 describes the methodology used for the design of the curriculum.
- Section 4 describes the Data Science curriculum. Initially are outlined the Data Science curriculum goals and objectives and then are described the educational modules of the curriculum. A proposal regarding the Data Science training requirements for different professional roles is given is given at the end of Section 4.
- Section 5 describes the Internet of Things curriculum. Initially are outlined the Internet of Things curriculum goals and objectives, and then are described the educational modules of the curriculum. A proposal regarding the Data Science training requirements for different professional roles is given is given at the end of Section 5.
- Finally, Section 6 describes the transversal skills curriculum.

2 Definitions

The definition of the main terms used in this deliverable is the following.

- **Curriculum**: A curriculum is a normative document (or a collection of documents) setting the framework for planning learning experiences. Depending on the country, the type of education and training, and the institution, curricula may define, among other, learning outcomes, objectives, contents, place and duration of learning, teaching and assessment methods to a greater or to a lesser extent [4].
- **Learning outcomes**: statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence [5].
- **Knowledge**: the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual [5].

- **Skill**: 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 (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments) [5].
- **Competence**: the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy [5].

3 Methodology for VET curriculum development

The methodology applied for the development of SEnDIng VET curriculum is based on the **constructive alignment approach**. The constructive alignment is an approach to curriculum design that maximises the conditions for quality learning by ensuring alignment throughout the process, from the forming of learning outcomes, to the choice of teaching methods to assessment. It assumes that when learning objectives, assessment methods, and teaching and learning activities are intentionally aligned, that the outcomes of learning are improved substantially [1]. The process of constructive alignment emphasizes that students are central to the creation of meaning, and must be provided with opportunities to actively select, and cumulatively construct their own knowledge [2]. According to Biggs,

"The fundamental principle of constructive alignment is that a good teaching system aligns teaching method and assessment to the learning activities stated in the objectives so that all aspects of this system are in accord in supporting appropriate student learning."

The elements involved in the process of constructively aligning the educational modules are three:

1. Defining the learning outcomes.
2. Choosing the learning and teaching methods that can lead to attainment of outcomes.
3. Assessing student learning outcomes.

Furthermore, the curriculum development process consists of three stages:

1. Defining curriculum goals and learning outcomes.
2. Developing teaching methods and forms of assessment. Develop the teaching methods and forms of assessment covering the tree phases of VET programs: online, face to face and work based learning. The assessment methods should be

in accordance with the learning outcomes of the module and should foster a deep approach to learning.

3. Reviewing and refining the curriculum. The curriculum review cycle is defined as a systematic approach to evaluating, reviewing and revising VET curricular within a specific timeframe which aims to identify gaps and weaknesses with a view to increasing curriculum effectiveness and continually improving VET learner/student learning experiences [3]. Normally it involves several phases including: research and selection; revision and development; implementation; and evaluation and monitoring. Reviewing is not a retrospective process, but it is an integral part of the module development, informing you before, during and after the process.

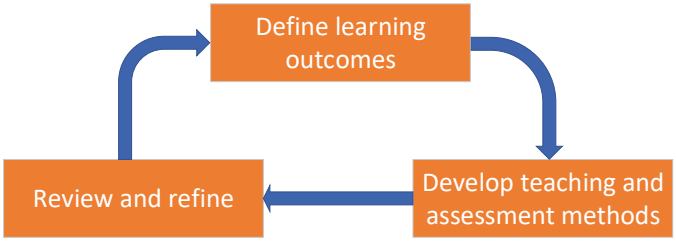


Figure 1: Curriculum development process

The curriculum follows a modular approach to fit to the specific needs of each learner and permit to each learner to build its own learning path. It is structured by educational modules and training units. Each educational module is divided into training units at three levels of proficiency:

- **Introductory** (I): The educational module is introduced and its most important facts are given.
- **Core** (C): All core aspects, principles and methods of the module are covered in sufficient detail as necessary to apply the knowledge and skills on the job. The learner becomes able to discuss matters with other stakeholders and acquire more knowledge when necessary.
- **Advanced** (A): Advanced aspects of the module are covered in sufficient detail as necessary to apply the knowledge and skills on the job.

The structure of a training unit is depicted in Figure 2. It includes the following elements:

- **Objectives.** The objectives of the training unit indicating its general direction or orientation in terms of its content.
- **Learning outcomes.** The learning outcomes of the training unit in terms of knowledge, skills and competences.

- **Content.** The content of the training unit
- **Learning methodologies.** The learning methodologies applied for the delivery of the training unit
- **Assessment methodologies.** The methodologies applied for the assessment of the learning outcomes
- **Duration.** The duration of the training unit duration. The indicative duration of each training unit is as follows: (a) Introduction: 1 to 2 hours, Core: 3 hours to 10 hours and Advanced: 5 hours to 10 hours.
- **Pre-requisite.** Pre-requisite knowledge and skills to attend the training unit.

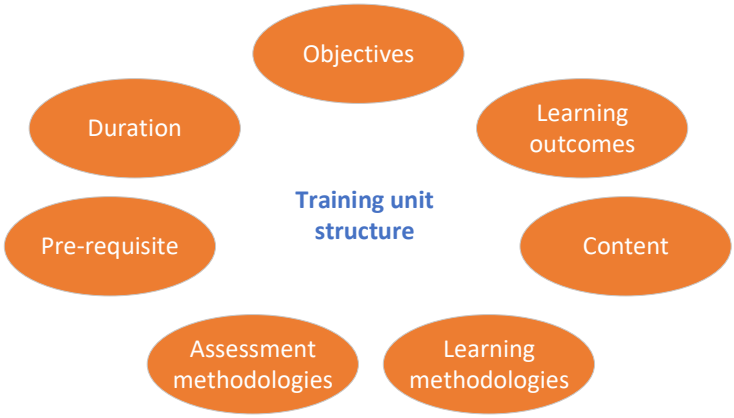


Figure 2: Training unit structure

4 Data Science

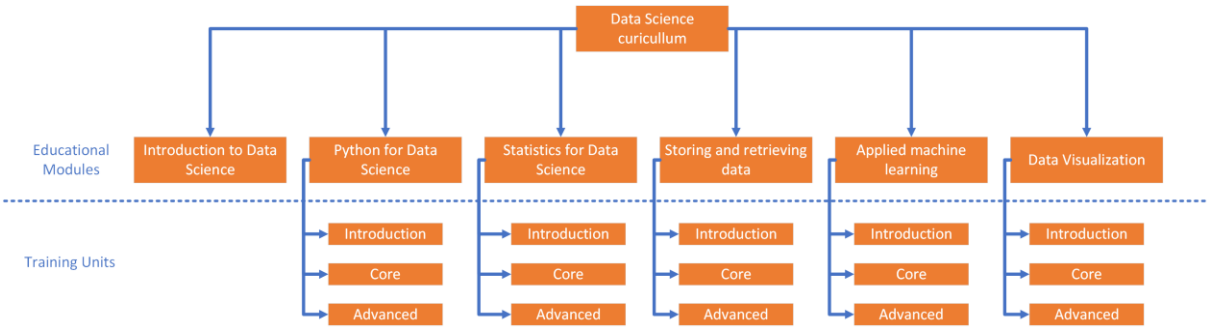
4.1 Data Science educational modules and training units

The Data Science educational modules are:

1. **Introduction to Data Science (DS-EM1)**. In this educational module learners will be introduced to Data Science and its application at various disciplines. The aim of the educational module is to understand the learners what is the Data Science and the various kinds of activities that a Data Scientist performs. It will teach the learners about methodologies involved in tackling data science problems and basic concepts and requirements related to information security and privacy of data. Learners will complete quizzes to apply their newly acquired skills and knowledge.
2. **Python for Data Science (DS-EM2).** In this educational module learners will be introduced to Python for solving Data Science problems. The aim of the educational module is to get the learners a detailed knowledge of Python tools and libraries for big data analysis, data visualization and machine learning. It will present to the

learners the fundamentals of Python programming language, the NumPy package and the Pandas, Matplotlib and Scikit-Learn libraries. Learners will complete quizzes to apply their newly acquired skills and knowledge.

3. **Statistics for Data Science (DS-EM3).** In this educational module, learners will be introduced to R and its use for solving Data Science problems. The aim of the educational module is to get the learners a detailed knowledge of R programming language and its libraries and packages for inferential statistical analysis, visualization and machine learning algorithms.
4. **Storing and retrieving data (DS-EM4).** In this educational module learners will be introduced to the Hadoop ecosystem and its application at storing and processing large volumes of data distributed across commodity servers. Learners will be equipped with the theoretical and practical background needed to perform Hadoop routine tasks and troubleshoot Hadoop clusters. Learners will complete self-assessment quizzes and hands-on activities, thus applying their newly acquired skills and knowledge. Completing this EM, learners will be able to administrate and establish a secure Hadoop environment and work with the common Hadoop-related processing frameworks and modules.
5. **Applied machine learning (DS-EM5).** In this educational module learners will be introduced to the concepts of Machine Learning and the application of machine learning techniques and methods in various domains. The aim of the educational module is to give learners a comprehensive overview of the topic machine learning and to assist them in understating what Machine Learning is, how machine learning algorithms work and how they could utilize Machine Learning techniques in solving various real world problems. In addition, the educational module will present to learners toolkits to design and formulate machine learning methods. Learners will complete quizzes to apply their newly acquired skills and knowledge.
6. **Data Visualization (DS-EM6).** In this educational module learners will be introduced to Data Visualization (DV) and its application at various disciplines in order to enhance visual communication. Learners will be equipped with the theoretical and practical tools needed to build effective and engaging data visualizations. Learners will complete self-assessment quizzes and implement projects, thus applying their newly acquired skills and knowledge. Additionally, the role of the Data Scientist from a data presentation and communication perspective will be defined. Completing this EM, learners will be able to design and develop visual stories with data, discover trends and patterns, and potentially communicate their findings to a non-technical or a broader audience.



The training units of each educational unit are presented in the next sections.

4.1.1 Introduction to Data Science – Introduction (DS-EM1)

As this is an introductory module, it is not divided into learning units.

Objectives

- Make the learners familiar with the Data Science concept
- Present to learners the basic principles of Data Science
- Make the learners familiar with the different roles involved in Data Science projects
- Make the learners familiar with the main duties of different Data Science roles
- Present to the learners the main tools used by Data Scientists
- Present to learners Data Science applications to solve business problems
- Present to learners the main security issues dealing with Data Science

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know the key concepts of Data Science,
- have an overall knowledge of the major steps involved in tackling a data science problem
- know the different roles involved in Data Science project,
- be familiar with the main duties of different Data Science roles,
- be aware of the main tools used by Data Scientists,
- have a general knowledge of Data Science applications to solve business problems,
- have an overall knowledge of the main security issues dealing with Data Science,

will be able to (skills):

- explain the key concepts of Data Science,
- analyse a Data Science problem,

- identify the steps of solving a Data Science problem
- identify the different Data Science roles,
- identify the main duties of different Data Science roles,
- communicate the different tools used by Data Scientists,
- communicate Data Science use cases,
- identify the main security issues raised in Data Science projects,

and will (competences)

- be able to recognize Data Science problems
- be able to recognize the limits between different Data Scientist roles.
- be able to recognize Data Science applications
- be able to recognize commons security risks in Data Science projects

Content

- Basic concepts of Data Science
- Methodologies involved in tackling Data Science problems
- Data Science roles: Data Analyst, Data Architect, Database Administrator, Machine Learning Engineer, Data Scientist
- Main duties of different Data Science roles. Data analysis, Databases design and administration, Data Visualization, Infrastructure for Data analysis, Design of machine learning algorithms
- Main tools for Data Science: Python, R, Tableau, SQL, NoSQL, MapReduce/Spark, Hadoop
- Data Science use cases. Data Science applications in ICT, in finance, in education, in marketing, in energy
- Security risks in Data Science projects. Data privacy, data protection, data integrity, conformity to GDPR

Learning methodologies

Online and work based learning

Duration

3 hours

Assessment

Quiz

Pre-requisite

Basic understanding of ICT principles

4.1.2 Introduction to Python for Data Science – Introduction (DS-EM2-I)

Objectives

Introduction to python and overview of its main characteristics

Learning outcomes

After successful completion of this unit learners will (knowledge)

- have an overall knowledge of the main features of Python programming language
- have a general knowledge of the main Python libraries for Data Scientists

will be able to (skills):

- explain the main characteristics of Python
- identify common applications of Python for data analysis and data visualization

will (competences):

- be competent to promote Python as an effective programming language for solving Data Science problems.

Content

- Main features of Python programming language
- Main libraries of Python for Data Science
- Python installation at Windows and Linux environments

Learning methodologies

Online and work based learning

Duration

2 hour

Assessment

Quiz

Pre-requisite

- Familiarity with Data Science main concepts
- General understanding of ICT

4.1.3 Introduction to Python for Data Science – Core (DS-EM2-C)

Objectives

- Presentation of Python language fundamentals, including basic syntax, variables, statements, types, functions, modules, packages and debugging tools.

Learning outcomes

After successful completion of this unit learners, will (knowledge)

- have detailed knowledge of the different types of Python variables
- have detailed knowledge of the different types of Python built-in datatypes
- have detailed knowledge of the different types of Python statements
- learn how to use functions in Python
- learn how to use classes in Python
- learn how to use modules in Python
- learn how to handle data files with python

will be able to (skills):

- create simple python programs
- troubleshoot simple python programs

will (competences):

- be competent to taking some responsibility in Data Science projects

Content

- Variables: creating variables, variables names, output variables
- Built-in datatypes: numeric, tuples and lists, strings, dictionaries, other built-in types
- Statements: Assignment statement, import statement, print statement, if: elif: else: statement, for: statement, while: statement, continue and break statements, try: except: statement, raise statement
- Functions: The def statement, Returning values, arguments, local variables, global variables and the global statement, lambda function
- Classes and objects: create a simple class, defining methods, constructors, member variables, class variables, class methods and static methods
- Modules: create a module, use a module, built-in modules, import from module
- File handling: read files, write/create files, delete files

Learning methodologies

Online and work based learning

Duration

12 hours

Assessment

Questionnaire and use cases

Pre-requisite

- Experience with a high level language (e.g. C/C++) is suggested. Prior knowledge of a scripting language (e.g. Perl) and Object-Oriented concepts is helpful but not mandatory.

4.1.4 Introduction to Python for Data Science - Advanced (DS-EM2-A)

Objectives

- Presentation of NumPy package for big data manipulation
- Presentation of Pandas library for big data analysis
- Presentation of Matplotlib library for data visualization
- Presentation of Scikit-Learn library for machine learning.

Learning outcomes

After successful completion of this unit learners, will (knowledge):

- have detailed knowledge of NumPy package to effectively create big arrays and matrixes with Python
- have detailed knowledge of Pandas library to analyse data with Python
- have detailed knowledge of Matplotlib library to visualize data with Python
- have detailed knowledge of Scikit-Learn to implement machine learning algorithms with Python

will be able to (skills):

- use NumPy Python library for big data manipulation
- make big data analysis with Pandas Python library
- make data visualization using the Matplotlib Python library
- use the Scikit-Learn Python for running machine learning algorithms
- use Python for data analysis, data visualization and machine learning

will (competences):

- be capable of taking some responsibility in Data Science projects
- become more effective in solving Data Science problems.

Content

- The NumPy package: create and examine arrays, stack arrays, vectorized operations
- The Pandas library for data analysis: create a dataframe, combine dataframes, rows and columns selection, sorting, descriptive statistics, file i/o
- Matplotlib library for data visualization: creating basic plots, creating scatter 2D plots, create density plots
- Time series analysis: pandas time series data structure, read data, recode data, exploratory data analysis, trends and seasonality in time series data.
- Python libraries for machine learning: Scikit-Learn.

Learning methodologies

Online and work based learning

Duration

6 hours

Assessment

Questionnaires and hands-on

Pre-requisite

The learner should have knowledge of Python fundamentals.

4.1.5 Statistics for Data Science – Introduction (DS-EM3-I)

Objectives

Introduction to R and overview of its main characteristics

Learning outcomes

After successful completion of this unit learners will (knowledge)

- have an overall knowledge of the main features of R programming language
- have a general knowledge of the main R packages for Data Science statistical tasks

will be able to (skills):

- explain the main characteristics of R

- identify common applications of R for the statistical analysis of data

will (competences):

- be competent to promote R as an effective programming language for solving Data Science problems that regard statistical analysis

Content

- Main features of R programming language
- Main packages of R for Data Science statistical analysis tasks
- R installation in Windows and Linux environments

Learning methodologies

Online and work based learning

Duration

2 hour

Assessment

Quiz

Pre-requisite

- Familiarity with Data Science main concepts
- Familiarity with basic probabilities and statistics concepts
- General understanding of ICT

4.1.6 Statistics for Data Science - Core (DS-EM3-C)

Objectives

- Presentation of R language fundamentals, including basic syntax, variables, operators, data types, loops, functions, vectors, lists, matrices, arrays, factors, data frames, packages and debugging.

Learning outcomes

After successful completion of this unit learners, will (knowledge)

- have detailed knowledge of the different types of R variables
- have detailed knowledge of the different types of R built-in data types
- have detailed knowledge of the different types of R statements
- learn how to use functions in R
- learn how to use R packages and libraries

- learn how to handle data files with R

will be able to (skills):

- create simple R programs for statistical analysis (descriptive statistics for data science).
- troubleshoot simple R programs

will (competences):

- be competent to taking some responsibility in Data Science projects that regard statistical analysis

Content

- Variables: creating variables, variables names, output variables
- Built-in data types and Objects: scalars, vectors (numerical, character, logical), matrices, data frames, and lists
- Control structures: conditional executions (comparison and logical operators, If and Ifelse statements), loops (For, While and Apply Loop Family)
- Functions and arguments in R
- Probability functions supported in R (Chi-Square, Exponential, F- distribution, Poisson, Binomial, Logistic, Normal, Lognormal, Uniform)
- Use R to calculate and visualize descriptive statistics (uni-variate analysis, multivariate analysis, function models) using respective R packages
- File handling (load datasets from excel, dbs, SPSS, SAS) and debugging

Learning methodologies

Online and work based learning

Duration

10 hours

Assessment

Questionnaire and use cases

Pre-requisite

- Experience with a high level language (e.g. C/C++) is suggested. Prior knowledge of a scripting language (e.g. Perl) and Object-Oriented concepts is helpful but not mandatory.
- Basic background of descriptive and inferential statistics is considered very helpful but not mandatory

4.1.7 Statistics for Data Science – Advanced (DS-EM3-A)

Objectives

- Presentation of R libraries and packages for inferential statistical analysis, visualization and machine learning algorithms.
- Presentation of R built-in functions and libraries for sampling distributions and estimations, hypothesis testing, correlation and regression
- Presentation of ggplot2 and plotly libraries for data visualization
- Presentation of mlr, dmlc XGBoost and caret libraries for machine learning.

Learning outcomes

After successful completion of this unit learners, will (knowledge):

- have detailed knowledge of R built-in functions and libraries to effectively calculate and visualize sampling distributions and estimations, apply hypothesis testing, correlation and regression models
- have detailed knowledge ggplot2 and plotly libraries to generate data visualizations with R
- have detailed knowledge mlr, dmlc XGBoost and caret libraries to implement machine learning algorithms with R

will be able to (skills):

- use R to calculate and visualize sampling distributions and estimations, apply hypothesis testing, correlation and regression models.
- Produce data visualizations with the ggplot2 and plotly libraries
- Apply machine learning algorithms with the mlr, dmlc XGBoost and caret libraries

will (competences):

- be capable of taking some responsibility in Data Science projects involving statistical analysis
- become more effective in solving Data Science statistical problems using R.

Content

- R functions and libraries for referential statistics (Sampling Distributions & Estimation, Hypothesis Testing, Correlation & Regression).
- Data visualization with R: ggplot2 and plotly libraries
- R libraries for machine learning: mlr, dmlc XGBoost, caret

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

Questionnaires and hands-on

Pre-requisite

The learner should have knowledge of R fundamentals and inferential statistics.

4.1.8 Storing and retrieving data – Introduction (DS-EM4-I)

Objectives

- Present to learners the Hadoop ecosystem.
- Make the learners familiar with Hadoop clusters.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- be introduced to the Hadoop components and the Hadoop ecosystem,
- know the unique features of Hadoop,
- be familiar with the basic architecture of a Hadoop cluster,

will be able to (skills):

- classify the Hadoop framework,
- explain the unique features of Hadoop,
- describe the basic architecture of a Hadoop cluster,

and will (competences)

- be competent to promote Hadoop in storing and managing vast amounts of data efficiently.

Content

- Big data and Hadoop
- Hadoop framework
- Data lake concept
- Hadoop clusters

Learning methodologies

Online and work-based learning

Duration

4 hours

Assessment

Self-assessment quizzes

Pre-requisite

- Basic understanding of ICT principles
- Basic knowledge of Big Data concepts

4.1.9 Storing and retrieving data - Core (DS-EM4-C)

Objectives

- Present to learners the key differences between Hadoop 1 and Hadoop 2
- Present to learners the Hadoop Distributed File System (HDFS – Data Storage)
- Present to learners the Hadoop Operating System (YARN – Data processing)
- Make the learners familiar to manage key Hadoop components from the command line

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know the architectural differences between Hadoop 1 and Hadoop 2,
- have a general knowledge of the data types that can be handled with Hadoop,
- have a good understanding of the Hadoop Distributed File System (HDFS),
- have a good understanding of the Hadoop Operating System (YARN – Yet Another Resource Negotiator),
- know how to perform basic administration tasks for key Hadoop components from command line,

will be able to (skills):

- explain the architectural differences between Hadoop 1 and Hadoop 2,
- support the main data types that can be handled with Hadoop framework,
- use the storage (HDFS) and processing (YARN) layer of Hadoop,
- manage key Hadoop components and modules from UNIX/Linux command line,

and will (competences):

- demonstrate Hadoop as an effective programming framework to manage (store) and analyse (retrieve) big data,
- become more flexible in Hadoop administration.

Content

- Architectural differences of Hadoop 1 and Hadoop 2
- The Hadoop Distributed File System (Data Storage)
- The Hadoop Operating System (Data Processing)
- Key areas of Hadoop Administration

Learning methodologies

Online and work-based learning

Duration

10 hours

Assessment

- Self-assessment quizzes
- Hands-on activities

Pre-requisite

- Basic knowledge about Big Data concepts
- Basic knowledge of Unix / Linux operating system
- Basic knowledge of Java programming language

4.1.10 Storing and retrieving data – Advanced (DS-EM4-A)

Objectives

- Present to learners the MapReduce Framework
- Short introduction to Hive interface and Pig high-level framework
- Present to learners the Spark Framework
- Make learners familiar with Hadoop Security

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- have a good understanding of the MapReduce Framework,
- have a general knowledge of the Hive interface and the Pig high-level framework,
- have a good understanding of the Spark Framework,
- know the key concepts of Hadoop security,

will be able to (skills):

- use the MapReduce Framework and the Spark Framework,
- explain the key concepts of both the Hive interface and the Pig high-level framework,
- assist in securing a Hadoop environment,

and will (competences)

- able to recognize the limits of the MapReduce Framework and migrate to the Spark Framework,
- be aware and sensitive with Hadoop security concepts.

Content

- Running applications – the MapReduce Framework
- Running applications – the Spark Framework
- Apache Hive and Apache Pig
- Securing Hadoop

Learning methodologies

Online and work-based learning

Duration

6 hours

Assessment

- Self-assessment quizzes
- Hands-on activities
- Use cases

Pre-requisite

- Basic knowledge of Unix / Linux operating system
- Basic knowledge of Java programming language

4.1.11 Applied machine learning – Introduction (DS-EM5-I)

Objectives

- Introduce learners to Machine Learning and make an overview of its characteristics
- Make learners familiar with the Machine Learning concepts
- Present to learners the basic principles of Machine Learning
- Explain the aims and the purpose of Machine learning systems

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know the main concepts of Machine Learning
- Know the main aims of Machine Learning systems

will be able to (skills):

- explain the key concepts of Machine Learning
- understand the aim of Machine Learning methods
- understand what machine learning can do

and will (competences)

- be able to recognize problems that Machine Learning methods can be applied
- be able to understand what

Content

- Aims and purpose of Machine Learning systems
- Main types of Learning (e.g. supervised, unsupervised, semi-supervised learning)
- Domains and topics of Machine Learning applications

Learning methodologies

Online and work based learning

Duration

2 hours

Assessment

Quiz

Pre-requisite

Basic understanding of ICT principles

4.1.12 Applied machine learning - Core (DS-EM5-C)

Objectives

- Present to learners the basic algorithms and techniques of Machine Learning
- Present to learners the main tools used by Machine Learning
- Assist learners in understanding the principles and the functionality of the ML methods and algorithms
- Present learners the main machine learning roles and the duties of each one

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- understand the functionality of machine learning methods
- know the different roles involved in Machine Learning project and the duties of each one
- be aware of the main toolkits used by Machine Learning

will be able to (skills):

- understand how machine learning methods operate
- identify the different Machine Learning roles and their duties
- understand the different toolkits used by Machine Learning

and will (competences)

- be able to analyze problems and face them with machine learning methods
- be able to specify appropriate Machine Learning methods for given problems
- be able to apply machine meaning methods and solve problems

Content

- Approaches used to analyse problems and design Machine Learning systems to face them
- Functionality of supervised and unsupervised learning
- Functionality of Semi-supervised learning
- Reinforcement learning
- Classification and Regression
- Main streams of Machine Learning methods and techniques
- Functionality of machine learning methods
- Machine Learning toolkits and frameworks
- Evaluation of machine learning systems

Learning methodologies

Online and work based learning

Duration

10 hours

Assessment

Quiz

Pre-requisite

- Basic knowledge of computer science concepts
- Basic knowledge of statistics fundamentals

4.1.13 Applied machine learning – Advanced (DS-EM5-A)

Objectives

- Present to learners Machine Learning applications in real world problems
- Help learners to understand and efficiently apply Machine Learning techniques
- Assist learner in designing machine learning systems

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- have a general knowledge of Machine Learning applications to solve business problems
- have an overall knowledge of the main security issues dealing with Machine Learning

will be able to (skills):

- developing practical skills on the application of machine learning methods in various domains
- design & develop machine learning systems to solve real world problem

and will (competences)

- be able to design & develop machine learning systems to solve real world problem

Content

- Formulation of Machine Learning Systems
- Machine Learning use cases

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

Quiz

Pre-requisite

- Basic knowledge of computer science concepts
- Basic knowledge of statistics fundamentals

4.1.14 Data Visualization – Introduction (DS-EM6-I)

Objectives

- Make the learners understand the importance of Data Visualization and Data Presentation Architecture (DPA)
- Present to learners the basic principles and techniques of Data Visualization

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know the key concepts of Data Visualization and Data Presentation Architecture,
- have an overall knowledge of the fundamental principles of visual information / information graphics / statistical graphics

will be able to (skills):

- explain the key concepts of Data Visualization and Data Presentation Architecture,
- communicate the fundamental principles of visual information / information graphics / statistical graphics,
- assist in visual information problems

and will (competences)

- be able to deal with information and statistical graphics

Content

- Key concepts of Data Visualization and Data Presentation Architecture
- Fundamental principles of visual information / information graphics / statistical graphics

Learning methodologies

Online and work based learning

Duration

2 hours

Assessment

Self-assessment quizzes

Pre-requisite

- Basic knowledge of computer programming

4.1.15 Data Visualization - Core (DS-EM6-C)

Objectives

- Motivate learners to build their Data Visualization background
- Familiarize learners with well-defined Communication / Presentation methodologies
- Present software tools and programs used for Data Visualization to learners

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- be familiar with well-established Communication / Presentation methodologies
- be aware of various innovative software tools and programs used to efficiently visualize business datasets,
- know specifically to design effective Visualizations / Presentations

will be able to (skills):

- apply common Data Visualization techniques and methods to real business and/or big datasets,
- communicate the different software tools and programs used for Data Visualization,
- deliver effective and targeted visual stories and presentations

and will (competences)

- be able to recognize trends and patterns
- demonstrate visual stories

Content

- Methodologies and effective ways to encode information into graphics
- Basic diagrams / charts used for Data Visualization
- Software tools and programs used for Data Visualization: Python, R, Tableau

Learning methodologies

Online and work based learning

Duration

10 hours

Assessment

- Self-assessment quizzes
- Hands-on activities

Pre-requisite

- Basic knowledge of algorithms and data structures
- Basic knowledge of computer programming.
- Basic knowledge of statistics fundamentals

4.1.16 Data Visualization – Advanced (DS-EM6-A)

Objectives

- Motivate learners to upskill their Data Visualization background
- Apply advanced Data Visualization techniques and methods to real business and/or big datasets
- Perform visual data mining in complex and massive representations of data

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- have a detailed knowledge of advanced Data Visualization techniques and methods
- be familiar with visual data mining in complex datasets

will be able to (skills):

- apply advanced Data Visualization techniques and methods to real business and/or big datasets,
- effectively communicate data,
- promote visual communication,
- perform visual data mining in massive representations of data,

and will (competences)

- become more effective in Data Visualization problems / issues
- demonstrate engaging data visualizations
- be competent in visually representing massive amounts of information and making data-driven decisions

Content

- Advanced diagrams / charts used for Data Visualization
- Dynamic Data Manipulation and Visualization with innovative software tools

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

- Self-assessment quizzes
- Hands-on activities
- Use cases

Pre-requisite

- Basic knowledge of statistics fundamentals
- Solid understanding of computer programming.

4.2 Data Science training requirement for different professional roles

As the professional roles involved in a Data Science project are many and are characterized by different training needs, we propose a mapping between each professional role and DS training unit. Table 1 provides guidance on which level of proficiency is typically required for different DS professional roles for the 6 DS educational units.

	Data Analyst	Data Architect	Database Administrator	Machine Learning Engineer	Data Scientist
Introduction to Data Science	I	I	I	I	A
Python for Data Science	A	C	I	A	A
Statistics for Data Science	C	C	I	A	A
Storing and retrieving data	C	A	A	C	A
Applied machine learning	I	I	I	A	A
Data Visualization	A	I	I	C	A

Table 1: Mapping of training units proficiency to Data Science professional roles

The Data Science professional roles are coming from the proposal done by the EDISON project for the extension of Data Science occupations at ESCO classification[1]. For simplicity reasons, we avoid the further classification of occupations at top level hierarchy

[1] EDISON project, Data Science Professional profiles definition (DSP), EDSF Part 4. Data Science Professional Framework (DSPP) Release 2, Version v0.4

(managers, professionals, technicians and associate professionals and clerical support workers).

The definition of each Data Science professional role is the following:

- **Data Analyst**. Analyses large variety of data to extract information about system, service or organization performance and present them in usable/actionable form.
- **Data Architect.** Designs and maintains the architecture of Data Science applications and facilities. Creates relevant data models and processes workflows.
- **Database Administrator.** Designs and implements, or monitors and maintains large scale cloud databases.
- **Machine Learning Engineer.** Designs and applies machine learning algorithms.
- **Data Scientist.** Data scientists find and interpret rich data sources, manage large amounts of data, merge data sources, ensure consistency of data-sets, and create visualizations to aid in understanding data. Build mathematical models, present and communicate data insights and findings to specialists and scientists, and recommend ways to apply the data.

5 Internet of Things

5.1 IoT educational modules and training units

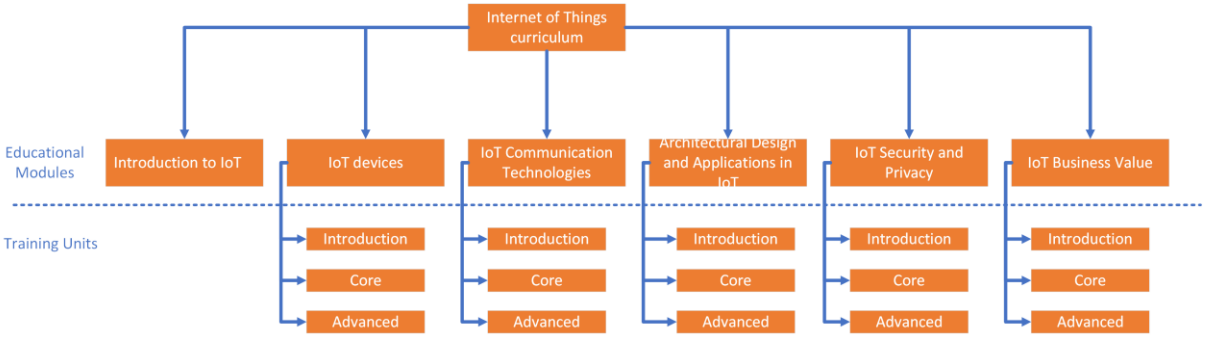
The Internet of Things educational modules are:

1. **Introduction to IoT (IoT-EM1).** This educational module consists an introduction to the IoT concept and its applications. It aims to make the learners familiar with the IoT technology and present the different roles involved in an IoT project and the common IoT application development tools and methods.
2. **IoT Devices (IoT-EM2)**. This educational module introduces the "Things" in the Internet of Things. More specifically, it is concerned about the different IoT devices (sensors, actuators, peripherals), their electronics, as well as, different microcontrollers and how they can interact with the environment. The module focuses on how to select and interface common sensors and actuators to support real life IoT applications.
3. **IoT Communication Technologies (IoT-EM3).** This educational module introduces the plethora of communication protocols and standards that are used for signaling and data exchange in IoT systems in a comprehensive and visual way. Emphasis is given on the main characteristics, features and metrics of each protocol and standard. The relationship between the traditional TCP/IP protocol stack with

IoT protocol stack is presented and explained. Moreover, the comparison of IoT communication technologies aims at presenting guidelines for the learners to be able to select the right protocol for different applications. Learners complete quizzes and projects to apply their newly acquired skills and knowledge.

4. **Architectural Design and Applications in IoT (IoT-EM4).** This module provides an introduction to the key aspects of the IoT system architecture (IoT edge devices, gateways) with emphasis on server-side infrastructure solutions (cloud computing service models, deployment models and public cloud providers). Furthermore, this module presents the non-functional requirements that should be taken into account when designing IoT applications, followed by a detailed presentation of the major IoT application domains. Moreover, selected IoT applications are presented along with their characteristics and are classified based on their goal. The learners will then be familiar with the software architectural styles in IoT applications (client-server, peer-to-peer, publish-subscribe, etc.) and how they relate to the predefined IoT application classes. The last sections of the module provide analysis of the considerations for designing IoT applications and present a reference architecture for an IoT Application. Finally, the learners are being guided on how to develop IoT applications in a public cloud provider infrastructure.
5. **IoT Security and Privacy (IoT-EM5).** The IoT may be the most unsecure network encounter so far. Things are now connected to each other forming their own network in a user's private life and also it is connected to the highly unsecure network, the Internet. The IoT is now part of our everyday routine. IoT applications include smart cities, transport and many more in which in certain cases the user cannot directly control. A computer owner can control the level of security in his/her computer by adapting security measures, not downloading certain applications, using security software etc. A citizen in a Smart City cannot control the security measures employed in the IoT and thus cannot control his/her privacy level. The same applies in every application in which the user may use and has access to the user's privacy. The current module introduces the risks of using IoT and possible measures to create a more secure environment. It aims to create a sense of awareness to the learner of the possible security breaches and how to avoid them by adapting security measures whenever possible.
6. **IoT Business Value (IoT-EM6).** This module includes an introduction of IoT in the business world clarifying why companies need to understand IoT business. The aim of this educational module is to get to know the advantages of involving IoT into the business world. The learners will initially see in theory how a company can

be transformed with the use of IoT by an overview of the IoT technologies already used in the specific area. Then, the learners can study the different IoT business model types, the different challenges that arise in this area of a business and the landscape of IoT Business. Finally, the learners will with the help of some case studies of successful companies that already have IoT strategies, get to know how all these information will be in practice. Learners will complete quizzes with questions based on their newly acquired skills and knowledge.



The training units of each educational unit are presented in the next sections

5.1.1 Introduction to IoT (IoT-EM1)

As this is an introductory module, it is not divided into learning units.

Objectives

- Make the learners familiar with the IoT concept
- Present to learners the basic principles of IoT applications
- Make the learners familiar with the different roles involved in an IoT project
- Present IoT as the evolution of M2M and the conditions that make it happen
- Make the learners familiar with the main duties of different IoT roles
- Present in details the required skills per role
- Present common IoT application development tools and methods

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- know the key concepts of IoT
- know the synergies between adjacent links in the IoT value chain
- know the different roles involved in an IoT project,
- be aware of the technology components of the IoT puzzle that have matured over time,

- be familiar with the main duties of different engineering and business analyst roles in an IoT project.
- have detailed knowledge of the expertise of the groups that compose an IoT application development team
- have detailed knowledge of the methodologies to create workflows
- have detailed knowledge of the Device Management functions
- be able to select the appropriate development platform for their application

will be able to (skills):

- be able to identify an opportunity for applying a solution by adopting the IoT paradigm.
- be able to select and evaluate the effectiveness of the appropriate business model of a product offering in any of the links of IoT value chain
- be able to identify an opportunity for applying a solution by adopting the IoT paradigm.
- identify the different IoT roles,
- identify the main technologies and their contribution to various IoT Projects.
- specify the responsibilities of the IoT specialists and the synergies among them.
- select and configure the edge computing platform which is appropriate for their application
- design SQL database schemas in their workflows and work with NoSQL databases
- Select and use the dataflow design platform according to their programming skills and expertise
- select the method and tools for data visualization

will (compentences):

- be competent to create a business model for a certain IoT product or service
- be able to recognize the limits between different IoT roles.
- be capable of taking some responsibility in the IoT Application Development process
- participate to system level architecture and design of IoT solutions

Content

- Layered structure of IoT: a non-standardized approach
- IoT value chain and the role of its links
- IoT economics and business models
- Major IoT verticals and application examples
- The evolved technologies of IoT: Sensors and Actuators, Edge Computing, IoT Networks, Cloud Computing and Databases, Infrastructure as a Service (IaaS),

Artificial Intelligence and Machine Learning, Analytics, Data Visualization, Solution as a Service (SaaS)

- The IoT roles: Business Analysts, IoT Product Manager, System Architect, Application Designers (Dashboards and Dataflows), Network Engineers, Embedded System Engineers, DevOps Engineers (optional).
- Edge Computing:
  - System SW design (e.g. Linux platform setup),
  - RTOS systems
  - Devices' interfaces (legacy and modern technologies)
  - Edge analytics
  - Common programming languages: C, C++, Java, Python
- Data exchange protocols – REST, MQTT, AMQP, LWM2M
- Device Management
- SQL databases and schema design
- NoSQL databases and concepts
- Data encoding (e.g. JSON, XML)
- Common cloud programming languages for workflow execution and rules: Java, C#
- Code-free workflow design methods based on modern IoT Application Development Enablement Platforms
- Data visualization tools

Learning methodologies

Online and work-based learning

Duration

3 hours

Assessment

Quiz

Pre-requisite

- Familiarity with the ICT industry of products and services
- Familiarity with M2M solutions.
- Knowledge on at least one of the following:
- Programming of networking embedded systems by using any of the following languages:
  - C/C++
  - Java

  - Python
- Experience with the use of databases in applications
- SW implementation of APIs
- User Interface development

5.1.2 IoT Devices – Introduction (IoT–EM2-I)

Objectives

The objectives of this module are to:

- Provide students the basic electronic design knowledge of IoT devices
- Help students to recognize IoT devices needed for different IoT applications
- Write simple applications to read data from basic IoT sensors (IR, temperature, humidity) using Arduino and/or Raspberry Pi.

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- have an overall knowledge of the electronics of the IoT devices
- be able to distinguish IoT devices and their role in IoT applications

will be able to (skills):

- write simple programs to read values from basic IoT sensors.
- design and implement simple circuits integrating basic IoT sensors.

and will (competences):

- be competent to accept responsibilities in projects that require low level integration with IoT devices/sensors.

Content

- Electronics for the IoT (signals, GPIO, ADC, microcontrollers).
- IoT sensors.
- Sensors integration.

Learning methodologies

Online and work-based learning

Duration

2 Hours

Assessment

Assessment is via quizzes, reports, presentation, demonstration and examination.

Pre-requisite

No prerequisite

5.1.3 IoT Devices - Core (IoT–EM2-C)

Objectives

The objectives of this module are to:

- Help learners to understand the importance of sensors and actuators in real IoT applications
- Present to learners different types of microcontrollers.
- Assist learners to interface sensors and actuators in an IoT system

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- have a detailed knowledge of the electronics of the IoT devices
- understand passive and active components
- be able to differentiate sensors and actuators and their role in different IoT applications

will be able to (skills):

- troubleshoot and solve IoT devices issues.
- design and implement IoT systems integrating sensors and actuators
- write programs to read sensor data and interface with actuators

and will (competences):

- be competent to participate to IoT system design and integration with different sensors and actuators.

Content

- Electronics for the IoT
- Sensor and Actuator integration
- Microcontrollers
- System interfaces

Learning methodologies

Online and work-based learning

Duration

6 hours

Assessment

Assessment is via quizzes, reports, presentation, demonstration and examination.

Pre-requisite

IoT Devices – Introduction module

5.1.4 IoT Devices - Advanced (IoT-EM2-A)

Objectives

The objectives of this module are:

- Help learners to interface the different devices and to build and test an IoT system that collects data from sensors and control actuator devices.
- Assist learners to advanced program and troubleshoot IoT devices.
- Help learners to select the correct hardware (microcontroller, sensors, actuators) to implement an IoT system

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- have an advanced knowledge of the electronics of the IoT devices
- understand the concept of open and closed loop systems
- be able to select the correct microcontroller for a problem solving.

· be able to understand the concept of analog-to-digital and digital-to-analog conversion

will be able to (skills):

- troubleshoot and solve IoT devices advanced issues.
- select the correct sampling frequency for different sensors
- program GPIOs to support communication with a variety of sensors and actuators
- be able to read data from any kind of sensor (IR, cameras, accelerometers, ultrasonic sensors, etc) or actuators like motors.

and will (competences):

- be competent to take the lead in any kind of IoT project integrating different types of sensors, actuators in either open or closed loop systems

Content

- Advanced Interfaces and Programming of IoT devices
- Open and closed loop systems using sensor and actuators

Learning methodologies

Online and work based learning

Duration

12 hours

Assessment

Assessment is via quizzes, reports, presentation, demonstration and examination.

Pre-requisite

IoT Devices – Core module

5.1.5 IoT Communication technologies – Introduction (IoT–EM3-I)

Objectives

- Introduction to LPWAN networks: LoRaWAN, NB-IoT, LTE/Cat-M1, Sigfox
- Network selection criteria for IoT applications

Learning outcomes

After successful completion of this unit learners will (knowledge)

- have an overall knowledge of the network technologies commonly used in IoT
- understand the pros and cons of each technology for an IoT application

will be able to (skills):

- select the right network type as well as the appropriate equipment (e.g. gateways) and device's technology

be competent to:

- create a proposal for equipment an IoT application requires, based on the appropriate selection of the network type

Content

- presentation of common LPWAN technologies
- Competitive advantages of each technology

- Devices' market landscape

Learning methodologies

Online and work based learning

Duration

2

Assessment

Questionnaires

Pre-requisite

- Basic knowledge of data networks

5.1.6 IoT Communication technologies – Core (IoT-EU3-C)

Objectives

- Present LPWAN technologies and the purpose they serve
- Present device requirements for communication over a specific type of LPWAN
- Present the use and benefits of private LPWAN

Learning outcomes

After successful completion of this unit learners, will (knowledge):

- Have good knowledge of LPWAN technologies
- Have a good knowledge of the types of platforms required for end-to-end application development over various LPWAN technologies
- Have a good understanding of the design principles of edge systems vs the network access method

will be able to (skills):

- Architect a system over a certain type of LPWAN
- Make cost assessment related to the selection of equipment for the use of a specific LPWAN

will (competences):

- be capable of taking some responsibility in system architecture and business analysis of IoT solutions over LPWAN IoT networks

Content

- IoT LPWAN Network Protocols. Principles of:
  - LTE/NB-IoT
  - LoRa
  - Sigfox
- Design principles of edge devices with regards to the network protocols
- System Design principles for bi-directional traffic over LPWAN
- Basics of data exchange between network providers and IoT application development platforms
- Private LPWAN

Learning methodologies

Online and work based learning

Duration

8

Assessment

Questionnaires

Pre-requisite

- Familiarization with wired and wireless communication protocols
- Network Layers

5.1.7 IoT Communication technologies - Advanced (IoT-EM3-A)

Objectives

- Presentation of available IoT Network technologies and their carriers
- Presentation of the access mechanisms to various IoT technologies
- Private IoT networks

Learning outcomes

After successful completion of this unit learners, will (knowledge):

- Have detailed knowledge of the network access protocols
- Have detailed knowledge of how to interface with the platform of the IoT Network provider
- Have detailed knowledge of how to setup a private IoT network

will be able to (skills):

- Exchange data with the core IoT network
- Program or use an edge computing system to send data to a carrier
- Apply design rules for low power bi-direction edge network devices

will (competences)

- be able to setup the infrastructure required for the data flow between edge devices and an IoT application development platform

Content

- Communication Layers in IoT
- IoT Network Protocols. Data exchange with core Networks of:
    - LTE/NB-IoT
    - LoRa
    - Sigfox
- Efficient use of limited available bandwidth,
- System design: Challenges with various IoT network protocols
    - bi-directional devices
    - Battery life
    - Buffering
    - Data encoding to comply with short data frames
    - Over the Air (OTA) upgrade

Learning methodologies

Online and work based learning

Duration

10

Assessment

Questionnaire and use cases

Pre-requisite

- Good knowledge of some wireless communication protocols
- Network Layers
- Design of Low Power wireless sensor and actuator devices

5.1.8 Architectural Design and Applications in IoT – Introduction (IoT-EM4-I)

Objectives

- Present to learners the key aspects of IoT Architecture: IoT edge devices types (sensors, actuators), IoT gateways, server-side infrastructure
- Present to learners a number of server-side infrastructure solutions: physical servers, virtual servers, virtual private servers, cloud computing
- Present to learners cloud computing service models (IaaS, PaaS, SaaS)
- Present to learners cloud computing deployment models (private, public, hybrid, community)
- Make the learners familiar with the Fog and Edge Computing concepts
- Present basic features of public cloud providers to learners
- Present to learners how to create an account on a public cloud provider (Microsoft Azure) and make use of IoT related services

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- be familiar with the roles of sensors, actuators, gateways and server-side infrastructure in an IoT architecture
- be familiar with the interaction patterns between edge devices and server-side architecture
- have detailed knowledge of the different server-side infrastructure solutions with emphasis on physical servers, virtual servers, virtual private servers and cloud computing
- be aware of the cloud computing service models: Infrastructure as a Service, Platform as a Service, Software as a Service
- be aware of public/private/hybrid/community cloud deployment models
- be familiar with fog and edge computing concepts
- be aware of basic features available in public cloud providers related to computation, big-data, analytics, intelligence, IoT, security, identification, access and developer operations
- be familiar with Microsoft Azure cloud and IoT related services

will be able to (skills):

- identify the available server-side infrastructure solutions
- explain the the cloud computing service and deployment models

- create account on public cloud provider
- use IoT services within a public cloud account
- simulate an IoT device sending data on the cloud on Python programming language

and will (competences):

- be competent to create public cloud accounts and use IoT related services

Content

- What is IoT
- Key aspects of IoT Architecture (IoT Edge Device Types, IoT Gateways, Server-side Infrastructure)
- Cloud Computing (service models (SaaS, PaaS, IaaS), deployment models (private, public, hybrid, community), public cloud computing services)
- Fog and Edge Computing
- Basic Features of Public Cloud Providers
- Hands on: Simulate an IoT Device sending data to the cloud

Learning methodologies

Online and work based learning

Duration

4 hours

Assessment

Quiz

Pre-requisites

Basic understanding of ICT principles and IoT fundamentals. Prior knowledge of a scripting language (e.g. Python) is helpful but not mandatory.

5.1.9 Architectural Design and Applications in IoT - Core (IoT-EM4-C)

Objectives

- Presentation of quality attributes for designing IoT Applications
- Presentation of major IoT Applications Domains
- Analysis of selected IoT Applications with their characteristics
- Classification of IoT Applications based on their goal

- Presentation of software architectural styles in IoT Applications (client-server, peer-to-peer, publish-subscribe, etc.) and how they relate to the predefined IoT Application classes

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- be familiar with the non-functional requirements (quality attributes) that should be taken into account when designing an IoT Application
- be aware of the major areas of activity (applications) in IoT
- have knowledge of the widely known IoT applications along with their characteristics
- get involved in classifying the presented IoT applications based on their purpose
- have a detailed knowledge of software architectural styles available in IoT which determine the organization of IoT architecture constituent components and describe the relationships among them

will be able to (skills):

- explain the non-functional requirements which are important in IoT
- explain the main characteristics of a given IoT Application
- identify software architectural styles available in IoT

and will (competences):

- be able to recognize the characteristics of any IoT Application
- be competent to promote software architectural styles for an IoT Application based on the required quality attributes

Content

- Requirements for designing IoT Applications
- Major IoT Applications Domains
- Selected IoT Applications Analysis
- IoT Applications Classification
- Software architectural styles in IoT

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

Quiz

Pre-requisites

The learner should have knowledge of IoT fundamentals.

5.1.10 Architectural Design and Applications in IoT – Advanced (IoT-EM4-A)

Objectives

- Analysis of the considerations for Designing IoT Applications
- Presentation of a reference architecture for an IoT Application
- Develop IoT applications in Microsoft Azure

Learning outcomes

After the successful completion of this unit, learners will (knowledge):

- have detailed knowledge of important considerations which should be taken into account when designing an IoT Application
- learn how to build an abstract realization of an architectural model (reference architecture) showing how an IoT application can be built while omitting any reference to specific technologies
- learn how to use a public cloud provider (Microsoft Azure) and its related IoT and data analysis (machine learning) services to create real-world IoT Applications (a simulated Raspberry Pi will be used)

will be able to (skills):

- make decisions on hardware and software components when designing an IoT Application
- design a reference architecture for a specific IoT Application when being aware of the functional and non-functional requirements
- use a world class public cloud provider to build real-world IoT applications

and will (competences):

- be capable of taking some responsibility in designing and implementing IoT Applications

Content

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

Quiz

Pre-requisites

Basic understanding of ICT principles and IoT fundamentals. Prior knowledge of Python and nodeJS is helpful but not mandatory.

5.1.11 IoT Security and Privacy – Introduction (IoT-EM5-I)

Objectives

The main objectives of the Introduction are the following:

- Provide an overview of what is Network Security, the vocabulary, the goals of Network Security and the risks that entail a security breach.
- Introduce the students to the IoT vulnerabilities, exploitation techniques and the possible impact on the network after the attack
- Introduce students to common attacks
- Introduce to common countermeasures

Learning outcomes

After completion of the current section, students are expected gain the basic knowledge on security in the IoT. Specifically the students are expected to be able to:

- Understand the importance of incorporating security measures within the IoT.
- Understand all terms defined.
- Be aware of the consequences of the IoT being under attack.
- Be aware basic attacks.
- Be aware common countermeasure techniques

Content

- Introduction on IoT Threats, Attacks, and Vulnerabilities.

Learning methodologies

Online and work based learning

Duration

2 hour

Assessment

Quizzes that include:

- Multiple choice questions, and
- True/False questions

Pre-requisites

- Basic Knowledge of computer science concepts
- Basic Knowledge of computer networks

5.1.12 IoT Security and Privacy - Core (IoT-EM5-C)

Objectives

The main objectives of the current section are the following:

- Types of attacks
- Present real life examples of IoT
- Present possible countermeasures to be taken to prevent attacks from happening

Learning outcomes

After completion of the current section, students are expected gain the basic knowledge on security in the IoT. Specifically the students are expected to be able to:

- Identify vulnerabilities in IoT applications.
- Understand the importance of preventing and detecting an attack with real life examples
- Know common countermeasures and adapt this measures to their personal and work IoT nodes and/or networks.
- Critically evaluate the potential countermeasures to attack techniques in order to evade attacks.

Content

- IoT applications and vulnerabilities
- Types of Attacks
- Mirai and Bashilte DDoS attacks
- Lessons Learned and how to avoid these types of attacks
- Response to an attack

Learning methodologies

Online and work based learning

Duration

8 hours

Assessment

Quizzes that include:

- Multiple choice questions, and
- True/False questions

Pre-requisites

- Basic Knowledge of computer science concepts
- Basic Knowledge of computer networks

5.1.13 IoT Security and Privacy – Advanced (IoT-EM5-A)

Objectives

The main objectives of the current section are the following:

- IoT network traffic
- Simulate IoT traffic from private network to the Internet

Learning outcomes

After completion of the current section, students are expected gain the basic skill in simulating an IoT environment, network monitoring and recognizing possible malicious network traffic and simulating an IoT. Specifically the students are expected to:

- Read and understand network traffic from and to a private IoT network.
- Simulate network traffic.
- Detect possible malicious network traffic.

Content

- Set up virtual machine and build private network
- Read network traffic using Wireshark
- Launch code to simulate Denial of Service attack
- Detect Denial of Service attack

Learning methodologies

Online and work based learning

Duration

10 hours

Assessment

Quizzes that include:

- Multiple choice questions, and
- True/False questions

Pre-requisites

- Basic Knowledge of computer science concepts
- Basic Knowledge of computer networks

5.1.14 IoT Business Value – Introduction (IoT-EU6-I)

Objectives

Introduction to Business IoT and overview of the IoT technologies used in the business world.

Learning outcomes

After successful completion of this unit learners will (knowledge):

- have an overview knowledge of the IoT Business.
- have a general knowledge of the term business value.
- have an overview of the IoT technologies in the business world.
- have a general knowledge of the method used by the devices be connected to each other, as well as their communication method.

will be able to (skills):

- explain how the connection and communication method of the devices work.
- identify improvements for future work using IoT business.

will (competences):

- be competence to introduce the IoT business in their future works.
- be capable of tracking some responsibility in IoT projects.

Content

- Introduction to IoT Business and their main characteristics.
- Smart devices that are used to function as remotes and send commands or request information over the network to IoT devices.
- Use the definition of ecosystem (mentioned above) to apply specific industry companies to improve their future model.

Learning methodologies

Online and work based learning

Duration

2

Assessment

Questionnaires, quiz and use cases

Pre-requisite

- Basic knowledge of business and computer science.
- Basic knowledge of computer network.

5.1.15 IoT Business Value - Core (IoT-EM6-C)

Objectives

An overview of IoT business model types and the different business challenges that can arise in the IoT area of a company (business).

Learning outcomes

After successful completion of this unit learners will (knowledge):

- learn the difference in creating a business model for IoT applications and normal products or services.
- have detailed knowledge of the different business model types in the IoT area.
- learn how each model type improves the company.
- learn the three categories of challenges in the IoT.
- have a general knowledge of the challenges in each category mentioned above.
- learn how to handle each category.

will be able to (skills):

- deal with each challenge
- identify improvements in the company with model type.

will (competences):

- be competent to deal/solve with challenges.
- be competent to improve the business model type with the IoT business model.

Content

- Basic IoT Business model types: compliance monitoring, preventative maintenance, remote diagnostics, asset tracking, automatic fulfilment.
- Challenges based on technology, business and society.
  - Technology: security, connectivity, compatibility and longevity, standards and intelligent analysis & actions
  - Business: consumer, commercial and industrial
  - Society: social, legal and privacy

Learning methodologies

Online and work based learning

Duration

12

Assessment

Questionnaire and use cases

Pre-requisite

- Knowledge of business and computer science.
- General knowledge of computer network.

5.1.16 IoT Business Value – Advanced (IoT-EM6-A)

Objectives

An overview of IoT Landscape and different companies that use IoT in a successful way.

Learning outcomes

After successful completion of this unit learners will (knowledge):

- learn different IoT applications/solutions that exist.
- have general knowledge of the benefits IoT gives based on real life examples of successful companies.

will be able to (skills):

- give an IoT solution to a general problem.

will (competences):

- be competent to introduce IoT in the company.
- be capable of tracking some responsibility in IoT projects.

Content

- Case studies of known companies that use IoT solutions successfully.

Learning methodologies

Online and work based learning

Duration

6

Assessment

Questionnaire and use cases.

Pre-requisite

- Computer science and business knowledge.
- General knowledge of use cases.

5.2 IoT training requirement for different professional roles

As the professional roles involved in an Internet of Things project are many and are characterized by different training needs, we propose a mapping between each professional role and DS training unit. Table 2 provides guidance on which level of proficiency is typically required for different IoT professional roles for the 6 IoT educational units.

	IoT Product Manager	IoT Architect	IoT Software Developer	Data Scientist	IoT Cloud Engineer	IoT Industrial Engineer
Introduction to IoT	I	I	I	I	I	I
IoT Devices	C	C	I	C	C	A
IoT Communication Technologies	C	C	C	C	A	C
Architectural Design and Applications in IoT	C	A	A	C	A	C
IoT Security and Privacy	I	C	C	I	A	C
IoT Business Value	A	I	I	I	I	C

Table 2: Mapping of training units proficiency to Internet of Things professional roles

A number of IoT occupations can be found in industry such as:

- **IoT Product Manager**. Supervises the execution part of the project. Collaborates with the development teams to take care of business requirements and implementations.
- **IoT Architect**. Manages the functional requirements gathering, technology (hardware, software, protocols) selection and solution architecture design for IoT systems and applications. An IoT Architect is responsible for designing solutions to meet customers' IoT needs. The IoT Architect is responsible for creating effective, efficient, scalable, secure, and innovative IoT Solutions.
- **IoT Software Developer**. Conducts research on existing IoT-related systems and applications and delineate industry best practices. Implements IoT systems and applications according to approved designs and conducts rigorous testing of the applications. Deploys the systems and applications to the cloud as well as app stores.
- **Data Scientist**. A Data scientist finds and interprets rich data sources, manages large amounts of structured and unstructured data, merges data sources, ensures consistency of data-sets, and creates visualizations to aid in understanding data collected from IoT systems and applications. Builds mathematical models, presents and communicates data insights and findings to specialists and scientists, and recommends ways to apply the data.
- **IoT Cloud Engineer**. Deploys the IoT system infrastructure on the cloud, from middleware to data storage (e.g. databases) for collecting, storing and processing data from the IoT devices in the network. IoT cloud engineer is also responsible for maintaining the cloud infrastructure and for working very closely with other ops team members to ensure reliability, scalability, availability and performance of IoT systems.
- **IoT Industrial Engineer**. The role of industrial engineers is to look into the hardware components involved in IoT systems and applications. The industrial engineer professionals are able to program robots and smart embedded devices.
- **IoT Industrial UI/UX designer**. The top of the IoT stack is dashboards or visual screens that end users look at. These are interfaces that are either used to control the sensors or to examine the data coming out of it. UI/UX designer is the integral part of the IoT professional ecosystem. UI/UX designer would take requirements on the end dashboard and would actually go on to design them.

6 Transversal skills

6.1 Transversal skills educational modules

The transversal skills aims to build upon academic and experiential learning and to prepare the ICT professionals for engaging within the business environment in a creative way, communicating effectively with the internal and external environment of a business and acting in a collaborative way. These educational modules will introduce a portfolio of skills and competencies required for effective communication and presentation, adaptation to changes, teamwork, goal-setting and thinking out of the box.

The transversal skills curriculum includes the following educational modules:

1. **Effective communication and presentation (TS-EM1)**
2. **Change management (TS-EM2)**
3. **Team working (TS-EM3)**
4. **Goal setting (TS-EM4)**
5. **Creative thinking (TS-EM5)**

As the learning outcomes aimed by the transversal skills curriculum are horizontal, the educational modules of this curriculum are not split into the three training units (introduction, core and advanced).

6.1.1 Effective communication and presentation (TS-EM1)

Objectives

Provide to the learners knowledge and skills for effective communication and presentation.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know the principles of effective verbal and non-verbal communication
- have a comprehensive understanding of the principles of active listening
- be acquainted with the possible barriers to communication
- have a thorough knowledge about the principles of effective communication with clients and colleagues
- know possible techniques to adapt communication style depending on the scope of the message and feedback received
- have an overall knowledge about the principles of effective presentations

will be able to (skills):

- analyze the factors related to communication with colleagues and clients
- tailor their communication strategy according to the specificities of each encounter
- communicate with clarity and conviction
- encourage participation and interaction when presenting to colleagues or clients

and will (competences)

- adapt effectively to challenging situations in communication
- listen actively
- develop self-awareness in communication
- present technical information clearly, concisely and persuasively

Content

- Principles of effective communication
- Active listening
- Barriers to communication
- Principles of effective communication with clients
- Effective presentation

Learning methodologies

Face-to-face training & work-based learning

Duration

4 hours for face to face training and 4 months for work-based learning

Assessment

- Observation checklist
- Questionnaire
- Self-assessment

Pre-requisite

No pre-requisite knowledge or skills exist

6.1.2 Change management (TS-EU2)

Objectives

Provide to the learners knowledge and skills for change management.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- know what change is about and why it is inevitable in the business environment

- have a good understanding about the importance of developing resilience to change
- be acquainted with the process of transition through change
- have a general knowledge about change management processes

will be able to (skills):

- overcome resistance to change
- support their organization in implementing changes

and will (competences)

- develop a willingness to move from their comfort zone and accept changes in their working environment

Content

- Understanding changes
- Developing resilience
- Transition through change
- Change management

Learning methodologies

Face-to-face training & work-based learning

Duration

4 hours for face to face training and 4 months for work-based learning

Assessment

- Observation checklist
- Questionnaire
- Self-assessment

Pre-requisite

No pre-requisite knowledge or skills exist

6.1.3 Team working (TS-EM3)

Objectives

Provide to the learners knowledge and skills for effective team working.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- have a comprehensive understanding about the characteristics, principles and advantages of teamwork
- be familiar with the characteristics of a balanced team
- be aware of the roles and responsibilities of the members and leader of a team
- have a good understanding about techniques of setting team objectives
- have an overall knowledge about principles of developing an effective team
- have a basic understanding of team leadership
- know the principles of effective communication within teams

will be able to (skills):

- set a common vision and objectives within a team
- be active within a team and improving their teamwork
- motivate the other members of a team
- handle conflicts within a team

and will (competences)

- recognize different personality types within a team
- define individual and team expectations
- understand team dynamics
- improve team motivation
- promote the formation and development of teams in ICT environment

Content

- Formation and development of teams
- The role of teamwork
- Characteristics of effective teams
- Responsibilities and roles within teams
- Setting common goals
- Developing a team
- Team leadership
- Effective communication in teams

Learning methodologies

Face-to-face training & work-based learning

Duration

4 hours for face to face training and 4 months for work-based learning

Assessment

- Observation checklist
- Questionnaire
- Self-assessment

Pre-requisite

No pre-requisite knowledge or skills exist

6.1.4 Goal setting (TS-EM4)

Objectives

Provide to the learners knowledge and skills for effective goal setting.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- have a good understanding of the meaning and importance of goal setting
- know the goal setting process
- know goal setting techniques and tools

will be able to (skills):

- identify what they want to achieve in their professional life
- initiate and run a goal-setting process
- use goal-setting tools and techniques

and will (competences)

- be competent in planning professional goals
- be able to look at their professional role and what services can provide to other people
- include other people from their work environment into their goal setting process

Content

- The benefits of goal setting
- Overcoming obstacles in goal setting
- Effective goal setting

Learning methodologies

Face-to-face training & work-based learning

Duration

4 hours for face to face training and 4 months for work-based learning

Assessment

- Observation checklist
- Questionnaire
- Self-assessment

Pre-requisite

No pre-requisite knowledge or skills exist

6.1.5 Creative thinking (TS-EM5)

Objectives

Provide to the learners knowledge and skills for creative thinking.

Learning outcomes

After the successful completion of this unit learners will (knowledge):

- understand different forms and definitions of creativity
- be acquainted with the phases of creative problem-solving procedures
- be familiar with tools of creative thinking
- have a general understanding about the characteristics of a creative environment
- understand the concept of agile thinking

will be able to (skills):

- gather information about a problem
- identify and analyze problems
- use techniques in order to generate ideas
- manage a creative thinking process
- organize ideas and select the best solutions
- use agile thinking in order to provide valuable solutions

and will (competences)

- be curious about why things are and trying to understand the dynamics of a situation
- see problems in a more positive way
- develop ideas into valuable solutions to the problems
- use creative thinking methodologies in order to support their clients
- think out of the box when they are trying to provide a solution

Content

- Creative behaviour
- Methods and techniques of creative thinking

- Agile thinking
- Characteristics of a creative environment

Learning methodologies

Face-to-face training & work-based learning

Duration

4 hours for face to face training and 4 months for work-based learning

Assessment

- Observation checklist
- Questionnaire
- Self-assessment

Pre-requisite

No pre-requisite knowledge or skills exist

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